REQUEST FOR LETTERS OF AUTHORIZATION

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

Submitted to:

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ACRONYMS AND ABBREVIATIONS

°	degree(s)
°C	degrees Celsius
°F	degrees Fahrenheit
µPa	micropascal(s)
$µPa^2$-s	micropascal squared second
A-S	Air-to-Surface
AAW	Anti-Air Warfare
AMW	Amphibious Warfare
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATCAA	Air Traffic Control Assigned Airspace
AUV	Autonomous Underwater Vehicle
BOMBEX	Bombing Exercise
C.F.R.	Code of Federal Regulations
CV	Coefficient of Variation
dB	decibel(s)
DBRC	Dabob Bay Range Complex
DICASS	Directional Command Activated Sonobuoy System
DoD	Department of Defense
DS	Doppler Sonar
DWADS	Deep Water Active Distributed System
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
EW	Electronic Warfare
FA	Fathometer
FR	Federal Register
ft.	foot/feet
g	gram(s)
GUNEX	Gunnery Exercise
HARP	High-frequency Acoustic Monitoring Package
HDC	High Duty Cycle
Helo	helicopter
HF	High-Frequency
HHS	Hand-Held Sonar
HRC	Hawaii Range Complex
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
IEER	Improved Extended Echo Ranging
IMS	Imaging Sonar
in.	inch(es)
IWC	International Whaling Commission
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
lb.	pound(s)
LF	Low-Frequency
LMR	Living Marine Resources
LOA	Letter of Authorization
m	meter(s)
msec	millisecond(s)
M	Acoustic Modem
MAC	Multistatic Active Coherent
MCM	Mine Countermeasures
MF	Mid-Frequency
mi.	mile(s)
$mi.^2$	square mile(s)
MINEX	Mining Exercise
MISSILEX	Missile Exercise
MIW	Mine Warfare
MMPA	Marine Mammal Protection Act
MOA	Military Operations Area
MPA	Maritime Patrol Aircraft
N	North
n/a	not applicable
NAEMO	Navy Acoustic Effects Model
NASWI	Naval Air Station Whidbey Island
NAVAIR	Naval Air Systems Command
NAVBASE	Naval Base
NAVSEA	Naval Sea Systems Command
Navy	U.S. Department of the Navy
NCA	National Command Authority
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight
nm	nautical mile(s)
nm^2	square nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSW	Naval Special Warfare
NSWC	Naval Surface Warfare Center
NSWCCD	Naval Surface Warfare Center, Carderock Division
NUWC	Naval Undersea Warfare Center
NWTRC	Northwest Training Range Complex
NWTT	Northwest Training and Testing
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
OPNAV N45	Chief of Naval Operations Energy and Environmental Readiness Division
oz.	ounce(s)
PACNW	Pacific Northwest
PCAD	Population Consequences of Acoustic

	Disturbance
PL	Public Law
PMRF	Pacific Missile Range Facility
POPS	Project Operations
PSAMP	Puget Sound Ambient Monitoring Program
PTS	Permanent Threshold Shift
R (1)	Acoustic Release
R (2)	Restricted Area
RDT&E	Research, Development, Test, and Evaluation
re	referenced to
rms	root mean square
ROV	Remotely Operated Vehicle
S	South
S-S	Surface-to-Surface
SAG	Scientific Advisory Group
SAR	Stock Assessment Report
SD	Swimmer Detection Sonar
SEAFAC	Southeast Alaska Acoustic Measurement Facility
SEL	Sound Exposure Level
SERDP	Strategic Environmental Research and Development Program
SINKEX	Sinking Exercise
SPL	Sound Pressure Level
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SSS	Side Scan Sonar
SUA	Special Use Airspace
SUS	Signal Underwater Sound
SUW	Surface Warfare
TNT	Trinitrotoluene
TORP	Torpedo
TRACKEX	Tracking Exercise
TTS	Temporary Threshold Shift
UNDET	Underwater Detonation
USFWS	U.S. Fish and Wildlife Service
U.S.	United States
U.S.C.	United States Code
UUV	Unmanned Underwater Vehicle
VHF	Very High-Frequency
W (1)	Warning Area
W (2)	West
yd.	yard(s)

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 (Take Authorization Requested), of marine mammals during the conduct of training and testing activities within the Northwest Training and Testing (NWTT) Study Area (hereafter referred to as the Study Area). The Navy activity to be authorized will occur from 2015 through 2020, and the Navy requests that each LOA cover the entire period.

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 5 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 affecting 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 EIS (OEIS) for the NWTT Study Area to evaluate all components of the proposed training and testing activities. A description of the Study Area (Figure 1-1) and various components is provided in Chapter 2 (Description of Proposed Action and Alternatives) of the NWTT EIS/OEIS, and in Chapter 2 (Duration and Location of Activities) of this LOA application. The proposed training and testing activities are described in Sections 1.3 through 1.6. This request for LOAs is based on the proposed training and testing activities of the Navy's Preferred Alternative (Alternative 1 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 a LOA is based on: (1) the analysis of spatial and temporal distributions of protected marine mammals in the Study Area, (2) the review of training and testing activities that have the potential to incidentally take marine mammals per the NWTT EIS/OEIS (U.S. Department of the Navy 2014a), and (3) a technical risk assessment to determine the likelihood of effects of Navy activity on marine mammals. 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 NWTT EIS/OEIS, the Navy has determined that only the use of active sonar and other acoustic sources and in-water explosives has 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.

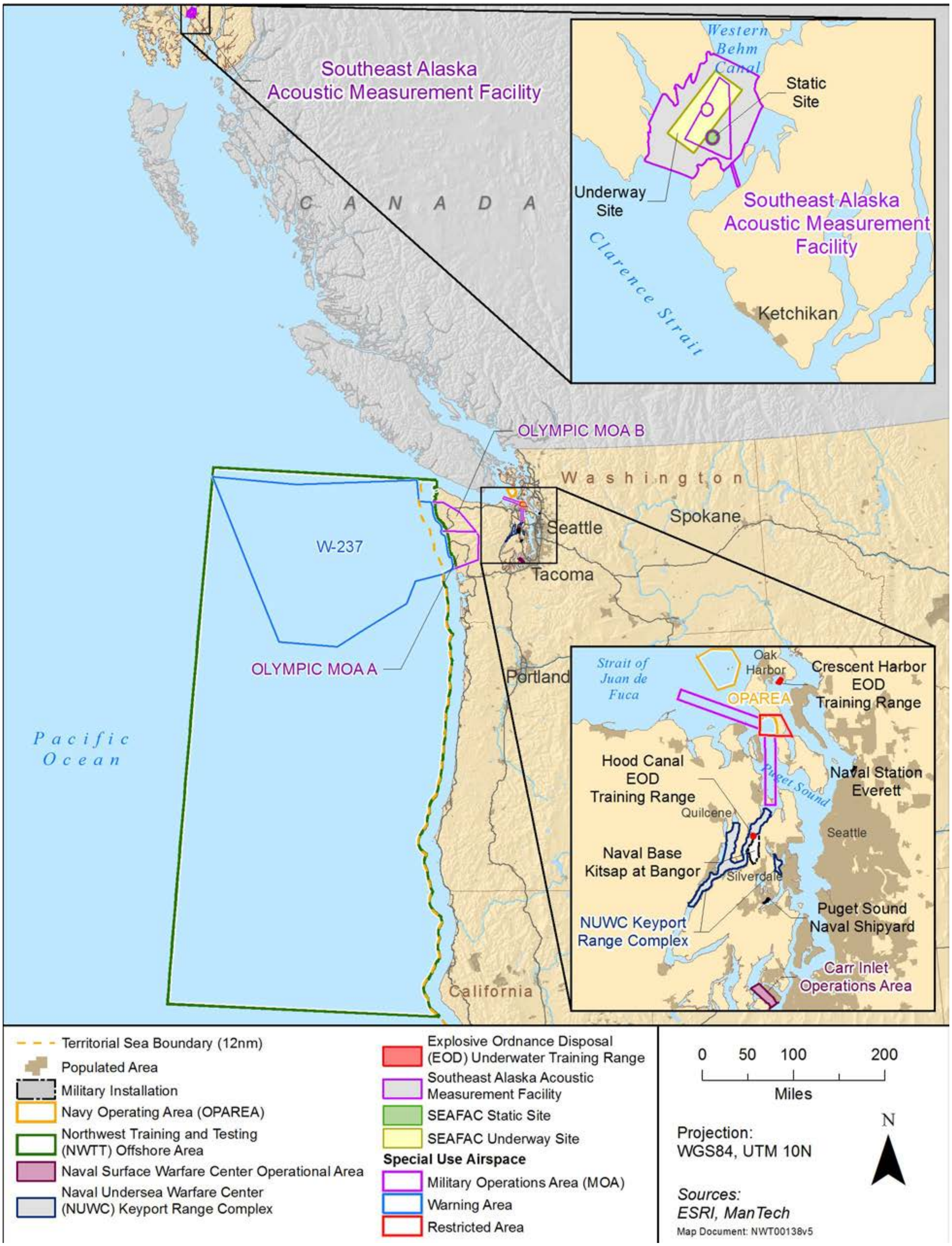

Figure 1-1: Northwest Training and Testing Study Area

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 (OPAREAs), and airspace needed to develop and maintain skills for conducting naval activities. Testing activities support development, installation, and maintenance of defensive and offensive systems, ensuring naval forces are fully equipped to meet their mission requirements.

The Navy's research and acquisition community, including the Navy's systems commands and associated scientific research organizations, provides Navy personnel with ships, aircraft, weapons, combat systems, sensors, and related equipment. The Navy's research and acquisition community is responsible for researching, developing, testing, evaluating, acquiring, and delivering modern platforms and systems to the fleet—and supporting the systems throughout their service lives.

To meet training and testing 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 NWTT EIS/OEIS, and National Marine Fisheries Service (NMFS) is a cooperating agency pursuant to 40 Code of Federal Regulations (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 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 Chapter 2 and Appendix A of the NWTT Draft EIS/OEIS (U.S. Department of the Navy 2014a). Each military training activity described meets a requirement that can be traced ultimately to requirements set forth by the National Command Authority (NCA).[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 [AAW]; Amphibious Warfare [AMW]; Strike Warfare; Anti-Surface Warfare [ASUW]; Anti-Submarine Warfare [ASW]; Electronic Warfare [EW]; Mine Warfare [MIW]; Naval Special Warfare [NSW]). Most training activities are categorized under one of these primary mission areas; those activities that do not fall within one of

[1] Title 10, Section 5062 of the U.S.C. 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.

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.

The Navy describes and analyzes the effects of its training activities within the NWTT Draft EIS/OEIS (U.S. Department of the Navy 2014a). In its assessment, the Navy concluded that of the activities conducted within the Study Area, sonar use and underwater detonations 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:

- ASUW (impulsive sources [underwater detonations])
- ASW (non-impulsive sources, impulsive underwater detonations)
- MIW (non-impulsive sources, impulsive underwater detonations)

The Navy's activities in AAW, EW, and NSW do not involve non-impulsive sources, underwater detonations, 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 NWTT EIS/OEIS.

1.3.1.1 Anti-Surface Warfare

The mission of ASUW is to defend against enemy ships or boats. In the conduct of ASUW, 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 in the Study Area includes surface-to-surface gunnery and missile exercises (GUNEX and MISSILEX), and air-to-surface GUNEX and MISSILEX. Some of the small- and medium-caliber GUNEXs analyzed. Also included in this mission area is a sinking exercise (SINKEX); however, SINKEX events will not be conducted in the Study Area and are not included in this application.

1.3.1.2 Anti-Submarine Warfare

The mission of ASW 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. Anti-submarine warfare training evaluates the ability of fleet assets to use systems, e.g., active and passive sonar and torpedo systems to counter hostile submarine threats. More advanced, integrated ASW training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This training integrates the full spectrum of ASW from detecting and tracking a submarine to attacking a target using simulated weapons.

1.3.1.3 Mine Warfare

The mission of MIW 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 (EOD) 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.

1.4 Overview of Testing Activities

Testing activities covered in this LOA request are briefly described below, and in more detail within Chapter 2 of the NWTT Draft EIS/OEIS (U.S. Department of the Navy 2014a). Each military testing activity described meets a requirement that can be traced ultimately to requirements set forth by the NCA.

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 (Description of Current Training Activities within the Study Area). 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 Hawaii-Southern California Training and Testing (HSTT) Final EIS/OEIS (U.S. Department of the Navy 2013a). In its assessment, the Navy concluded that, for the HSTT Final 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.

The individual commands within the research and acquisition community included in the NWTT EIS/OEIS and in this application are:

- Naval Sea Systems Command (NAVSEA). Within NAVSEA are the following field activities:
  - Naval Undersea Warfare Center (NUWC) Division, Keyport
  - Naval Surface Warfare Center, Carderock Division (NSWCCD), Detachment Puget Sound
  - NSWCCD Southeast Alaska Acoustic Measurement Facility (SEAFAC)
  - Puget Sound Naval Shipyard and Intermediate Maintenance Facility
  - Various NAVSEA program offices
- Naval Air Systems Command (NAVAIR)

1.4.1 NAVAL SEA SYSTEMS COMMAND TESTING EVENTS

NAVSEA is responsible for engineering, building, buying, and maintaining the Navy's ships and submarines and associated combat systems. NAVSEA is broken up into two types of warfare centers: NUWC and the Naval Surface Warfare Center (NSWC).

NUWC provides Fleet readiness support for submarines, surface ships, torpedoes, mines, land attack systems, and Fleet training systems. NAVSEA has several field activities operating out of Naval Base (NAVBASE) Kitsap, including NUWC Division Keyport, NSWCCD Detachment Puget Sound, and Puget Sound Naval Shipyard and Intermediate Maintenance Facility. NSWCCD Detachment Puget Sound also operates the SEAFAC facility in Alaska.

Each major category of NAVSEA activities in the Study Area is represented below. NUWC Division, Keyport and NSWCCD Detachment Puget Sound activities are grouped together in the discussion below to simplify review due to the diversity of activity types and locations they work in. Puget Sound Naval Shipyard and Intermediate Facility activities are grouped with the general activities conducted by NAVSEA. 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.

1.4.1.1 Naval Undersea Warfare Center Division, Keyport Testing Activities

NUWC Division Keyport's mission is to provide test and evaluation services and expertise to support the Navy's evolving manned and unmanned vehicle program activities. NUWC Keyport has historically provided facilities and capabilities to support testing of torpedoes, other unmanned vehicles, submarine readiness, diver training, and similar activities that are critical to the success of undersea warfare. Range support requirements for such activities include testing, training, and evaluation of system capabilities such as guidance, control, and sensor accuracy in multiple marine environments (e.g., differing depths, salinity levels, sea states) and in surrogate and simulated war-fighting environments. Technological advancements in the materials, instrumentation, guidance systems, and tactical capabilities of manned and unmanned vehicles continue to evolve in parallel with emerging national security priorities and threat assessments. However, NUWC Keyport does not utilize explosives in any testing scenarios.

1.4.1.2 Naval Surface Warfare Center, Carderock Division

NSWCCD includes two organizations that conduct testing activities contained in this EIS/OEIS: NSWCCD, Detachment Puget Sound and NSWCCD SEAFAC. Detachment Puget Sound testing activities are aligned with its mission to provide research, development, test, and evaluation (RDT&E), analysis, acquisition support, in-service engineering, logistics and integration of surface and undersea vehicles and associated systems; develop and apply science and technology associated with naval architecture and marine engineering; and provide support to the maritime industry. Activities and support include engineering, technical, operations, diving, and logistics required for the RDT&E associated with:

- Advanced Technology Concepts, Engineering and Proofing
- Experimental Underwater Vehicles, Systems, Subsystems and Components
- Specialized Underwater Systems, Equipment, Tools and Hardware
- Acoustic Data Acquisition, Analysis and Measurement Systems (required to measure U.S. Navy Acoustic Signatures

These activities can be broken down into four major testing categories to include: System, Subsystem and Component Acoustic Testing Pierside; Performance Testing at Sea; Development Testing and Training; and Proof of Concept Testing.

NSWCCD SEAFAC makes high fidelity directive volumetric and line arrays passive acoustic signature measurements. The SEAFAC site includes directive line arrays and data collection and processing systems for real-time data analysis and signature evaluation.

SEAFAC provides the capability to perform RDT&E analyses to determine the sources of radiated acoustic noise, to assess vulnerability, and to develop quieting measures. Unforeseen emergent Navy requirements may influence actual testing activities during the time period under consideration. Testing activities that would occur at SEAFAC are identified to the extent practicable throughout this application.

1.4.1.3 Naval Sea Systems Command Program Office Sponsored Testing Activities

NAVSEA also conducts tests that are not associated with NUWC Keyport or NSWCCD. Activities are conducted at Navy piers at NAVBASE Kitsap, Bremerton; NAVBASE Kitsap, Bangor; and Naval Station Everett; and in conjunction with fleet activities off the coast of Washington, Oregon, and northern California. Tests within this category include, but are not limited to, Life Cycle Activities, Shipboard Protection Systems and Swimmer Defense Testing, Unmanned Vehicle Testing, ASUW/ASW Testing, and New Ship Construction.

1.4.2 Naval Air Systems Command Testing Events

NAVAIR testing events generally fall into the primary mission areas used by the fleets. NAVAIR events include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons and systems are integrated into the fleet.

In this application, NAVAIR testing activities are limited to ASW testing of sonobuoys. The sonobuoys tested include both passive and active non-impulsive, sonobuoys using impulsive sources, and high duty cycle sonobuoys.

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

The Navy uses a variety of sensors, platforms, weapons, and other devices, including those 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 sources of impulsive sounds. Sonar and other active acoustic sound producing systems are categorized as non-impulsive sound sources in this LOA application.

1.5.1 Sonar and Other Active Acoustic 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 general, 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 (ASW) and mines (MIW); safe navigation and effective communications; use of unmanned undersea vehicles; and oceanographic surveys. Sources of sonar and other active acoustic sources include surface ship sonar, sonobuoys, torpedoes, and unmanned underwater vehicles.

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 (NEW), which considers the type and quantity of the explosive substance without the packaging, casings, bullets, etc. Net explosive weight 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 (in.) shell fired from a Navy gun is analyzed at approximately 9.5 pounds (lb.) (4.3 kilograms [kg]) of NEW. The Navy also uses non-explosive ordnance in place of explosive ordnance in many training and testing events. Non-explosive ordnance munitions look and perform similarly to 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, laser and video sensors to locate and classify suspect mines. Aircraft, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.
- **Airborne Laser Mine Detection Systems.** Airborne laser detection systems work in concert with neutralization systems. The detection system initially locates mines and a neutralization system is then used to relocate and neutralize the mine.

- **Unmanned/Remotely Operated Vehicles.** These in-water vehicles use acoustic, video and lasers to locate and classify mines. Unmanned/remotely operated vehicles provide unique MIW capabilities in nearshore littoral areas, surf zones, ports, and channels.
- **Marine Mammal System.** 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.
- **Towed Mechanical Mine Sweeping Systems.** These systems tow a sweep wire to snag the line that attaches a moored mine to its anchor and then uses a series of cables and cutters to sever those lines. Once these lines are cut, the mines float to the surface where Sailors can neutralize the mines.
- **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.
- **Projectiles.** Small- and medium-caliber projectiles, fired from surface ships or hovering helicopters, are used to neutralize floating and near-surface mine.
- **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.

Explosive charges are used during these training activities; however, only non-explosive mines or mine shapes would be used.

1.5.5 Classification of Impulsive and Non-Impulsive Acoustic Sources Analyzed

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater acoustic sound or explosive 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 regulatory 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 NEW) within that bin; which:
    - allows analysis to be conducted in a more efficient manner, without any compromise of analytical results; and
    - provides a framework to support the reallocation of source usage (hours/count) between different source bins, within certain limitations of the Navy's regulatory compliance parameters (i.e., MMPA LOA and ESA biological opinion). 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 acoustic sources: impulsive and non-impulsive. A description of each source classification is provided in Table 1-1, Table 1-2, and Table 1-3. Impulsive source class bins are based on the NEW of the munitions or explosive devices or the source level for air and water guns. Non-impulsive acoustic sources are grouped into source class bins based on the frequency,[3] source level,[4] and, when warranted, the application in which the source would be used. 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)

[3] Bins are based on the typical center frequency of the source. Although harmonics may be present, those harmonics would be several dB lower than the primary frequency.
[4] Source decibel levels are expressed in terms of sound pressure level (SPL) and are values given in dB referenced to one micropascal at 1 meter.

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 analyzed in the Study Area.

Table 1-2 shows non-impulsive sources (e.g., sonar) associated with Navy training activities analyzed in this application.

Table 1-3 shows the non-impulsive sources associated with Navy testing.

Table 1-1: Training and Testing Impulsive (Explosives) Source Classes Analyzed

Source Class	Representative Munitions	Net Explosive Weight (pounds [lb.])
E1	Medium-caliber projectiles	0.1–0.25
E3	Large-caliber projectiles	> 0.5–2.5
E4	Improved Extended Echo Ranging Sonobuoy	> 2.5–5.0
E5	5-inch projectiles	> 5–10
E8	MK-46 torpedo	> 60–100
E10	Air-to-surface missile	> 250–500
E11	MK-48 torpedo	> 500–650
E12	2,000 lb. bomb	> 650–1,000

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

Source Class Category	Source Class	Description
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1–10 kHz) signals	MF1	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	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)
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 100 kHz) signals	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	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 ASW training activities	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)

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

Source Class Category	Source Class	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals	LF4	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1–10 kHz) signals	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
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 100 kHz) signals	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF3	Hull-mounted submarine sonar (classified)
	HF5[1]	Active sources (greater than 200 dB)
	HF6	Active sources (equal to 180 dB and up to 200 dB)
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	VHF2	Active sources with a frequency greater than 100 kHz, up to 200 kHz with a source level less than 200 dB
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of ASW testing activities	ASW1	Mid-frequency Deep Water Active Distributed System (DWADS)
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – sources analyzed by number of items (sonobuoys)
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., High Duty Cycle) – 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)
	TORP2	Heavyweight torpedo (e.g., MK-48, electric vehicles)
Acoustic Modems (M): Systems used to transmit data acoustically through water	M3	Mid-frequency acoustic modems (greater than 190 dB) (e.g., Underwater Emergency Warning System, Aid to Navigation)
Swimmer Detection Sonar (SD): Systems used to detect divers and submerged swimmers	SD1	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	High frequency unmanned underwater vehicle (UUV) (e.g., UUV payloads)

1 Notes: (1) For this analysis, HF5 consists of only one source; the modeling was conducted specifically for that source. (2) DICASS = Directional Command Activated Sonobuoy System

1.5.7 Source Classes Excluded From Quantitative Analysis for Training and Testing

As described in the NWTT Draft EIS/OEIS (U.S. Department of the Navy 2014a), 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 the EIS/OEIS hereafter to determine the appropriate determinations under the MMPA and ESA:

- Acoustic sources with frequencies greater than 200 kHz (based on known marine mammal hearing ranges)
- Sources with source levels less than 160 dB.

An entire source bin, or some sources from a bin, may be excluded from quantitative analysis within the scope of this LOA request if one or more 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.
- Shock Wave Action Generator contains approximately 0.5 ounce (oz.) (15 grams [g]) of explosives and will not be analyzed in a quantitative manner for impacts to marine mammals due to the low level of explosive contained in the device.

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 Category	Source Bin	Justification
Doppler Sonar/Speed Logs (DS) 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 their 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 quantitative modeling is required for marine species that might encounter these sound sources.
Fathometers (FA) High-frequency sources used to determine water depth	FA1–FA4	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow downward-directed beam). Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources. Fathometers use a downward-directed, 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 generates very high frequency sound at low power levels, short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for marine species at a very short range, and they are under positive control of the diver on which direction the sonar is pointed, marine species reactions are not likely. No additional quantitative modeling is required for marine species that might encounter these sound sources.

Table 1-4: Source Classes Excluded from Quantitative Analysis (continued)

Source Category	Source Bin	Justification
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 representative of a downward looking source, narrow beam, and operates above 180 kHz (basically a fathometer).	IMS1, IMS2	These side scan sonar operates 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), pinnipeds, manatees, and sea turtles and pinnipeds, and, therefore, not expected to affect these species in the 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 marine species may be less likely to react to these types of systems 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 imaging sonar 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 quantitative modeling is required for marine species that might encounter these sound sources.
High Frequency Acoustic Modems and Tracking Pingers (M, P)	M2, P1, P2, P3, P4	Acoustic modems and tracking pingers operate at frequencies between 2 and 170 kHz, have low duty cycles (single pings in some cases), short pulse lengths (typically 20 msec), and relatively low source levels. Marine species are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics as described above. Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for animals that might encounter 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	Acoustic releases operate at mid- and high-frequencies. Since these types of devices are only used to retrieve bottom mounted devices, they typically transmit only a single ping. Marine species are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely short in duration. Such reactions are not considered to constitute “taking” and, therefore, no additional quantitative modeling is required for marine species that might encounter 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 quantitative modeling is required for marine species that might encounter these sound sources.

Notes: dB = decibel, HF = high frequency, kHz = kilohertz, m = meter, msec = millisecond, NWTT = Northwest Training and Testing, VHF = very high-frequency

1.6 PROPOSED ACTION

The Navy has been conducting training and testing activities in the Study Area for decades, with some activities dating back to at least the early 1900s. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in war fighting doctrine and procedures, and force structure (organization of ships, submarines, aircraft, weapons, and Sailors) changes.

Such developments influence the frequency, duration, intensity, and location of required training and testing activities.

The Navy analyzed many training and testing activities in the Study Area in the Tactical Training Theater Assessment and Planning Program Phase I and earlier documents, specifically the following environmental planning documents: *Northwest Training Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy 2010a), *NAVSEA NUWC Keyport Range Complex Extension Final Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy 2010b), and the *Final Environmental Impact Statement for the Southeast Alaska Acoustic Measurement Facility (SEAFAC)* (U.S. Department of the Navy 1988).

The NWTT EIS/OEIS (which is part of Phase II of the program) accounts for planned adjustments to tempo and types of activities dictated by military readiness requirements.

1.6.1 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, type of non-impulsive or impulsive sources used in the activity, and the number of activities per year.

More detailed activity descriptions can be found in Appendix A of the NWTT EIS/OEIS. The Navy's Proposed Activities are anticipated to meet training needs in the years 2015–2020.

Table 1-5: Training Activities within the Study Area

Category	Training Activity	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Anti-Surface Warfare (ASUW)				
Impulsive	Gunnery Exercise, Surface-to-Surface (Ship) (GUNEX-S-S [Ship])	Ship crews engage surface targets with ship's small-, medium-, and large-caliber guns. Some of the small- and medium-caliber gunnery exercises analyzed.	Small-, Medium-, and Large-caliber high explosive rounds	200
Impulsive	Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing aircrews simulate firing precision-guided missiles, using captive air training missiles against surface targets.	High explosive missiles	4
Impulsive	Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.	High explosive bombs	30
Anti-Submarine Warfare (ASW)				
Non-impulsive	Tracking Exercise – Submarine (TRACKEX – Sub)	Submarine searches for, detects, and tracks submarine(s) and surface ship(s).	Mid- and high-frequency submarine sonar	100
Non-impulsive	Tracking Exercise – Surface (TRACKEX – Surface)	Surface ship searches for, tracks, and detects submarine(s).	Mid-frequency surface ship sonar (e.g., SQS-53 and SQS-60); acoustic countermeasures (e.g., SLQ-25 NIXIE), and high-frequency active sources	65
Non-impulsive	Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter searches, tracks, and detects submarine(s).	Mid-frequency dipping sonar systems (e.g., AQS-22 and AQS-13), sonobuoys such as DICASS	4
Non-impulsive	Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Maritime patrol aircraft use sonobuoys to search for, detect, and track submarine(s).	Sonobuoys, such as DICASS sonobuoys	300
Impulsive and Non-impulsive	Tracking Exercise – Maritime Patrol Aircraft MAC sonobuoys (TRACKEX- MPA MAC)	Maritime patrol aircraft crews search for, detect and track submarines using multistatic active coherent system sonobuoys.	mid-frequency multistatic active coherent sonobuoys (e.g., SSQ-125)	24

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

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Mine Warfare (MIW)				
Impulsive	Mine Neutralization – Explosive Ordnance Disposal	Personnel disable threat mines. Explosive charges may be used.	2.5 lb.	6
Non-impulsive	Submarine Mine Exercise	Submarine crews practice detecting non-explosive training mine shapes in a designated area.	Submarine high-frequency active sonar	8
Non-impulsive	Civilian Port Defense	Civilian port defense is a naval mine warfare activity conducted at various ports and harbors, in support of maritime homeland defense/security.	Mine detection, classification, and neutralization sonar (e.g., SQQ-32, AQS-20, ASQ-235, and AQS-20)	1 (every 2 years)
Other				
Non-impulsive	Surface Ship Sonar Maintenance	Pierside and at-sea maintenance of surface ship sonar systems	Surface ship sonar, such as SQS-53	13
Non-impulsive	Submarine Sonar Maintenance	Pierside and at-sea maintenance of submarine sonar systems	Submarine sonar, such as BQQ-10 and submarine HF sonar	22
Impulsive	Transit Protection System	Small boat escort of submarines	Small boat movement, small-caliber rounds (blanks)	226

Notes: DICASS = Directional Command Activated Sonobuoy System, lb. = pounds, U.S. = United States

1.6.2 TESTING

The Navy's proposed testing activities are representative of the types of events anticipated for the years 2015–2020. Full descriptions of these activities can be found in Appendix A of the NWTT EIS/OEIS.

The testing activities that the Navy proposes to conduct in the Study Area are described in Table 1-6 and Table 1-7.

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

Category	Testing Activity	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Naval Undersea Warfare Center Division Keyport Testing Activities				
Non-impulsive	Torpedo Non-Explosive Testing	Test of a non-explosive torpedo against a target	Torpedo sonar (e.g., MK-46 and MK-48), countermeasure systems, DICASS sonobuoys, other mid-frequency active sources	61
Non-impulsive	Unmanned Underwater Vehicle Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads (e.g., an active acoustic system or a passive acoustic or non-acoustic sensor) used for different purposes	Submarine sonar, high-frequency sources (e.g., UUV sonar), torpedo sonar (e.g., MK-46 and MK-48)	151
Non-impulsive	Cold Water Training	Fleet training for divers in a cold water environment and other diver training related to Navy divers supporting range operations.	High-frequency and mid-frequency sources	85
Non-impulsive	Post-Refit Sea Trial	Following periodic maintenance periods or repairs, sea trials are conducted to evaluate submarine propulsion, sonar systems, and other mechanical tests	Mid-frequency acoustic modems and other mid-frequency active sources	32
Non-impulsive	Anti-Submarine Warfare (ASW) Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines	Hull-mounted high duty cycle sonar systems and other mid-frequency active sources	5
Non-impulsive	Side Scan/Multibeam	Side Scan/Multibeam systems associated with a vessel or UUV are tested to ensure they can detect, classify, and localize targets in a real world environment	[No acoustic sources currently associated with this activity]	54
Non-impulsive	Countermeasures Testing	Countermeasures emit active acoustic energy of varying frequencies into the water to mimic the magnetic characteristics of a target so that the actual threat or target remains undetected	Mid-frequency active acoustic countermeasures	67
Non-impulsive	Acoustic Test Facility	Various acoustic component testing is conducted in a controlled experimental environment to measure performance of modified, upgraded, and experimental devices	Low-, mid-, high-, and very high-frequency active sources	176

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

Category	Testing Activity	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Naval Undersea Warfare Center Division Keyport Testing Activities (continued)				
Non-impulsive	Pierside Integrated Swimmer Defense	Swimmer detection testing ensures that systems can effectively detect swimmer and diver threats in harbor environments	Low-, and mid-frequency active sources, high-frequency short pulse length sources used for swimmer detection	38
Naval Surface Warfare Center, Carderock Division Detachment Puget Sound				
Non-impulsive	Pierside Acoustic Testing	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes (including experimental vehicles, systems, equipment, tools and hardware) underwater in a static or dynamic condition within 500 yd. of an instrumented platform moored pierside.	Low- and mid-frequency active sources, including mid-frequency acoustic modems	60
Non-impulsive	Performance Testing at Sea	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes underwater at sea. Systems will be exercised to obtain operational performance measurements of all subsystems and components used for navigation and mission objectives.	Mid- and high-frequency active sources, including mid-frequency acoustic modems	60
Non-impulsive	Development Training and Testing	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes underwater at Sea. Systems will be exercised to validate development and to provide operator familiarization and training with all subsystems and components used for navigation and mission objectives.	Low- and mid-frequency active sources, including mid-frequency acoustic modems and high-frequency synthetic aperture sonar	36
Non-impulsive	Proof-of-Concept Testing	Design, fabrication and installation of unique hardware and towing configurations in support of various surface and underwater demonstrations as proof-of-concept	Mid- and high-frequency active sources, including mid-frequency acoustic modems and high-frequency synthetic aperture sonar	30

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

Category	Testing Activity	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility				
Non-impulsive	Surface Vessel Acoustic Measurement	Conduct acoustic trial measurements of surface vessels	High-frequency hull-mounted submarine sonar, mid-frequency active sources	12
Non-impulsive	Underwater Vessel Acoustic Measurement	Conduct acoustic trial measurements of underwater vessels	Low- and mid-frequency active sources, including underwater communications, high-frequency hull-mounted submarine sonar	26
Non-impulsive	Underwater Vessel Hydrodynamic Performance Measurement	Conduct hydrodynamic performance trial measurements	Low- and mid-frequency active sources, including underwater communications, high-frequency hull-mounted submarine sonar	3
Non-impulsive	Cold-water Training	Involves Navy personnel conducting insertion training in cold-water conditions. The training may include ingress and egress from subsurface vessels and small surface craft.	Mid- and high-frequency active sources, including underwater communications	1
Non-impulsive	Component System Testing	Conduct testing on individual components of new defense acquisition systems	Mid- and high-frequency active sources, including underwater communications	4
Non-impulsive	Countermeasures Testing	Conduct engineering and acceptance testing of Countermeasures	[No acoustic sources currently associated with this activity]	4
Non-impulsive	Electromagnetic Measurement	Conduct new construction, post-PSA, and lifecycle electromagnetic measurements	Mid-frequency active sources, including underwater communications	5
Non-impulsive	Measurement System Repair/Replacement	Conduct repairs, replacements and calibration of acoustic measurement systems	Mid-frequency active sources, including underwater communications	1
Non-impulsive	Project Operations (POPS)	Support testing of fleet assets	Mid- and high-frequency active sources, including underwater communications	3
Non-impulsive	Target Strength Trial	Asset moored to static site. Acoustic projectors and receive arrays will be rotated around asset. Broadband waveforms will be transmitted. Underwater tracking system will be utilized to monitor relative positions.	High-frequency active sources	1

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

Category	Testing Activity	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Additional Naval Sea Systems Command Testing Activities				
Non-impulsive	Pierside Sonar Testing	Pierside testing of submarine and surface ship sonar systems occurs periodically following major maintenance periods and for routine maintenance	Submarine mid- and high-frequency active sonar, mid-frequency acoustic modems, mid-frequency underwater communications; Surface ship sonar	67
Non-impulsive	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer and diver threats in harbor environments	Low- and mid-frequency active sources, and high-frequency short pulse length sources used for swimmer detection	1
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	No acoustic sources currently associated with this activity. Also, no activities tied to "LFBB" (MF9 – Underwater Comms)	4
Impulsive and Non-impulsive	Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive torpedoes against artificial targets	Torpedo sonar and explosive warheads (e.g., MK-46 and MK-48)	3
Non-impulsive	Torpedo (Non-explosive) Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels	Torpedo sonar (e.g., MK-46 and MK-48)	3
Non-impulsive	Countermeasure Testing	Countermeasure testing involves the testing of systems that would detect, localize, track, and attack incoming weapons	Lightweight torpedo sonar (e.g., MK-46), mid-frequency active acoustic countermeasures, and high-frequency active sources	21
Non-impulsive	Anti-Submarine Warfare (ASW) Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines	Mid-frequency DWADS, active acoustic countermeasures, dipping sonar systems (e.g., AQS-22 and AQS-13), sonobuoys such as DICASS high duty cycle variable depth sonar, lightweight torpedo sonar (e.g., MK-46)	8

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

Category	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual NWTT Events
Naval Air Systems Command Anti-Submarine Warfare (ASW) Testing Activities				
Non-impulsive	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (DICASS)	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using DICASS sonobuoys	DICASS sonobuoys	28
Non-impulsive	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (MAC)	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the MAC sonobuoy system.	MAC sonobuoys	14
Impulsive and non-impulsive	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (SUS)	This test evaluates the sensors and systems used by maritime patrol aircraft to communicate with submarines using any of the family of SUS systems.	Impulsive SUS buoys (e.g., MK-61, MK-64, MK-82), Non-impulsive SUS buoys (e.g., MK-84)	5
Impulsive	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (IEER)	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the IEER system.	IEER sonobuoy detonations	6
Non-Impulsive	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (HDC)	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the HDC sonobuoy system.	HDC sonobuoys	1

Notes: DICASS = Directional Command Activated Sonobuoy System, MAC = Multistatic Active Coherent, SUS = Signal Underwater Sound, IEER = Improved Extended Echo Ranging, HDC = High Duty Cycle, yd. = yards

1.6.3 SUMMARY OF IMPULSIVE AND NON-IMPULSIVE SOURCES

The Navy is requesting the level of take discussed in Chapter 5 based on the annual sonar and other active acoustic and explosive bin use listed in the following sections.

1.6.3.1 Training Sonar and Other Active Acoustic Source Classes

Table 1-8 provides a quantitative annual summary of training activities by sonar and other active acoustic source class analyzed in this LOA request.

Table 1-8: Annual Hours of Sonar and Other Active Acoustic Sources Used during Training within the Study Area

Source Class Category	Source Class	Units	Annual Use
Mid-Frequency (MF) Active sources from 1 to 10 kHz	**MF1**	Hours	166
	MF3	Hours	70
	MF4	Hours	4
	MF5	Items	896
	MF11	Hours	16
High-Frequency (HF): Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 100 kHz	**HF1**	Hours	48
	HF4	Hours	384
	HF6	Hours	192
Anti-Submarine Warfare (ASW) Active ASW sources	**ASW2**	Items	720
	ASW3	Hours	78

1.6.3.2 Testing Sonar and Other Active Acoustic Source Classes

Table 1-9 provides a quantitative annual summary of testing activities by sonar and other active acoustic source class analyzed in this LOA request.

Table 1-9: Annual Hours of Sonar and Other Active Acoustic Sources Used during Testing within the Study Area

Source Class Category	Source Class	Units	Annual Use
Low-Frequency (LF) Sources that produce signals less than 1 kHz	**LF4**	Hours	110
	LF5	Hours	71
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	**MF3**	Hours	161
	MF4	Hours	10
	MF5	Items	273
	MF6	Items	12
	MF8	Hours	40
	MF9	Hours	1,183
	MF10	Hours	1,156
	MF11	Hours	34
	MF12	Hours	24
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 100 kHz	**HF1**	Hours	161
	HF3	Hours	145
	HF5[1]	Hours	360
	HF6	Hours	2,099
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	**VHF2**	Hours	35
Anti-Submarine Warfare (ASW) Tactical sources used during ASW training and testing activities	**ASW1**	Hours	16
	ASW2[2]	Hours	64
	ASW2[2]	Items	170
	ASW3	Hours	444
	ASW4	Items	1,182
Acoustic Modems (M): Systems used to transmit data acoustically through water	**M3**	Hours	1,519
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	**TORP1**	Items	315
	TORP2	Items	299
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	**SD1**	Hours	757
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	**SAS2**	Hours	798

[1] For this analysis, HF5 consists of only one source; the modeling was conducted specifically for that source.
[2] The ASW2 bin contains sources that are analyzed by hours and some that are analyzed by count of items. There is no overlap of the numbers in the two rows.

1.6.3.3 Training and Testing Impulsive Source Classes

Table 1-10 provides a quantitative annual summary of training explosive source classes analyzed in this application. Table 1-11 is the quantitative annual summary of testing explosive source classes.

Table 1-10: Annual Number of Training Explosive Source Detonations

Explosive Class Net Explosive Weight (NEW)	Annual In-Water Detonations Training
E1 (0.1 pound [lb.]–0.25 lb. NEW)	48
E3 (> 0.5 lb.–2.5 lb. NEW)	6
E5 (> 5 lb.–10 lb. NEW)	80
E10 (> 250–500 lb. NEW)	4
E12 (> 650–1,000 lb. NEW)	10

Table 1-11: Annual Number of Testing Explosive Source Detonations

Explosive Class Net Explosive Weight (NEW)	Annual In-Water Detonations Testing
E3 (> 0.5 pound [lb.]–2.5 lb. NEW)	72
E4 (> 2.5 lb.–5 lb. NEW)	70
E8 (> 60–100 lb. NEW)	3
E11 (> 500–650 lb. NEW)	3

1.6.4 Other Stressors – Vessel Strikes

As explained in Section 1.1 (Introduction), in addition to potential impacts to marine mammals from activities using explosives or sonar and other active acoustic sources, the Navy also recognizes that ship strikes could result in harassment, injury, or mortality to marine mammals. The Navy assessed that no additional stressors would result in a take and require authorization under the MMPA.

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-foot (ft.) (5-meter [m]) rigid hull inflatable boats to aircraft carriers 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 1-12.

Large Navy ships greater than 65 ft. (20 m) generally operate at speeds in the range of 10–15 knots for fuel conservation when cruising. Submarines generally operate at speeds in the range of 8–13 knots during transit and slower for certain tactical maneuvers. Small craft (for purposes of this discussion less than 65 ft. [20 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 2 weeks. Vessel movement and the use of in-water devices as part of the proposed action would be concentrated in certain portions of the Study Area (such as Western Behm Canal [Alaska] or Hood Canal in the inland waters portion of the Study Area) but may occur anywhere within the Study Area (Chapter 2, Duration and Location of Activities).

The Navy is analyzing the potential environmental impacts of approximately 226 ongoing annual Maritime Security Operations events in Puget Sound and the Strait of Juan de Fuca. These critical events have been occurring since 2006 and exercise the Navy's Transit Protection System, where up to nine escort vessels provide protection during all nuclear ballistic missile submarine (SSBN) transits between the vessel’s homeport and the dive/surface point in the Strait of Juan de Fuca or Dabob Bay. During a Transit Protection System event, the security escorts enforce a moving 1,000 yard security zone around the SSBN to prevent other vessels from approaching while the SSBN is in transit on the surface. These events include security escort vessels, U.S. Coast Guard personnel and their ancillary equipment and weapons systems. The Transit Protection System involves the movement of security vessels and also includes periodic exercises and firearms training (with blank rounds). Given the relative slow speed of the escorted and blocking vessels and multiple lookouts, no marine mammal vessel strikes are expected as a result of these events.

Navy policy (Chief of Naval Operations Instruction 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 (OPNAV N45) and cumulatively provided to NMFS on an annual basis. In addition, 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 duration of the LOAs. There have been no reports of vessel strikes of marine mammals during training and testing in the NWTT Study Area.

Table 1-12: Representative Vessel Types, Lengths, and Speeds

Type	Example(s)	Length	Typical Operating Speed	Max Speed
Aircraft Carrier	Aircraft Carrier	> 980 ft. (> 300 m)	10–15 knots	30+ knots
Surface Combatant	Cruisers, Destroyers, Frigates, Littoral Combat Ships	330–660 ft. (100–200 m)	10–15 knots	30+ knots
Support Craft/Other	Range Support Craft, Combat Rubber Raiding Craft; Landing Craft, Mechanized; Landing Craft, Utility; Submarine Tenders; Yard Patrol Craft; Protection Vessels; Barge	16–250 ft. (5–80 m)	Variable	20 knots
Support Craft/Other – Specialized High Speed	Patrol Coastal Ships, Patrol Boats, Rigid Hull Inflatable Boat, High Speed Protection Vessels	33–130 ft. (10–40 m)	Variable	50+ knots
Submarines	Fleet Ballistic Missile Submarines, Attack Submarines, Guided Missile Submarines	330–660 ft. (100–200 m)	8–13 knots	20+ knots

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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 Study Area throughout the year from October 2015 through October 2020.

The Study Area is composed of established maritime operating and warning areas in the eastern North Pacific Ocean region, including areas of the Strait of Juan de Fuca, Puget Sound, and Western Behm Canal in southeastern Alaska. The Study Area includes air and water space within and outside Washington state waters, Alaska state waters, and outside state waters of Oregon and Northern California. The eastern boundary of the Offshore Area is 12 nm (22 km) off the coastline for most of the Study Area, including southern Washington, Oregon, and Northern California. The Offshore Area includes the ocean all the way to the coastline only along the Washington coast beneath the airspace of W-237 and the Olympic Military Operating Area (MOA) and the Washington coastline north of the Olympic MOA (Figure 2-1). The Study Area includes four existing range complexes and facilities: the Northwest Training Range Complex (NWTRC), the Keyport Range Complex, Carr Inlet Operations Area, and SEAFAC. In addition to these range complexes, the Study Area also includes Navy pierside locations where sonar maintenance and testing occurs as part of overhaul, modernization, maintenance and repair activities at NAVBASE Kitsap, Bremerton; NAVBASE Kitsap, Bangor; and Naval Station Everett.

A range complex is a designated set of specifically bounded geographic areas and encompasses a water component (above and below the surface), and may encompass airspace and a land component where training and testing of military platforms, tactics, munitions, explosives, and EW systems occurs. Range complexes include established OPAREAs, Restricted Areas, and special use airspace (SUA), which may be further divided to provide better control of the area and events for safety reasons.

- **OPAREA:** A maritime area defined by geographic coordinates with defined surface and subsurface areas and associated SUA, 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 C.F.R. Part 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 C.F.R. Part 334).
- **SUA:** 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 Joint Order 7400.8 series). Special use airspace found in the Study Area includes 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 non-participant aircraft. Some areas are under strict control of the Department of Defense (DoD) and some are shared with non-military agencies.

- **Military Operations Areas (MOAs):** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training 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.

- **Special Activity Airspace/Airspace Assigned by Air Traffic Control:** Air Traffic Control Assigned Airspace (ATCAA) is that airspace of defined vertical/lateral limits, assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activity being conducted within the assigned airspace and other instrument flight rules traffic. ATCAAs are assigned by the Federal Aviation Administration and are not SUA.

The Study Area (Figure 2-1) includes only the at-sea components of the training and testing areas and facilities. The Navy is using “at-sea” to cover activity in, on, and over the water, but not activity on or over the land, which may include activities in the surf zone or supported from shore-side locations.

Military activities in the Study Area occur (1) on the ocean surface, (2) beneath the ocean surface, and (3) in the air. To aid in the description of the ranges covered in the NWTT EIS/OEIS, the ranges are divided into three distinct geographic and functional subdivisions. All of the training and testing activities proposed in this application would occur in one or more of these three range subdivisions:

- The Offshore Area
- The Inland Waters
- Western Behm Canal, Alaska

2.1 OFFSHORE AREA

The Offshore Area of the Study Area includes air, surface, and subsurface OPAREAs extending generally west from the coastline of Washington, Oregon, and Northern California for a distance of approximately 250 nm into international waters. The eastern boundary of the Offshore Area is 12 nm (22 km) off the coastline for most of the Study Area, including southern Washington, Oregon, and Northern California. The Offshore Area includes the ocean all the way to the coastline only along the Washington coast beneath the airspace of W-237 and the Olympic MOA and the Washington coastline north of the Olympic MOA. The components of the Offshore Area are described below and depicted in Figure 2-2.

2.1.1 AIRSPACE

The SUA in the Offshore Area is comprised of Warning Area 237 (W-237), which extends westward off the coast of Northern Washington State and is divided into nine sub-areas (A-H, and J). The eastern boundary of W-237 lies 3 nm off the coast of Washington. The floor of W-237 extends to the ocean surface and the ceiling of the airspace varies between 27,000 ft. (8,200 m) in areas E, H, and J; 50,000 ft. (15,200 m) in areas A and B; and unlimited in areas C, D, F, and G, with a total area of 25,331 square nautical miles (nm^2). The Olympic MOA overlays both land (the Olympic Peninsula) and sea (extending to 3 nm off the coast of Washington into the Pacific Ocean). The MOA lower limit is 6,000 ft. (1,800 m) above mean sea level but not below 1,200 ft. above ground level, and the upper limit is up to, but not including, 18,000 ft. (5,500 m), with total area coverage of 1,614 nm^2. Above the Olympic MOA is the Olympic ATCAA, which has a floor coinciding with the Olympic MOA ceiling. The ATCAA has an upper limit of 35,000 ft. (10,700 m). For this application, the Olympic MOA and the Olympic ATCAA are components of the Offshore Area.

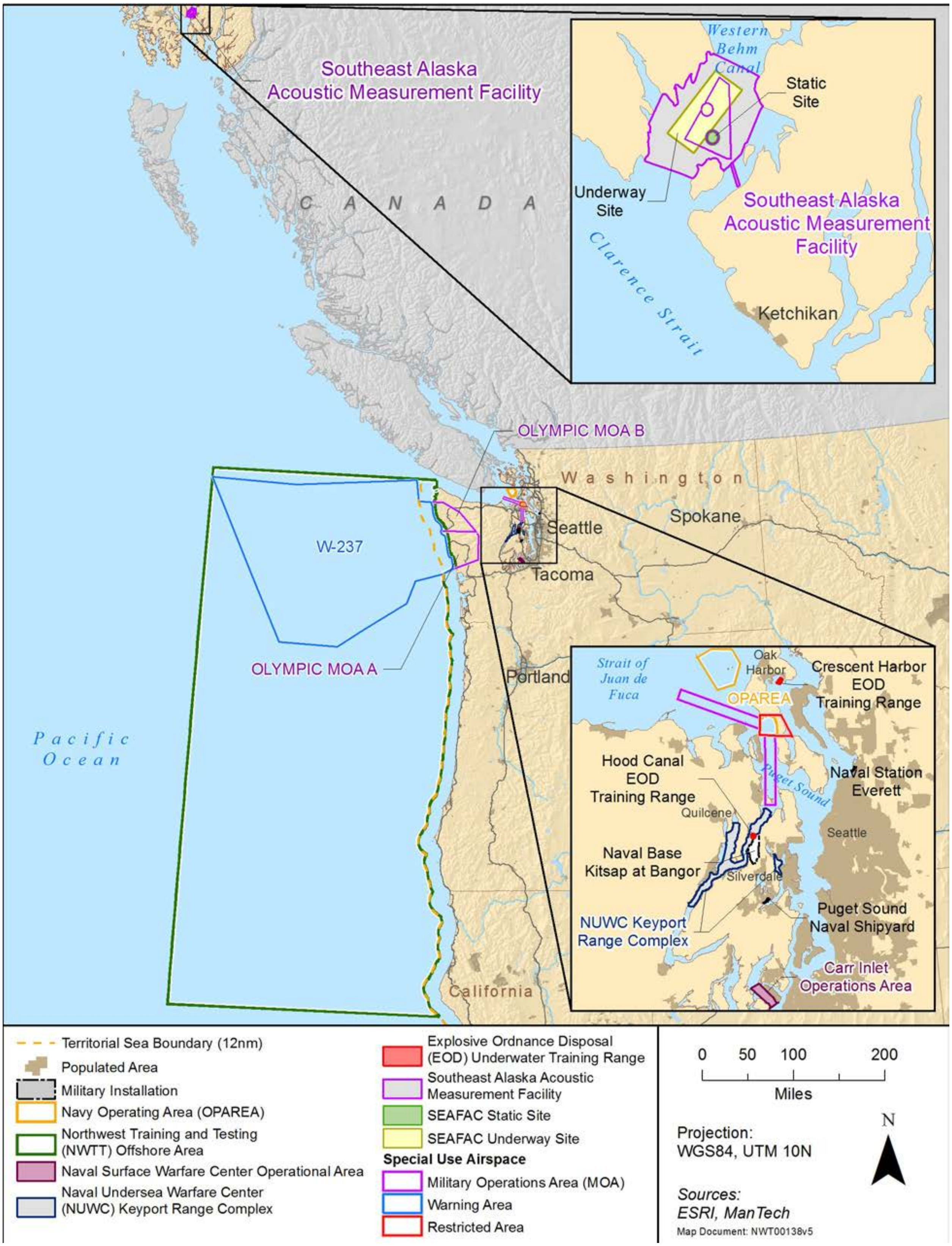

Figure 2-1: Northwest Training and Testing Study Area

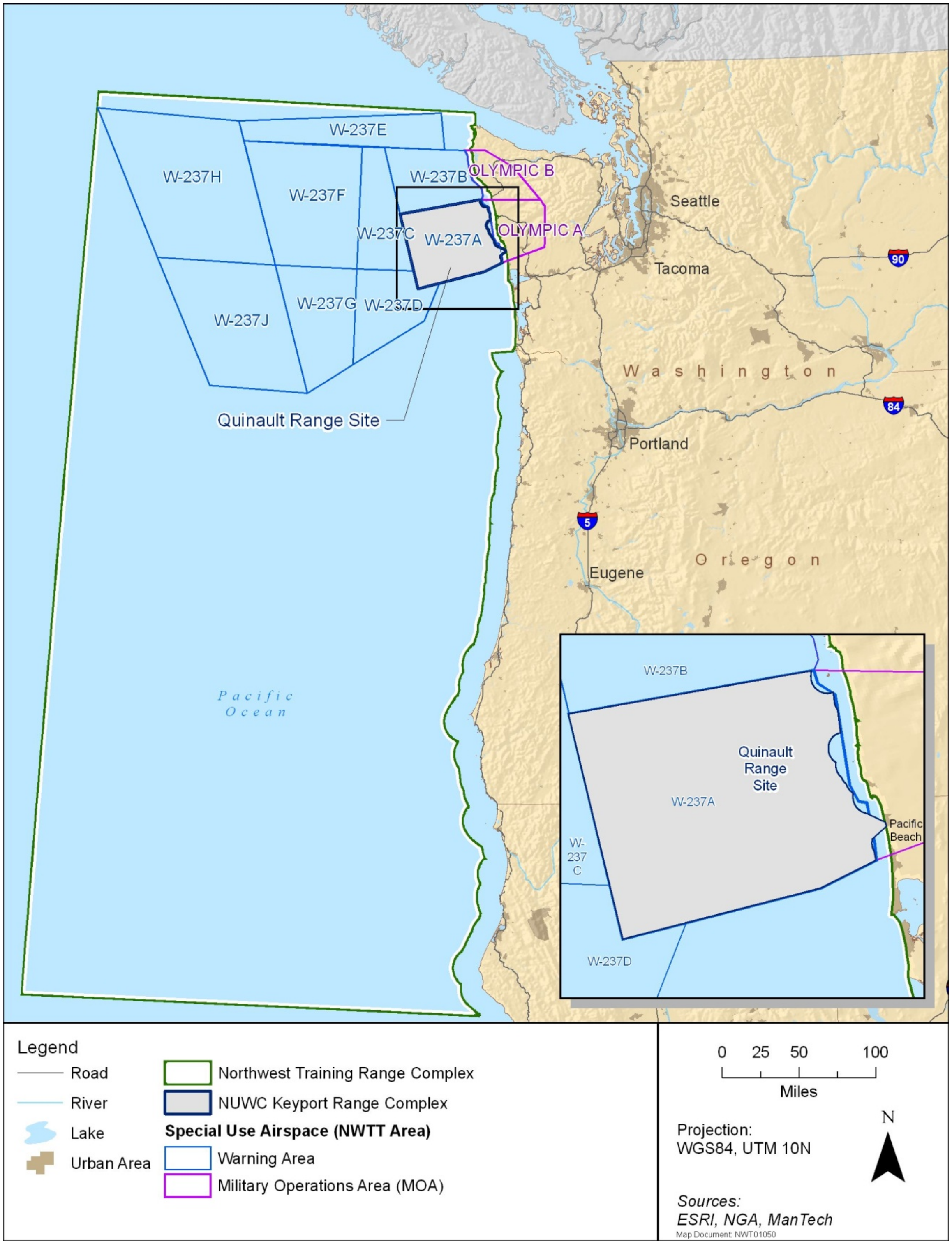

Figure 2-2: Offshore Area of the Northwest Training and Testing Study Area

2.1.2 SEA AND UNDERSEA SPACE

The Offshore Area includes sea and undersea space approximately 510 nm in length from the northern boundary at the mouth of the Strait of Juan de Fuca to the southern boundary at 40 degrees (°) north (N) latitude, and 250 nm from the coastline to the western boundary at 130° west (W) longitude. Total surface area of the Pacific Northwest (PACNW) OPAREA is 121,600 nm^2. While the PACNW OPAREA extends to the shoreline throughout its length, the Study Area excludes that portion from the coastline of southern Washington (south of the Olympic MOA), Oregon, and Northern California out to 12 nm at sea.

The majority of surface ship tracking exercise (TRACKEX) training events tend to occur within the W-237 part of the PACNW OPAREA (see Figure 2-2).

Commander Submarine Force, U.S. Pacific Fleet Pearl Harbor uses this water space as a function of the safe operation of U.S. submarines. While the sea space is ample for all levels of Navy training, no infrastructure is in place to support training. For example, there are no dedicated training frequencies, no permanent instrumentation, no meteorological and oceanographic operations system, and no established target systems. In this region of the Pacific Ocean, storms and high sea states can create challenges to surface ship training between October and April. In addition, strong undersea currents in the Pacific Northwest make it difficult to place bottom-mounted instrumentation such as hydrophones.

Within the defined boundaries of the PACNW OPAREA lies the Quinault Range Site (see Figure 2-2). The Quinault Range Site coincides with the boundaries of W-237A, and also includes a surf zone component. The surf zone component extends north to south 5 nm along the eastern boundary of W-237A, extends approximately 3 nm to shore along the mean lower low water line, and encompasses 1 mile (mi.) (1.6 kilometers [km]) of shoreline at Pacific Beach, Washington. Surf-zone activities would be conducted from an area on the shore and seaward.

2.2 INLAND WATERS

The Inland Waters includes air, sea, and undersea space inland of the coastline, from buoy "J" at 48° 29.6' N, 125°W, eastward to include all waters of the Strait of Juan de Fuca, the Puget Sound. None of this area extends into Oregon or California. Within the Inland Waters are specific geographic components in which training and testing occur. The Inland Waters and its component areas are described below and depicted in Figure 2-3.

2.2.1 AIRSPACE

Restricted Area 6701 (R-6701, Admiralty Bay) is a Restricted Area over Admiralty Bay, Washington with a lower limit at the ocean surface and an upper limit of 5,000 ft. This airspace covers a total area of 56 nm^2.

Chinook A and B MOAs are 56 nm^2 of airspace south and west of Admiralty Bay (Figure 2-3). The Chinook MOAs extend from 300 ft. to 5,000 ft. above the ocean surface.

2.2.2 Sea and Undersea Space

2.2.2.1 Explosive Ordnance Disposal Underwater Ranges

Two active EOD ranges are located in the Inland Waters at the following locations, as depicted by Figure 2-3:

- Hood Canal EOD Training Range
- Crescent Harbor EOD Training Range

The underwater sites are also used for swimmer training in Mine Countermeasures.

2.2.2.2 Surface and Subsurface Testing Sites

There are three geographically distinct range sites in the Inland Waters where the Navy conducts surface and subsurface testing and some limited training. The Keyport Range Site is located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach (also known as Port Orchard Narrows). The Dabob Bay Range Complex (DBRC) Site is located in Hood Canal and Dabob Bay, in Jefferson, Kitsap, and Mason counties. The Carr Inlet OPAREA is located in southern Puget Sound.

The Keyport Range Site is located adjacent to NAVBASE Kitsap, Keyport, providing approximately 3.2 nm^2 for testing, including in-shore shallow water sites and a shallow lagoon to support integrated undersea warfare systems and vehicle maintenance and engineering activities. Water depth at the Keyport Range Site is less than 100 ft. (30.5 m). Underwater tracking of test activities can be accomplished by using temporary or portable range equipment. The Navy has conducted testing at the Keyport Range Site since 1914.

The DBRC Site includes the Dabob Bay and the Hood Canal from 1 mi. (1.6 km) south of the Hood Canal Bridge to the Hamma Hamma River, a total area of approximately 45.7 nm^2. The Navy has conducted underwater testing at the DBRC Site since 1956, beginning with a control center at Whitney Point. The control center was subsequently moved to Zelatched Point.

Dabob Bay is a deep-water area in Jefferson County approximately 14.5 nm^2 in size and contains an acoustic tracking range. The acoustic tracking space within the range is approximately 7.3 nm by 1.3 nm (9 nm^2) with a maximum depth of 600 ft. (182.9 m). The Dabob Bay tracking range, the only component of the DBRC Site with extensive acoustic monitoring instrumentation installed on the seafloor, provides for object tracking, communications, passive sensing, and target simulation. Many activities conducted within Dabob Bay are supported by land-based facilities at Zelatched Point.

Hood Canal averages a depth of 200 ft. (61 m) and is used for vessel sensor accuracy tests and launch and recovery of test systems where tracking is optional.

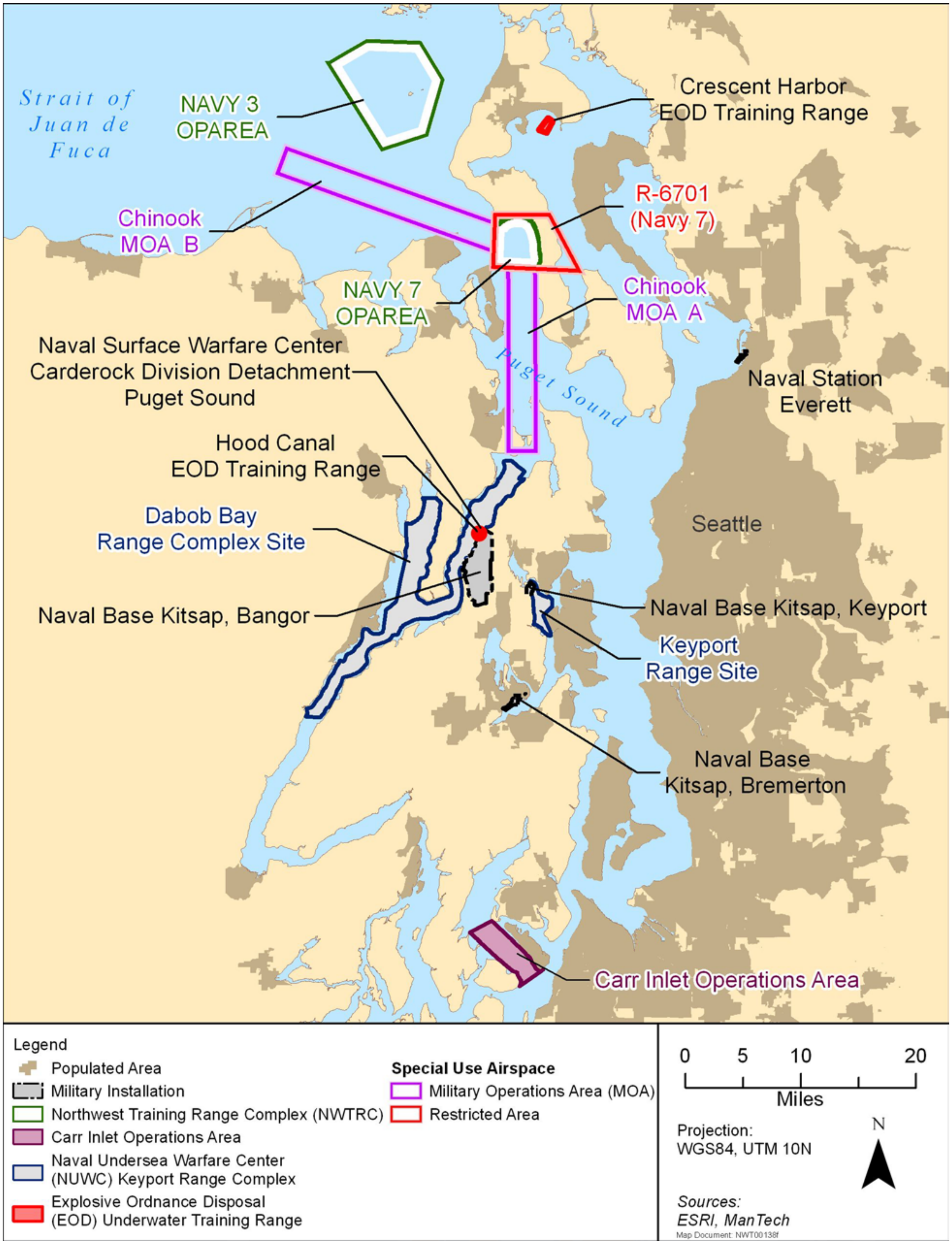

Figure 2-3: Inland Waters of the Northwest Training and Testing Study Area

The Carr Inlet OPAREA is a quiet deep-water inland range approximately 12 nm^2 in size. It is located in an arm of water between Key Peninsula and Gig Harbor Peninsula. Its southern end is connected to the southern basin of Puget Sound. Northward, it separates McNeil Island and Fox Island as well as the peninsulas of Key and Gig Harbor. The acoustic tracking space within the range is approximately 6 nm by 2 nm with a maximum depth of 545 ft. (166 m). The Navy performed underwater acoustic testing at Carr Inlet from the 1950s through 2009, when activities were relocated to NAVBASE Kitsap, Bangor. While no permanently installed structures are present in the Carr Inlet OPAREA, the waterway remains a Navy-restricted area.

2.2.2.3 Pierside Testing Facilities

In addition to the training and testing ranges, at which most of the training and testing assessed in this document occurs, the Navy conducts some testing at or near Navy piers. Most of this testing is sonar maintenance and testing while ships are in port for maintenance or system re-fitting. These piers within the Study Area are all within Puget Sound and include the NAVBASE Kitsap, Bremerton in Sinclair Inlet; NAVBASE Kitsap, Bangor Waterfront in Hood Canal, and Naval Station Everett (see Figure 2-3).

2.2.2.4 Navy Surface Operations Areas

In addition to the areas mentioned above, there are two surface and subsurface operations areas used for Navy training and testing within the Inland Waters. Navy 3 OPAREA is a surface and subsurface area off the west coast of northern Whidbey Island. Navy 7 OPAREA is the surface and subsurface area that lies beneath R-6701. This area covers a total area of 61 nm^2.

2.3 Description of the Western Behm Canal, Alaska

The Western Behm Canal is located in Southeast Alaska, near the city of Ketchikan, Alaska. SEAFAC is located in the Western Behm Canal and covers an area of 48 nm^2. The U.S. Navy has been conducting testing activities at SEAFAC since 1992. The facility replaced the Santa Cruz Acoustic Range Facility in Southern California and is now the location for some acoustic testing previously conducted at the NSWC Carr Inlet Acoustic Range in Washington State.

SEAFAC is comprised of land-based facilities and in-water assets. The land-based facilities located within 5.5 acres (2 hectares) on Back Island and are not included in the scope of this analysis. The in-water assets include two sites: the underway site and the static site. These assets and the operational area of SEAFAC are located in five restricted areas. The underway site arrays are in Area 1. The static site is in Area 2. All associated underwater cabling and other devices associated with the underway site are located in Area 3. Area 4 provides a corridor for utility power and a phone cable. Area 5 is an operational area to allow for safe passage of local vessel traffic. Notifications of invoking restriction of Area 5 occur at least 72 hours prior to SEAFAC operations in accordance with 33 C.F.R. § 334.1275. During test periods, all vessels entering Area 5 are requested to contact SEAFAC to coordinate safe passage through the area. Area 5 defines the SEAFAC Study Area boundary, which is comprised only of the in-water area and excludes the land-based supporting facilities and operations. These areas are all depicted in Figure 2-4.

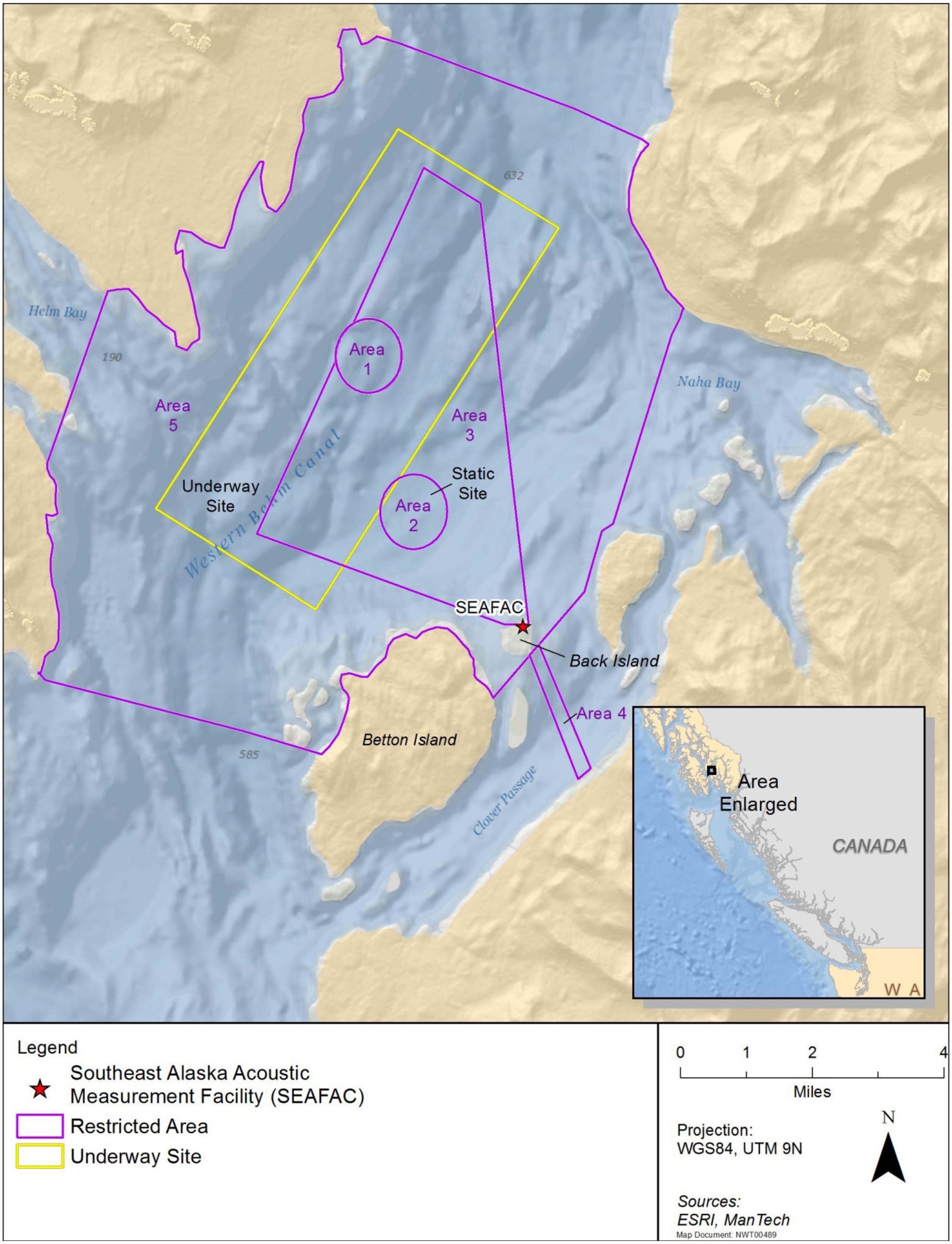

Figure 2-4: Southeast Alaska Acoustic Measurement Facility

The SEAFAC at-sea areas are:

- Restricted Areas 1 through 5. The five restricted areas are located within Western Behm Canal. The main purposes of the restricted areas are to provide for vessel and public safety, lessen acoustic encroachment from non-participating vessels, and prohibit certain activities that could damage SEAFAC's sensitive in-water acoustic instruments and associated cables. Area 5 encompasses the entire SEAFAC operations area.
- Underway Measurement Site. The underway measurement site is in the center of Western Behm Canal and is 5,000 yards (yd.) (4,572 m) wide and 12,000 yd. (10,973 m) long. The acoustic arrays are located at the center of this area (Area 1).
- Static Site. The static site is approximately 2 nm northwest of Back Island. During testing, a vessel is tethered between two surface barges. In most scenarios, the vessel submerges to conduct acoustic measurements. The static site is located at the center of Area 2.
- Area 3 and Area 4. These restricted areas provide protection to underwater cables and bottom-mounted equipment they encompass.

Bottom-moored acoustic measurement arrays are located in the middle of the site. These instrumented arrays are established for measuring vessel signatures when a vessel is underway (underway site) and is at rest and moored (static site). The instruments are passive arrays of hydrophones sensing the acoustic signature of the vessels (i.e., the sounds emitted when sonar units are not in operation). Hydrophones on the arrays pick up noise in the water and transmit it to shore facilities, where the data are processed. SEAFAC's sensitive and well-positioned acoustic measurement equipment provides the ability to listen to and record the radiated signature of submarines, as well as other submerged manned and unmanned vehicles, selected National Oceanic and Atmospheric Administration (NOAA) surface vessels, and cruise ships.

The sensors at SEAFAC are passive and measure radiated noise in the water, such as machinery on submarines and other underwater vessels. Vessels do not use tactical mid-frequency active sonar while undergoing testing at SEAFAC. Active acoustic sources are used for communications, range calibration, and to provide position information for units operating submerged on the range.

3 MARINE MAMMAL SPECIES AND NUMBERS

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

Marine mammal species known to occur in the Study Area and their currently recognized stocks are presented in Table 3-1 as presented in the NMFS' U.S. Pacific Marine Mammal Stock Assessment Report (Carretta et al. 2014) and the Alaska Marine Mammal Stock Assessment Report (Allen and Angliss 2014). All these species are managed by NMFS or the U.S. Fish and Wildlife Service (USFWS) in the U.S. Exclusive Economic Zone (EEZ).

The species carried forward for analysis are those likely to be found in the Study Area based on the most recent data available, and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which were extirpated from factors such as nineteenth and twentieth century commercial exploitation). Several species that may be present in the northwest Pacific Ocean have an extremely low probability of presence in the Study Area. These species are considered extralimital, meaning there may be a small number of sighting or stranding records within the Study Area, but the area of concern is outside the species range of normal occurrence. These species include Bryde's whale, false killer whale, and long-beaked common dolphin, which have been excluded from further discussion and analysis.

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

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region	ESA/MMPA
Order Cetacea						
Suborder Mysticeti (baleen whales)						
Family Balaenidae (right whales)						
North Pacific right whale	*Eubalaena japonica*	Offshore	Eastern North Pacific	31 (0.23)	Rare Extralimital in Inland Waters	Endangered/ Depleted
Family Balaenopteridae (rorquals)						
Humpback whale	*Megaptera novaeangliae*	Western Behm Canal, Alaska	Central North Pacific	10,103 (n/a)	Likely spring through fall months but may be sighted year-round	Endangered/ Depleted
		Offshore Area	California, Oregon, & Washington	1,918(0.03)	Likely with highest numbers in summer and fall but may be present year-round	Endangered/ Depleted
		Inland Waters			Seasonal to rare (varies by water body) with highest likelihood spring to fall	
Blue whale	*Balaenoptera musculus*	Offshore Area	Eastern North Pacific	1,647 (0.07)	Seasonal; highest likelihood in summer and fall and detected acoustically August through February (no acoustic detections between April and July)	Endangered/ Depleted
Fin whale	*Balaenoptera physalus*	Western Behm Canal, Alaska	Northeast Pacific	1,214 (minimum estimate)	Rare	Endangered/ Depleted
		Offshore Area	California, Oregon, & Washington	3,051 (0.18)	Seasonal; high numbers in summer and fall and detected acoustically July through April (no acoustic detections May and June)	Endangered/ Depleted
Sei whale	*Balaenoptera borealis*	Offshore Area	Eastern North Pacific	126 (0.53)	Likely	Endangered/ Depleted
Minke whale	*Balaenoptera acutorostrata*	Western Behm Canal, Alaska	Alaska	Not available	Rare	-
		Offshore Area	California, Oregon, & Washington	478 (1.36)	Likely	-
		Inland Waters			Seasonal: More likely spring to fall, Rare in Puget Sound	

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

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region	ESA/MMPA
Family Eschrichtiidae (gray whale)						
Gray whale	*Eschrichtius robustus*	Offshore Area	Eastern North Pacific	19,126 (0.07)	Likely: Highest numbers during seasonal migrations; small Pacific Coast Feeding Group year-round	-
		Inland Waters			Seasonal to rare (varies by water body). More likely winter to spring	
		Offshore Area	Western North Pacific	155 (n/a)	Rare: Individuals may migrate through offshore portion of study area	Endangered/ Depleted
Suborder Odontoceti (toothed whales)						
Family Physeteridae (sperm whale)						
Sperm whale	*Physeter macrocephalus*	Western Behm Canal, Alaska	North Pacific	Not available	Rare due to pelagic nature and no sightings in study area	Endangered/ Depleted
		Offshore Area	California, Oregon, & Washington	971 (0.31)	Likely; More likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/ Depleted
Family Kogiidae (pygmy and dwarf sperm whale)						
Pygmy sperm whale	*Kogia breviceps*	Offshore Area	California, Oregon, & Washington	579 (1.02)	Likely	-
Dwarf sperm whale	*Kogia sima*	Offshore Area	California, Oregon, & Washington	Not available	Rare	-
Family Delphinidae (dolphins)						
Killer whale	*Orcinus orca*	Western Behm Canal, Alaska	Alaskan Resident	2,347 (n/a)	Rare	-
		Western Behm Canal, Alaska	Northern Resident	261 (n/a)	Likely	-
		Western Behm Canal, Alaska & Offshore Area	West Coast Transient	243 (95% CI: 180–339)	Likely	-
		Inland Waters			Likely to Rare in some areas	
		Offshore Area	Eastern North Pacific Offshore	240 (0.49)	Likely	-
		Inland Waters			Extralimital	

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

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region	ESA/MMPA
Family Delphinidae (dolphins) (continued)						
Killer whale (continued)	*Orcinus orca*	Offshore Area & Inland Waters	Eastern North Pacific Southern Resident	85 (direct count)	Likely to Rare in some areas	Endangered/ Depleted
Short-finned pilot whale	*Globicephala macrorhynchus*	Offshore Area	California, Oregon, & Washington	760 (0.64)	Rare	-
Short-beaked common dolphin	*Delphinus delphis*	Offshore Area	California, Oregon, & Washington	411,211 (0.21)	Likely; more likely off California	-
Bottlenose dolphin	*Tursiops truncatus*	Offshore Area	California, Oregon, & Washington Offshore	1,006 (0.48)	Rare	-
		Inland Waters			Extralimital	-
Striped dolphin	*Stenella coeruleoalba*	Offshore Area	California, Oregon, & Washington	10,908 (0.34)	Rare	-
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Western Behm Canal, Alaska	North Pacific	26,880	Rare; usually offshore but occasionally ventures into inshore waters	-
		Offshore Area	California, Oregon, & Washington	26,930 na	Likely	-
		Inland Waters			Rare but more likely summer and fall Extralimital in Puget Sound	
Northern right whale dolphin	*Lissodelphis borealis*	Offshore Area	California, Oregon, & Washington	8,334 (0.40)	Likely	-
Risso's dolphin	*Grampus griseus*	Offshore Area	California, Oregon, & Washington	6,272 (0.30)	Likely	-
Family Phocoenidae (porpoises)						
Harbor porpoise	*Phocoena phocoena*	Western Behm Canal, Alaska	Southeast Alaska	11,146 (0.24)	Likely; more likely spring through fall, but may occur year-round	-
		Offshore Area	Northern Oregon/WA Coast	21,487 (0.44)	Likely	-
		Offshore Area	Northern CA/southern OR	35,769 (0.52)	Likely	-

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

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region	ESA/MMPA
Family Phocoenidae (porpoises) (continued)						
Harbor porpoise (continued)	*Phocoena phocoena*	Inland Waters	WA Inland Waters	10,682 (0.38)	Likely to Rare (varies by water body)	-
Dall's porpoise	*Phocoenoides dalli*	Western Behm Canal, Alaska	Alaska	83,400 (0.097)	Likely; more likely spring through fall, with higher numbers in spring and summer	-
		Offshore Area	California, Oregon, & Washington	42,000 (0.33)	Likely	-
		Inland Waters			Likely to Rare (varies by water body)	
Family Ziphiidae (beaked whales)						
Cuvier's beaked whale	*Ziphius cavirostris*	Western Behm Canal, Alaska	Alaska	Not available	Rare	-
		Offshore Area	California, Oregon, & Washington	6,590 (0.55)	Likely	-
Baird's beaked whale	*Berardius bairdii*	Western Behm Canal, Alaska	Alaska	Not available	Rare	-
		Offshore Area	California, Oregon, & Washington	847 (0.81)	Likely	-
Mesoplodont beaked whales[5]	*Mesoplodon spp.*	Offshore Area	California, Oregon, & Washington	694 (0.65)	Likely; distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior; limited sightings; generally seaward of 500–1,000 m depth	-
Suborder Pinnipedia[6]						
Family Otariidae (fur seals and sea lions)						
Steller sea lion	*Eumetopias jubatus*	Western Behm Canal, Alaska	Eastern U.S.	63,160–78,198	Likely	-
		Offshore Area			Likely	
		Inland Waters			Seasonal (unlikely June to September)	

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

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region	ESA/MMPA
Suborder Pinnipedia[6]						
Family Otariidae (fur seals and sea lions)						
California sea lion	*Zalophus californianus*	Western Behm Canal, Alaska	U.S.	296,750	Rare	-
		Offshore Area			Likely	-
		Inland Waters			Seasonal (unlikely in July)	-
Northern fur seal	*Callorhinus ursinus*	Western Behm Canal, Alaska	Eastern Pacific	639,545	Likely	Depleted
		Offshore Area	California	12,844	Likely	-
		Inland Waters	Eastern Pacific	639,545	Extralimital	Depleted
Guadalupe fur seal[7]	*Arctocephalus townsendi*	Offshore Area	Mexico	14,000–15,000	Seasonal migrants; mainly breeds on Guadalupe Island, Mexico, May–July	Threatened/ Depleted
		Inland Waters			Extralimital	
Family Phocidae (true seals)						
Northern elephant seal	*Mirounga angustirostris*	Western Behm Canal, Alaska	California Breeding	124,000	Extralimital	-
		Offshore Area			Seasonal	-
		Inland Waters			Seasonal to Rare in some areas; Infrequent in Puget Sound	-
Harbor seal	*Phoca vitulina*	Western Behm Canal, Alaska	Southeast Alaska (Clarence Strait)	152,602 (23,289)	Likely	-
		Offshore Area	OR/WA Coastal	24,732	Likely	-
		Offshore Area	California	30,196	Likely	-
		Inland Waters	WA Northern Inland Waters	11,036	Likely	-
			Southern Puget Sound	1,568	Likely	-
			Hood Canal *	3,555	Likely	-

* Based on recent discussion with regional NMFS subject matter experts and subsequent to the publication of the 2014 SAR, the Navy and NMFS applied research presented in London et al. (2012) to reevaluate the Hood Canal stock abundance. Using updated tag data from London et al. 2012, the count of harbor seals collected in 1999 (n=711) from aerial surveys (Jeffries et al. 2003) was corrected to account for harbor seal haulout behavior that most closely aligned with the season and time of day in which the original survey was conducted. The tag data showed that during this month and time of day, approximately 80% of the animals would be in the water. Therefore, the corrected Hood Canal stock abundance (based on the 1999 aerial survey) is calculated as 711/0.20 or 711*5 = 3,555. While this aerial survey data is considered out of date based on the standards of NOAA stock assessment reports, this revised Hood Canal harbor seal abundance represents the best available science based on publically available data.

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

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region	ESA/MMPA
Order Carnivora						
Family Mustelidae (otters)[8]						
Northern sea otter	*Enhydra lutris kenyoni*	Western Behm Canal, Alaska	Southeast Alaska	25,712	Extralimital	-
		Offshore Area	Washington	1,125	Rare/Likely[9]	-
		Inland Waters			Rare	-

[1] Taxonomy follows Perrin et al. 2009.
[2] Stock abundance estimates and names from Carretta et al. 2014, Allen and Angliss 2014, and U.S. Fish and Wildlife Service 2013 except where noted.
[3] The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. For example, a CV of 0.85 would indicate high uncertainty in the population estimate. 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.
[4] Extralimital: There may be a small number of sighting or stranding records, but the area is outside the species range of normal occurrence.
Rare: The distribution of the species is near enough to the area that the species could occur there, or there are a few confirmed sightings.
Infrequent: Confirmed, but irregular sightings.
Likely: Confirmed and regular sightings of the species in the area year-round.
Seasonal: Confirmed and regular sightings of the species in the area on a seasonal basis.
[5] In waters off the U.S. west coast, the *Mesoplodon* species *M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri and M. densirostris* have been grouped by NMFS into a single management unit (*Mesoplodon* spp.) in the 2014 Pacific Stock Assessment report (Carretta et al. 2014).
[6] There are no data regarding the CV for any pinnipeds given that abundance is determined by different methods than those used for cetaceans.
[7] The abundance estimate for Guadalupe fur seal is from Esperon-Rodriguez and Gallo-Reynoso (2012).
[8] There are no data regarding the CV for sea otter given that abundance is determined by different methods than those used for cetaceans.
[9] The northern sea otter would be considered rare in the offshore portions of the Study Area. However, portions of the population overlap with nearshore portions of the NUWC Keyport Range Complex, where their occurrence would be considered likely to the 20-fathom isobath.

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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. Additional information on the general biology and ecology of marine mammals are included in Rice (1998), Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009). In addition, NMFS annually publishes stock assessment reports (SARs) for all marine mammals in U.S. EEZ waters, including stocks that occur within the NWTT Study Area (Allen and Angliss 2014; Carretta et al. 2014).

North Pacific Right Whale (*Eubalaena japonica*)

Status and Management

North Pacific right whales are listed as depleted under the MMPA and endangered under the ESA. Once abundant, the North Pacific right whale is one of the most endangered whale species in the world (Wade et al. 2011a). This species was listed as endangered under the ESA since 1973 when it was considered the "northern right whale" (including both the North Atlantic [*Eubalaena glacialis*] and North Pacific right whales). In 2008, NMFS listed the right whales as two separate, endangered species. Previously designated critical habitat within the Gulf of Alaska and the Bering Sea was then re-designated as North Pacific right whale critical habitat. In March 2012, NMFS announced a 5-year review of North Pacific right whale under the ESA (National Marine Fisheries Service 2012a) and, in April 2012, announced its intent to prepare a recovery plan for this species (National Marine Fisheries Service 2012b). Although there is designated critical habitat for this species in the western Gulf of Alaska and an area in the southeastern Bering Sea, there is no designated critical habitat for this species within the Study Area. NMFS currently recognizes two stocks of North Pacific right whale: (1) an Eastern North Pacific stock and (2) a Western North Pacific stock (Allen and Angliss 2014).

Abundance

The most recent estimated population for the North Pacific right whale is between 28 and 31 individuals, and although this estimate may be reflective of a Bering Sea subpopulation, the total eastern North Pacific population is unlikely to be much larger (Wade et al. 2006, 2011a, 2011b).

Distribution

Right whales occur in subpolar to temperate waters. They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (Kraus et al. 1986; Clapham et al. 2004). Historical whaling records provide virtually the only information on North Pacific right whale distribution. This species historically occurred across the Pacific Ocean north of 35°N, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and the Sea of Japan (Omura et al. 1969; Scarff 1986; Clapham et al. 2004). Right whales were probably never common along the west

coast of North America (Scarff 1986; Brownell et al. 2001). The rarity of reports for right whales in more southern coastal areas in winter in either historical or recent times suggests that their breeding grounds may have been offshore (Clapham et al. 2004). Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell et al. 2001; Shelden et al. 2005; Shelden and Clapham 2006; Wade et al. 2006). There are far fewer sightings of North Pacific right whales in the Gulf of Alaska than the Bering Sea (Brownell et al. 2001). In addition to sighting data (see Wade et al. 2011a, b; Matsuoka et al. 2013), passive acoustic data have indicated the presence of North Pacific right whales in the Gulf of Alaska (Mellinger et al. 2004), although recently, no right whales were detected from more than 5,324 hours of passive acoustic data obtained from two High-frequency Acoustic Recording Packages in the north-central Gulf of Alaska (Baumann-Pickering et al. 2012b). Right whales were also not detected from passive acoustic data collected from two bottom deployed monitoring devices in the offshore waters of Washington State from January through November 2011 (Širović et al. 2012b). Based on this information, and considering their current extremely low population numbers, it is highly unlikely for this species to be encountered in any of the regions of the Study Area.

Offshore – Various sightings of North Pacific right whales in the general vicinity of the Study Area have occurred on an irregular basis. Bruce Mate (2013) reported that he flew over a dead stranded North Pacific right whale in the early 1980s along a remote part of the southern Oregon coast. Two right whales were sighted in 1983 on Swiftsure Bank at the entrance to the Strait of Juan de Fuca (Osborne et al. 1988). In May 1992, there was a sighting of a single of North Pacific right whale over Quinault submarine canyon (Green et al. 1992; Rowlett et al. 1994). Susan Riemer, from the Oregon Department of Fish and Wildlife, reported a sighting of a North Pacific right whale at 3 Arch Rocks, Oregon in 1994 (Riemer 2013). There were no sightings of North Pacific right whales during six ship surveys conducted in summer and fall off California, Oregon, and Washington from 1991 through 2008 (Barlow 2010). In June 2013, a single right whale was sighted in the waters north of the Study Area (off Haida Gwaii, British Colombia) (Hume 2013). Approximately 4 months later (October 2013) of that same year, another (different) right whale was sighted in a group of humpbacks off the entrance to the Strait of Juan de Fuca (Pynn 2013); this sighting was just north of the northern border of the Study Area in Canadian waters. Because of the low population numbers in the North Pacific, few individuals have been observed (Brownell et al. 2001; Wade et al. 2006, 2011a). As noted above, right whales were not detected during recent passive acoustic monitoring in waters off the state of Washington (Širović et al. 2012b), Based on this information, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the Study Area and their occurrence is therefore considered rare.

Inland Waters (Puget Sound) – As noted above, the rarity of coastal records suggests right whales would not be present in more inland areas. The occurrence of a North Pacific right whale within the Inland Waters is considered extralimital.

Western Behm Canal, Alaska – North Pacific right whales were not observed during the Alaska Fisheries Science Center's National Marine Mammal Laboratory 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Given their small population size and lack of sightings in southeast Alaska as noted above, North Pacific right whales are considered extralimital within the Behm Canal portion of the Study Area.

Humpback Whale (*Megaptera novaeangliae*)

Status and Management

Humpback whales are listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species in the North Pacific. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or down-listing from the U.S. Endangered Species List (National Marine Fisheries Service 2009). In the U.S. 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. 2014). NMFS has designated four stocks: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to feeding areas from southeast Alaska to the Alaska Peninsula; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to feeding areas off Russia, the Aleutian Islands, and the Bering Sea; (3) the California, Oregon, and Washington stock, consisting of winter and spring populations in coastal Central America and coastal Mexico that migrate to feed off the west coast of the United States; and (4) the American Samoa stock, with feeding areas largely undocumented but occurring as far south as the Antarctic Peninsula (Carretta et al. 2014). The Central North Pacific stock and the California, Oregon, and Washington stock occur within the Study Area.

Abundance

A large-scale photo-identification sampling study of humpback whales was conducted from 2004 to 2006 throughout the North Pacific (Calambokidis et al. 2008; Barlow et al. 2011). Known as the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) Project, the study was designed to sample all known North Pacific feeding and breeding populations. Overall humpback whale abundance in the North Pacific based on the SPLASH Project was estimated at 21,808 individuals (coefficient of variation [CV] = 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 indicate that the North Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Calambokidis et al. 2008).

The Central North Pacific stock has been estimated at 10,103 individuals based on data from their wintering grounds throughout the main Hawaiian Islands (Allen and Angliss 2014). In summer, the majority of humpback whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and southeast Alaska/northern British Columbia, where relatively high densities of whales occur (Allen and Angliss 2014). There is a high rate of interchange between whales found in southeast Alaska and northern British Columbia, and based on data from both inshore and offshore waters in these regions, abundance estimates range from 2,883 to 6,414 animals (Calambokidis et al. 2008).

The current best estimate for the California, Oregon, and Washington stock is 1,918 (CV ~0.03) which also includes humpback whales associated with the northern Washington and southern British Columbia feeding group (Carretta et al. 2014). Calambokidis et al. (2008) reported a range of photographic mark-recapture abundance estimates (145 –469) for a northern Washington and southern British Columbia humpback whale feeding group most recently in 2005. The best model estimate from that paper was reported as 189 (CV not reported) animals which included in the total stock estimate above. .

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 (Calambokidis et al. 2008; Barlow et al. 2011).

Offshore – The California, Oregon, and Washington stock of humpback whales uses the waters off the west coast of the United States as a summer feeding ground. They are present off the northern California coast mainly between April and December and off the Oregon and Washington coasts mainly from May through November (Dohl et al. 1983; Green et al. 1992; Forney and Barlow 1998; Calambokidis et al. 2004, 2009a). Visual surveys and acoustic monitoring studies have detected humpbacks along the Washington coast year-round, with peak occurrence during the summer and fall (Oleson et al. 2009). Consistent with previous recordings from two Navy-funded offshore passive acoustic monitoring devices (Širović et al. 2012a, 2012b), humpback whales were most commonly detected in acoustic recordings between September and December, which is also the peak time for humpback whale singing (Širović et al. 2012b). Lower levels of humpback whale calling were also detected from February through May (Oleson et al. 2009; Širović et al. 2012). Visual and acoustic detections of humpback whales in this area do not fully overlap, as most visual sightings occur during the summer and early fall (Oleson et al. 2009), which is likely the result of the strong seasonal variation in humpback whale singing and other vocal behavior (Širović et al. 2012a, 2012b). Photo-identification studies suggest that whales feeding in this region are part of a small sub-population that primarily feeds from central Washington to southern Vancouver Island (Calambokidis et al. 2004, 2008). Whales appear to range broadly throughout the continental shelf waters, with significant seasonal trends in distribution; however, detailed knowledge of habitat use and individual residency patterns while in this feeding area cannot be determined easily through visual surveys alone (Schorr et al. 2012). In winter and spring (roughly January–March), most whales are south on their breeding grounds and are likely not as abundant in this region of the Study Area during these times.

Off the U.S. west coast, humpback whales are more abundant in shelf and slope waters (< 6,562 ft. [< 2,000 m] deep), and are often associated with areas of high productivity (Forney et al. 2012; Becker et al. 2012b). Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005). Off Washington, higher concentrations have been reported between Juan de Fuca Canyon and the outer edge of the shelf break in a region called “the Prairie,” near Barkley and Nitnat Canyons, and near Swiftsure Bank (Calambokidis et al. 2004). Five humpback whales were satellite tagged off Washington between May 2010 and May 2013. Although tag durations were short with a median duration of 7 days, tag tracks showed all five whales using both shelf and slope waters as well as some underwater canyons, such as the Juan de Fuca Canyon (used by one of five whales) (Schorr et al. 2013; U.S. Department of the Navy 2013d).

Inland Waters (Puget Sound) – Although humpback whales were common in inland Washington waters prior to the whaling period, few sightings had been reported in this area until the last 10 years (Scheffer and Slipp 1948; Calambokidis and Steiger 1990; Pinnell and Sandilands 2004). More recently, with creation (in 2001) of the Orca Network online forum available to compile whale sighting reports, and increased public interest in reporting whale sightings, the number of humpback whale sightings in inland waters has increased. Inland water opportunistic sightings primarily occur from April through July, but sightings are reported in every month of the year. Most sightings occur in the Strait of Juan de Fuca and in the San Juan Island area, with only occasional sightings in Puget Sound.

In Puget Sound (defined as south of Admiralty Inlet), Calambokidis et al. (2002) recorded only six individuals between 1996 and 2001. However, from January 2003 through July 2012, there were over 60 sightings reported to Orca Network, some of which could be the same individuals (Orca Network 2012). A review of the reported sightings in Puget Sound indicates that humpback whales usually occur as individuals or in pairs (Orca Network 2012).

Sightings of humpback whales in Puget Sound vary by location, but are infrequent. In the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton and Keyport, only one unverified sighting of a humpback whale was reported to Orca Network (2012) from January 2003 through July 2012. In Hood Canal and Dabob Bay (where NAVBASE Kitsap Bangor and the DBRC Site are located, respectively), one humpback whale was observed for several weeks in January and February 2012 (Calambokidis 2012). Prior to this sighting, there were no confirmed reports of humpback whales entering Hood Canal or Dabob Bay (Calambokidis 2012). In the Saratoga Passage area (between Naval Station Everett and Naval Air Station Whidbey Island [NASWI]), one humpback whale was reported in Penn Cove south of Crescent Harbor in July 2008. This is the only humpback report from January 2003 through September 2012 that was considered a likely positive identification (Orca Network 2012). There have been no verified humpback sightings in the Carr Inlet area between January 2003 and July 2012. Two unverified sightings were reported to Orca Network to the north of Carr Inlet, near Point Defiance, Tacoma, over the same time period. The last verified sighting was in June and July 1988 when two individually identified juvenile humpback whales were observed traveling throughout the waters of southern Puget Sound for several weeks (Calambokidis and Steiger 1990).

Given their general migration patterns, this species is rare in the inland waters, but is expected to be more likely to occur in the warmer months (May–November), but not be present in all areas, nor remain for long time periods.

Western Behm Canal, Alaska – In summer, relatively high densities of humpback whales occur throughout much of southeast Alaska (Allen and Angliss 2014). Because this species makes extensive use of inland coastal waters, it is the large whale species most likely to be found in the Southeast Alaska area. Humpback whales are commonly sighted in Ernest Sound (north of SEAFAC) and near the mouth of Boca de Quadra (south of SEAFAC), but specific data are lacking (U.S. Department of the Navy 1991). Although specific data are lacking, it is likely that humpback whales occasionally use the Behm Canal heading to Gedney Pass (U.S. Department of the Navy 1991). Humpback whales were observed frequently during the 1991–2007 surveys (spring through fall) of the inland waters of southeast Alaska (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, observations have been made of humpback whales that have not migrated south but remained in Alaskan waters to feed (Moran et al. 2009).

Blue Whale (*Balaenoptera musculus*)

Status and Management

The blue whale is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species. For the MMPA SARs, 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. 2014).

Abundance

Widespread whaling over the last century is believed to have decreased the blue whale population to approximately 1 percent of its pre-whaling population size (Sirovic et al. 2004; Branch et al. 2007). Moonahan et al. (2014) estimated however, that the bulk of whaling took blue whales from the western Pacific stock. The eastern Pacific blue whale stock was estimated to have been 35% of all blue whale whaling mortalities resulting in the loss of 3,411 individuals (Moonahan et al 2014). The best estimate of blue whale abundance is taken from the Chao model results of Calambokidis (2013) for the period 2008 to 2011, or 1,647 (CV=0.07) whales (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 58 blue whales (CV = 0.41) occur in waters off Washington and Oregon (Barlow 2010). There was a documented increase in the blue whale population size between 1979–80 and 1991 (Barlow 1994) and between 1991 and 1996 (Barlow 1997), but there has not been evidence to suggest an increase in the population of the eastern North Pacific stock since then (Barlow and Taylor 2001; Carretta et al. 2014). Based on line-transect surveys conducted off California between 1991 and 2005, the abundance estimates of blue whales declined in these waters over the survey period (Barlow and Forney 2007). However, this apparent decline was likely due to variability in the distribution patterns of blue whales off the coast of North America rather than a true population decline (Calambokidis et al. 2009b). Calambokidis et al. (2009b) suggested that when feeding conditions off California are not optimal, blue whales may move to other regions to feed, including waters further north. A comparison of survey data from the 1990s to 2008 indicates that there has been a northward shift in blue whale distribution within waters off California, Oregon, and Washington (Barlow 2010). Subsequent mark-recapture estimates “indicated a significant upward trend in abundance of blue whales” at a rate of increase just under 3 percent per year for the U.S. west coast blue whale population in the Pacific (Calambokidis et al. 2009a). Consistent with the earlier suggested variability in the distribution patterns, Carretta et al. (2013) report that blue whales from the U.S. west coast have been increasingly found feeding to the north and south of the U.S. west coast during summer and fall.

Distribution

Blue whales inhabit all oceans and are distributed from the ice edges to the tropics in both hemispheres (Jefferson et al. 1993). Most blue whale sightings are in coastal nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović 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 (Širović et al. 2004). Recently it has been suggested that the migration patterns of blue whales in the North Pacific change during different oceanographic conditions (Calambokidis et al. 2009b). 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. 2009b). These animals have shown site fidelity, returning to their mother’s feeding grounds on their first migration (Calambokidis and Barlow 2004). Blue whales are known to migrate to waters off Mexico and as far as the Costa Rican Dome (Calambokidis and Barlow 2004; Calambokidis et al. 2009b). 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).

Offshore – The U.S. west coast is known to be a feeding area for blue whales during summer and fall (Bailey et al. 2010; Calambokidis et al. 2009b), although primary occurrence for this species is south of 44°N (Hamilton et al. 2009; Forney et al. 2012). Blue whales are feeding in the area as late as October,

although fewer individuals are seen because the majority of the population migrates south. Acoustic data collected by Sound Surveillance System hydrophones reveal that males are calling at this time of the year in this area (Stafford et al. 2001). More recently, Navy-funded acoustic monitoring studies have detected blue whales along the Washington coast between August and February, with peak calling from October to December, and no detections between April and July (Širović et al. 2012a, 2012b). An individual blue whale was also sighted off Washington in January 2009, in waters approximately 3,281 ft. (1,000 m) deep (Oleson et al. 2012).

Inland Waters (Puget Sound) – Blue whales are not expected to occur within the Inland Waters region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

Western Behm Canal, Alaska – Blue whales are not expected to occur within the SEAFAC region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

Fin Whale (*Balaenoptera physalus*)

Status and Management

The fin whale is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species. Fin whale population structure in the Pacific Ocean is not well known. In the North Pacific, NMFS recognizes three fin whale stocks: (1) an Alaska (or Northeast Pacific) stock; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014).

Abundance

Currently there are no reliable population estimates for the Alaska/Northeast Pacific stock of fin whales. A minimum estimate for the stock is 1,652 based on surveys west of the Kenai Peninsula to Amchitka Pass which covered only a portion of the stock's range (Zerbini et al. 2006, Allen and Angliss 2014).

The current best available abundance estimate of fin whales in California, Oregon, and Washington waters is 3,051 (CV = 0.18) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 416 fin whales (CV = 0.28) occur in waters off Washington and Oregon (Barlow 2010). A recent study indicates that the abundance of fin whales in waters off the U.S. west coast has increased during the 1991–2008 survey period, most likely from *in situ* population growth combined with distribution shifts (Moore and Barlow 2011).

Distribution

The fin whale is found in all the world's oceans (Jefferson et al. 2008) but appears to have a preference for temperate and polar waters (Reeves et al. 2002). Locations of breeding and calving grounds for the fin whale are largely unknown, but they typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al. 2006; MacLeod et al. 2006a). During the summer in the Pacific, fin whales are distributed from the southern Chukchi Sea (69°N) south to 30°N in the California Current (Mizroch et al. 2009). They have been observed during the summer in the central Bering Sea (Moore et al. 2000). During the winter, fin whales are sparsely distributed from 60°N, south to the northern edge of the tropics, near which it is assumed that they mate and calve (Mizroch et al. 2000).

Offshore – This species has been documented from 60°N to 23°N, and they have frequently been recorded in waters offshore Oregon and Washington (Barlow and Forney 2007). Based on predictive habitat models derived from line-transect survey data collected between 1991 and 2008 off the U.S. west coast, relatively high densities of fin whales are predicted off Washington during the summer and fall (Barlow et al. 2009; Becker et al. 2012b; Forney et al. 2012). During visual surveys conducted from August 2004 to September 2008, there was a single sighting of two fin whales off the Washington coast in December 2005, in waters approximately 3,281 ft. (1,000 m) deep (Oleson et al. 2009). Navy-funded offshore passive acoustic monitoring off Washington from 2004 to 2013 has reported fin whales as the most commonly detected baleen whale call type detected, with peak calling in winter and spring and low calling in summer (Kerosky et al. 2013; Širović et al. 2012a, b; U.S. Department of the Navy 2013d). Fin whale calls were detected on more than 90 percent of the days during the months of October, December, January, and February, but were not detected in either May or June (Širović et al. 2012a, 2012b). Between May 2010 and May 2013, 11 fin whales were tagged with satellite tracking tags off Washington. Average tag duration was 19 days (range 1–71 days). In general, fin whales were most commonly using waters associated with the outer shelf edge (median distance to shore: 72 km) (Schorr et al. 2013; U.S. Department of the Navy 2013d).

Inland Waters (Puget Sound) – Prior to commercial whaling off British Columbia, fin whales were occasionally sighted in the Inland Waters (Osborne et al. 1988). However, fin whales are now extremely rare within Puget Sound (Wade 2005). Strandings reported within Puget Sound have all been individuals struck by ships, and they presumably were carried on the bow into the sound (Norman et al. 2004).

Western Behm Canal, Alaska – Fin whales were observed seven times in the summer during surveys of the inland waters of southeast Alaska from 1991 to 2007 (Dahlheim et al. 2009). Given the limited number of sightings in inland waters and their more pelagic nature, fin whales are considered rare in the SEAFAC region of the Study Area.

Sei Whale (*Balaenoptera borealis*)

Status and Management

The sei whale is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (National Marine Fisheries Service 2011). Only a single Eastern North Pacific stock is recognized in the U.S. EEZ (Carretta et al. 2014). However, some mark-recapture, catch distribution, and morphological research indicate that multiple stocks exist (Masaki 1976, 1977; Carretta et al. 2014). The Eastern North Pacific population has been protected since 1976, but is likely still impacted by the effects of continued unauthorized takes from whaling (Carretta et al. 2014).

Abundance

The best current estimate of abundance for the Eastern North Pacific stock of sei whales that occur off California, Oregon, and Washington waters out to 300 nm is 126 animals (CV = 0.53) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 52 sei whales (CV = 0.62) occur in waters off Washington and Oregon (Barlow 2010). No data are available on current population trends.

Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes (Horwood 1987). Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999). In the North Pacific, sei whales are thought to occur mainly south of the Aleutian Islands. In the summer they are present across the temperate Pacific from 35°N to 50°N (Masaki 1977; Horwood 2009; Smultea et al. 2010) and in the winter were recently found south of 20°N near the Mariana Islands (Fulling et al. 2011). Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep relief, such as the continental shelf break, canyons, or basins between banks and ledges (Kenney and Winn 1987; Schilling et al. 1992; Gregr and Trites 2001; Best and Lockyer 2002). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified.

Offshore – Sei whales are distributed offshore in waters off the U.S. west coast (Carretta et al. 2014). They are generally found feeding along the California Current (Perry et al. 1999). During six systematic ship surveys conducted between 1991 and 2008 in waters off the U.S. west coast to approximately 300 nm offshore, there were a total of 10 sei whale sightings, 4 of which were in waters off Oregon and Washington (Barlow 2010). There were no sei whale sightings during more coastal (out to about the 656 ft. [200 m] isobath) ship surveys off the northern Washington coast between 1995 and 2002 (Calambokidis et al. 2004).

Inland Waters (Puget Sound) – Sei whales are considered extremely rare in Puget Sound. A sei whale washed ashore west of Port Angeles during September 2003 (Preston 2003), but this is considered an unusual event.

Western Behm Canal, Alaska – Sei whales are not expected to occur within the SEAFAC region of the Study Area since it is well inland of the areas normally inhabited by sei whales.

Minke Whale (*Balaenoptera acutorostrata*)

Status and Management

The minke whale is protected under the MMPA and is not listed under the ESA. Minke whales from two stocks may occur in the Study Area: (1) the Alaska stock and (2) the California/Oregon/Washington stock (Carretta et al. 2014). In the northern part of their range minke whales are believed to be migratory, whereas in the inland waters of Washington and along central California they appear to establish home ranges (Dorsey et al. 1990). Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales further north, minke whales in Alaska are considered a separate stock from minke whales in the coastal waters of California, Oregon, and Washington (including the Inland Waters) (Carretta et al. 2014).

Abundance

Abundance estimates are not available for the Alaska stock of minke whales because only portions of the stock’s range have been surveyed (Allen and Angliss 2014). The number of minke whales off California Oregon, and Washington is estimated to be the arithmetic mean of two ship line transect surveys conducted in summer and autumn 2005 and 2008 (Barlow and Forney 2007 ; Forney 2007;

Barlow 2010); or 478 (CV=1.36) whales (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 147 minke whales (CV = 0.68) occur in waters off Washington and Oregon (Barlow 2010). Two minke whales were seen during 1996 aerial surveys in Washington and British Columbia inland waters (Calambokidis et al. 1997), but no abundance estimates were made.

Distribution

Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993); they are less common in the tropics than in cooler waters. 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 are present in the North Pacific from near the equator to the Arctic (Horwood 1990). The summer range extends to the Chukchi Sea (Perrin and Brownell 2002). In the winter, minke whales are found south to within 2° of the equator (Perrin and Brownell 2002). The distribution of minke whale vocalizations (specifically, "boings") suggests that the winter breeding grounds are the offshore tropical waters of the North Pacific Ocean (Rankin and Barlow 2005). Numerous acoustic detections of minke whales were made during a 2007 winter ship survey of the Mariana Islands (Fulling et al. 2011).

The migration paths of the minke whale include travel between breeding and feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al. 2008). In the northern part of their range, minke whales are believed to be migratory, whereas they appear to establish home ranges in the inland waters of Washington State and along central California (Dorsey 1983; Dorsey et al. 1990), and exhibit site fidelity to these areas between years (Dorsey et al. 1990).

Offshore – During six systematic ship surveys conducted by the SWFSC between 1991 and 2008 in waters off the U.S. west coast to approximately 300 nm offshore, there were a total of 18 minke whale sightings, 3 of which were in waters off Oregon and Washington (Barlow 2010). Minke whales tend to be more common in some nearshore areas (Stern 1992), which are not well-sampled during the SWFSC large ship surveys. Plots of all sighting locations from SWFSC ship surveys conducted from 1986 to 2005 show this species has a predominant nearshore distribution along the coast of North America (Hamilton et al. 2009). There were four minke whale sightings during coastal (out to about the 656 ft. [200 m] isobath) ship surveys off the northern Washington coast between 1995 and 2002 (Calambokidis et al. 2004). During surveys along the Washington coast between 2004 and 2008, there was a single minke whale sighting of one individual in November 2004 in waters approximately 125 ft. (38 m) deep (Oleson et al. 2009). Minke whales were not acoustically detected in recordings made by two Navy-funded passive acoustic monitoring devices bottom deployed off Washington from 2008 to 2013 (Kerosky et al. 2013; Širović et al. 2012a, b).

Inland Waters (Puget Sound) – As noted above, minke whales appear to establish home ranges in the inland waters of Washington (Dorsey 1983; Dorsey et al. 1990). Minke whales are reported in the inland waters year-round, although the majority of the records are from March through November (Calambokidis and Baird 1994). Minke whales are sighted primarily in the San Juan Islands and Strait of Juan de Fuca but are relatively rare in Puget Sound south of Admiralty Inlet (Stern 2005; Orca Network 2012). In the Strait of Juan de Fuca, individuals move within and between specific feeding areas around submarine banks (Stern 2005). Dorsey et al. (1990) noted minke whales feeding in locations of strong tidal currents. Hoelzel et al. (1989) reported that 80 percent of feeding observations in the San Juan

Islands were over submarine slopes of moderate incline at a depth of about 66 ft. (20 m) to 328 ft. (100 m). Three feeding grounds have been identified in the Strait of Juan de Fuca and San Juan Islands area (Osborne et al. 1988; Hoelzel et al. 1989; Dorsey et al. 1990; Stern 2005). There is year-to-year variation in the use of these feeding areas, and other feeding areas probably exist (Osborne et al. 1988; Dorsey et al. 1990).

Sightings in Puget Sound south of Admiralty Inlet are infrequent. Approximately 55 minke whale opportunistic sightings were recorded with Orca Network between January 2005 and August 2012 in Puget Sound. The majority of those sightings (41) were in Admiralty Inlet. No sightings were reported in the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton and Keyport. Only two sightings were reported for the Saratoga Passage area near NASWI and Naval Station Everett. Both Saratoga Passage sightings were in 2006, and one was an uncertain identification. There are no known sightings for Hood Canal or Dabob Bay and only one sighting south of Point Defiance in southern Puget Sound near Carr Inlet.

Western Behm Canal, Alaska – Minke whales were observed infrequently during the spring through fall 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, it is possible that minke whales may be present in the winter.

Gray Whale (*Eschrichtius robustus*)

Status and Management

There are currently two formally recognized North Pacific populations of gray whales: the Western Pacific subpopulation (also known as the Western North Pacific or the Korean-Okhotsk population) that is critically endangered and shows no apparent signs of recovery, and the Eastern Pacific population (also known as the Eastern North Pacific or the California-Chukchi population) that 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 subpopulation is listed as endangered under the ESA and is depleted under the MMPA, but there is no designated critical habitat for this species.

A group of a few hundred gray whales known as the Pacific Coast Feeding Group feeds along the Pacific coast between southeastern Alaska and southern California throughout the summer and fall (Calambokidis et al. 2002). This group of whales has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al. 2014). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is demographically distinct (Calambokidis et al. 2010; Mate et al. 2010; Frasier et al. 2011). Currently, the Pacific Coast Feeding Group is not treated as a distinct stock in the NMFS SARs, but this may change in the future based on new information (Carretta et al. 2014). In 2012–2013, the Navy funded a satellite tracking study of Pacific Coast Feeding Group gray whales (U.S. Department of the Navy 2013d). Tags were attached to 11 gray whales near Crescent City, California, in fall 2012. Good track histories were received from 9 of the 11 tags, which confirmed an exclusive near shore (< 15 km) distribution and movement along the California, Oregon, and Washington coast. The whales did not linger near any submarine canyons or other underwater features, remaining entirely on the continental shelf (Mate 2013; U.S. Department of the Navy 2013d).

Gray whales began to receive protection from commercial whaling in the 1930s. However, hunting of the western population continued for many more years. The International Whaling Commission (IWC)

sets a quota allowing catch of gray whales annually from the eastern population for aboriginal subsistence. In 2007 the IWC approved a 5-year quota (2008–2012) of 620 whales, with an annual maximum of 140 whales for Russian and U.S. (Makah Indian Tribe) aboriginals. Russia and the United States agreed to a shared annual harvest of 120 and 4 whales, respectively; however, all takes during this time period were from Russia (The International Whaling Commission 2013).

Abundance

Recent abundance estimates for the Eastern North Pacific gray whale population have ranged between 17,000 and 20,000 (Swartz et al. 2006; Rugh et al. 2008; Punt and Wade 2010). For stock assessment purposes, NMFS currently uses an abundance of 19,126 animals (CV = 0.07; Carretta et al. 2014). In 1999–2000 an unusually large number of gray whales stranded along the coast, from Mexico to Alaska (Gulland et al. 2005). Gray population rebounded after the 1999-2000 mortality event although currently a relatively low reproductive output reported is consistent with little or no population growth (Laake et al. 2012; Punt and Wade 2012; Carretta et al. 2014). Little population growth from a formally rebounding population may be indicative of a population getting close to its biological carrying capacity (Hui 2006).

Based on a defined range for the Pacific Coast Feeding Group between 41°N and 52°N, the 2010 abundance estimate is 188 (CV=0.10)) whales (Calamboikidis et al. 2012; Carretta et al. 2014).

The western subpopulation of gray whale was once considered extinct but now small numbers are known to exist (Weller et al. 2002). The most recent estimate of this population is 155 individuals (95 percent confidence interval = 142–165 whales; International Union for Conservation of Nature 2012).

Distribution

Eastern gray whales are known to migrate along the U.S. west coast on both their northward and southward migration. This species makes the longest annual migration of any mammal: 9,321–12,427 mi. (15,000–20,000 km) roundtrip (Jefferson et al. 2008; Jones and Swartz 2009). The migration connects summer arctic and north Pacific feeding grounds with winter mating and calving regions in temperate and subtropical coastal waters. Winter grounds extend from central California south along Baja California, the Gulf of California, and the mainland coast of 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 that have remained in the breeding area longer, allowing calves to strengthen and rapidly increase in size before the northward migration (Jones and Swartz 2009; Herzing and Mate 1984). Beginning in the fall, whales start the southward migration from the summer feeding areas (spanning the coast from the northern Gulf of Alaska to the Study Area) to winter calving areas and mainly follow the coast to Mexico. The trip averages 2 months. During the southbound migration, peak sightings occur between early December and mid-February off the Oregon coast and in January off the Washington coast (Herzing and Mate 1984; Rugh et al. 2001).

Most of the Eastern North Pacific stock summers in the shallow waters of the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1981), but a small proportion (approximately 200 individuals) spend the summer and fall feeding along the Pacific coast from southeastern Alaska to central California (Gosho et al. 2011; Carretta et al. 2014; Sumich 1984; Calambokidis et al. 1987, 2002). These whales, collectively known as the "Pacific Coast Feeding Group," are a trans-boundary population

within the United States and Canada and are defined by the IWC as a gray whale that is observed between 1 June and 30 November within the region between northern Vancouver Island and northern California and has been photo-identified within this area during 2 or more years (Carretta et al 2014; Punt and Moore 2013). These whales are also referred to as “resident gray whales” by the local population in Oregon and Northern California, even though the whales do migrate and are not present year-round as the name resident suggests (Irvine 2013).

The migration routes of the western subpopulation of gray whales are poorly known (Weller et al. 2002). Previous sighting data suggested that the remaining population of western gray whale had a limited range extent between the Okhotsk Sea off the coast of Sakhalin Island and the South China Sea (Weller et al. 2002). However, recent long-term studies of radio-tracked whales indicate that the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of the migratory route (Weller et al. 2012). There is also photographic evidence of a match between a whale found off Sakhalin and the Pacific coast of Japan, more than 932 mi. (1,500 km) south of the Sakhalin feeding area (Weller et al. 2008). Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were sighted off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al. 2013).

Offshore – During visual surveys off the Washington coast from August 2004 through September 2008, there were a total of 55 gray whale sightings of 116 individuals (Oleson et al. 2009). Clear seasonal differences in gray whale distribution were noted based on three distinct time periods: (1) winter (December–January), corresponding to the timing of their southbound migration; (2) spring (February–April), corresponding to the timing of their northbound migration; and (3) summer/fall (May–October), a time when any gray whales present are primarily members of the Pacific Coast Feeding Group. Oleson et al. (2009) found significant differences in the sighting distributions between these three time periods, based on an analysis of distance from shore, distance from the shelf break, and water depth. During the winter southbound migration, gray whales were sighted mainly offshore, with an average distance of 18 mi. (29 km) from the coast. This compared to the spring northbound migration when the average distance was 6.2 mi. (10 km) from shore. During summer and fall, gray whale sightings were clustered in two areas, in and around the entrance to Grays Harbor and in an offshore area approximately 12.4–15.5 mi. (20–25 km) from shore (Oleson et al. 2009). These offshore sightings were unusual given that in the Pacific Northwest, the Pacific Coast Feeding Group is typically close to shore (Calambokidis et al. 2002).

The occurrence of Eastern North Pacific gray whales and members of the Pacific Coast Feeding Group is considered seasonally likely in the offshore portion of the Study Area. Given their small population size and limited number of sightings off the U.S. west coast, the occurrence of Western North Pacific gray whales in the offshore portion of the Study Area is considered rare.

Inland Waters (Puget Sound) – As the majority of gray whales migrate past the Strait of Juan de Fuca en route to or from their feeding or breeding grounds, a few of them enter the inland waters to feed (Stout et al. 2001). Gray whales are observed in Washington inland waters in all months of the year (Calambokidis et al. 2010; Orca Network 2012), with peak numbers from March through June (Calambokidis et al. 2010). Fewer than 20 gray whales have been documented in the inland waters of Washington and British Columbia (Orca Network 2011, as cited by Washington Department of Fish and Wildlife 2012). Calambokidis et al. (2010) reported that Puget Sound (mudflats near the Whidbey Island and Camano Island area) is used as a springtime feeding area for a small, regularly occurring group of

gray whales. Observed feeding areas are located in Saratoga Passage between Whidbey and Camano Islands including Crescent Harbor, and in Port Susan Bay located between Camano Island and the mainland in Possession Sound. These areas are between NASWI (Crescent Harbor) and Naval Station Everett.

In the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton and Keyport, 11 opportunistic sightings of gray whales were reported to Orca Network between January 2003 and July 2012. One stranding occurred at NAVBASE Kitsap Bremerton in January 2013. There are typically anywhere from 2 to 10 stranded gray whales per year in Washington (Cascadia Research 2012a). Gray whales have been sighted in Hood Canal south of the Hood Canal Bridge on six occasions since 1999, including a stranded whale at Belfair State Park (Calambokidis 2013). The most recent report in Hood Canal was of characteristic "blows" (air exhaled through the whale's blowhole) in the waters near Lilliwaup in November 2010 (Calambokidis 2013).

Western Behm Canal, Alaska – Gray whales were not observed during 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009), and they are considered extralimital in this region of the Study Area.

Sperm Whale (*Physeter macrocephalus*)

Status and Management

The sperm whale is listed as depleted under the MMPA and has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009), but there is no designated critical habitat for this species in the North Pacific. Sperm whales are divided into three stocks in the Pacific: (1) the Alaska/North Pacific stock; (2) the California, Oregon, and Washington stock; and (3) the Hawaii stock.

Abundance

Currently there is no reliable abundance estimate for the Alaska/North Pacific stock of sperm whales (Allen and Angliss 2014). The number of sperm whales within the eastern temperate North Pacific (between 20°N and 45°N) was estimated at 26,300 (CV = 0.81) from visual surveys and 32,100 (CV = 0.36) from acoustic detections (Barlow and Taylor 2005). The current best available estimate of abundance for the California, Oregon, and Washington stock is 971 (CV = 0.31) (Forney 2007; Barlow 2010; Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 329 sperm whales (CV = 0.45) occur in waters off Washington and Oregon (Barlow 2010). The Barlow (2010) sperm whale density estimate for waters off Washington and Oregon (1.0 animals per 386 square miles [$mi.^2$] [1,000 square kilometers {km^2}]) is similar to the worldwide global average for this species (1.4 animals per 386 $mi.^2$ [1,000 km^2]; Whitehead 2002). For the California/Oregon/Washington sperm whale stock, Moore and Barlow (2014) reported that from 1991 to 2008, the precision of the growth rate estimate was too low to make any firm conclusions regarding abundance trends, but that the numbers of this endangered species have been stable. For the segment of the population traveling alone or in pairs (most likely reproductive adult males), data were sufficient to indicate a high probability of a 2-fold increase in the number of those animals during the 1991 to 2008 time period.

Distribution

Male sperm whales are found from tropical to polar waters in all oceans of the world, between approximately 70°N and 70° south (S) (Rice 1998). The female distribution is more limited and corresponds approximately to the 40° parallels but extends to 50° in the North Pacific (Whitehead 2003). Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice 1989; Whitehead 2003; Whitehead et al. 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40°N and 45°N (Rice 1989; Whitehead 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al. 2007). In the northern hemisphere, “bachelor” groups (males typically 15–21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007). Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Offshore – Sperm whales were seen in every season except winter (December–February) during systematic surveys off Washington and Oregon from 1989 to 1990 (Green et al. 1992). More recently, sperm whales were detected acoustically year-round at offshore sites monitored from 2004 to 2008 off the Washington coast, with a peak occurrence from April to August, and at an inshore recording station they were detected from April to November (Oleson et al. 2009). Acoustic detections of sperm whale were also reported at the inshore monitoring site every month from June through January 2009; there was an absence of detections between February and May 2009 (Širović et al. 2012a).

Two noteworthy sperm whale stranding events occurred in this region of the Study Area. During November 1970, there was an incident that was well-publicized by the media of attempts to dispose of a decomposed sperm whale carcass on an Oregon beach by using explosives. A mass stranding of 47 sperm whales occurred in Oregon during June 1979 (Rice et al. 1986; Norman et al. 2004).

Inland Waters (Puget Sound) – Given their documented preference for deep offshore waters, sperm whales are unlikely to occur within the inland waters region of the Study Area and would be considered extralimital.

Western Behm Canal, Alaska – Given their documented preference for deep offshore waters, sperm whales are unlikely to occur within the SEAFAC region of the Study Area since it is characterized by coastal waters removed from the continental shelf break.

Pygmy Sperm Whale (*Kogia breviceps*) and Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the pygmy sperm whale and the dwarf sperm whale. Before 1966 they were considered to be the same species until morphological distinction was shown (Handley 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008), hence their combined discussion here.

Status and Management

Both the pygmy sperm whale and the dwarf sperm whale are protected under the MMPA but not listed under the ESA. Pygmy sperm whales are divided into two discrete stocks: (1) the California, Oregon, and Washington stock; and (2) the Hawaii stock (Carretta et al. 2014). Dwarf sperm whales are also divided into two discrete stocks: (1) the California, Oregon, and Washington stock; and (2) the Hawaii stock (Carretta et al. 2014).

Abundance

Few abundance estimates have been made for the two *Kogia* species, and too little information is available to obtain reliable population estimates in west coast waters (Carretta et al. 2014). The current abundance estimate for pygmy sperm whales found along the U.S. west coast is based on the mean of two ship surveys conducted in California, Oregon, and Washington waters in 2005 and 2008. The resulting abundance estimate of 579 (CV = 1.02) individuals is considered the best estimate for the California, Oregon, and Washington stock of pygmy sperm whales (Carretta et al. 2014). An abundance estimate for the California, Oregon, and Washington stock of dwarf sperm whales is not available (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 229 *Kogia* spp. (both pygmy and dwarf sperm whales) (CV = 1.11) occur in waters off Washington and Oregon (Barlow 2010). This estimate includes sightings categorized as the genus *Kogia*; however, it is likely that these sightings were of pygmy sperm whales given previous sighting data and historical stranding data (Carretta et al. 2014).

Distribution

Both species of *Kogia* apparently have a worldwide distribution in tropical and temperate waters (Jefferson et al. 1993), and tend to occur along the continental shelf break and over the continental slope (McAlpine 2002; Bloodworth and Odell 2008). *Kogia* is known to occur in eastern North Pacific waters around Washington (Scheffer and Slipp 1948; Hubbs 1951; Roest 1970; Everitt et al. 1979) and, possibly, British Columbia (Baird et al. 1996). Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available. Based on sighting data collected by SWFSC during systematic surveys in the Northeast Pacific between 1986 and 2005, the pygmy sperm whale frequents more temperate habitats than the dwarf sperm whale, which is more of a tropical species (Hamilton et al. 2009) and so are assumed to be rare.

Offshore – Although deep oceanic waters may be the primary habitat for pygmy and dwarf sperm whales, very few oceanic sightings offshore have been recorded within this region of the Study Area (Hamilton et al. 2009; Barlow 2010). However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell 1989). Their range generally includes tropical and temperate warm water zones and is not likely to extend north into subarctic waters (Bloodworth and Odell 2008; Jefferson et al. 2008). There are eight confirmed stranding records of *Kogia* from Oregon and Washington and all are of the pygmy sperm whale (Norman et al. 2004). There is one stranding record of the dwarf sperm whale from British Columbia (Nagorsen and Stewart 1983; Willis and Baird 1998a), but this was considered an extralimital stray.

Inland Waters (Puget Sound) – Pygmy sperm whales are not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – Pygmy sperm whales are not expected to occur within the SEAFAC region of the Study Area.

Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called "ecotypes" (Ford 2008; Morin et al. 2010). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits. In the North Pacific, these recognizable geographic forms are variously known as ''residents,'' ''transients,'' and "offshore" ecotypes (Hoelzel et al. 2007).

Status and Management

The killer whale is protected under the MMPA, and the overall species is not listed on the ESA. The Eastern North Pacific Southern Resident population is listed as depleted under the MMPA and endangered under the ESA. The AT1 Transient stock of killer whales is also designated as depleted under the MMPA; this stock's current abundance estimate is seven animals (Allen and Angliss 2014). Eight killer whale stocks are recognized within the Pacific U.S. EEZ, including (1) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock (Prince William Sound through the Aleutian Islands and Bering Sea), (2) the AT1 Transient stock (Alaska from Prince William Sound through the Kenai Fjords), (3) the Alaska resident stock (southeastern Alaska to the Aleutian Islands and Bering Sea), (4) the Northern Resident stock (British Columbia through part of southeastern Alaska), (5) the West Coast Transient stock (Alaska through California), (6) the Offshore stock (southeast Alaska through California), (7) the Southern Resident stock (mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California), and (8) the Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014).

In November 2006, NMFS designated critical habitat for Southern Resident killer whales within 2,560 $mi.^2$ (6,630 km^2) of marine habitat that includes Haro Strait and the waters around the San Juan Islands, Puget Sound, and the Strait of Juan de Fuca. Eighteen sites owned or controlled by the DoD are excluded from this critical habitat designation, including Navy installations within Puget Sound. The primary constituent elements essential for conservation of the Southern Resident killer whale critical habitat have been identified as: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (National Marine Fisheries Service 2006).

Abundance

The current best available abundance estimates for the five killer whale stocks expected to occur in the Study Area are as follows: Alaska Resident stock = 2,347 animals; Northern Resident stock = 261 animals; West Coast Transient stock = 243 animals; Offshore stock = 240 animals; and Southern Resident stock = 85 individuals (Allen and Angliss 2014; Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 536 (CV = 0.46) killer whales occur in waters off Washington and Oregon (Barlow 2010). In these offshore waters, there is currently no way to reliably distinguish the different stocks of killer whales from sightings at sea (Carretta et al. 2014); therefore, this estimate includes animals from both the Offshore and West Coast Transient stocks.

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; Forney and Wade 2006). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the North Pacific (Steiger et al. 2008). In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south.

Based on sightings, strandings, and acoustic detections along the west coast of North America, all three killer whale ecotypes (residents, transients and offshore) are known to occur, including along the entire Alaskan coast, in British Columbia and Washington inland waterways, and along the outer coasts of Washington, Oregon, and California (Forney et al. 1995; Baird and Dill 1996; Ford and Ellis 1999; Calambokidis and Barlow 2004; Dahlheim et al. 2008; Barbieri et al. 2013).

Offshore – Along the west coast of the United States, three stocks of killer whale may occur: the West Coast Transient stock, the Offshore stock, and the Southern Resident stock (Carretta et al. 2014), although Northern Resident killer whales may be found infrequently in waters off Washington (Allen and Angliss 2014). Killer whales tend to show up along the Oregon coast during late April and May and may target gray whale females and calves migrating north. Based on food type, these probably are transients. As noted above, when observed offshore it is difficult to determine if a particular whale is a transient, offshore, or a resident ecotype.

Offshore killer whales usually occur 9 mi. (15 km) or more offshore but also visit coastal waters and occasionally enter protected inshore waters (Wiles 2004). Offshore killer whales have been documented off the west coast of Vancouver Island (National Marine Fisheries Service 2005), and groups of offshore killer whales have been encountered as far south as Los Angeles, mostly during winter (Ford et al. 1994).

Southern Resident killer whales regularly visit coastal sites off Washington State and Vancouver Island (Ford et al. 1994) and in the winter are known to travel as far south as Monterey off central California (Black 2001).

Inland Waters (Puget Sound) – Among the genetically distinct assemblages of killer whales in the northeastern Pacific, the West Coast Transient stock and the Southern Resident stocks are the two that occur in the inland waters region of the Study Area, although individuals of the Northern Resident stock occasionally venture into the area. Transient killer whales in the Pacific Northwest spend most of their time along the outer coast of British Columbia and Washington, but visit inland waters in search of harbor seals, sea lions, and other prey. Transients may occur in inland waters in any month (Orca Network 2010) but several studies have shown peaks in occurrences: Morton (1990) found bimodal peaks in spring (March) and fall (September–November) for transients on the northeastern coast of British Columbia. Baird and Dill (1995) found some transient groups frequenting the vicinity of harbor seal haulout sites around southern Vancouver Island during August and September, which is the peak period for pupping through post-weaning of harbor seal pups. However, not all transient groups were seasonal in these studies, and their movements appear to be unpredictable. The number of West Coast Transient killer whales in Washington inland waters at any one time is probably fewer than 20 individuals (Wiles 2004). Transient killer whale occurrences inside marine waters have increased

between 1987 and 2010, possibly because the abundance of some prey species (e.g., seals, sea lions, and porpoises) has increased (Houghton et al., in preparation).

The Eastern North Pacific Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. Photo-identification of individual whales through the years has resulted in a substantial understanding of this stock's structure, behaviors, and movements in inland waters. In 1993, the three pods comprising this stock totaled 96 killer whales (Ford et al. 1994). The population increased to 99 whales in 1995, then declined to 79 whales in 2001. The current abundance estimate for this stock is 85 whales (Carretta et al. 2014). In spring and summer months, the Southern Resident stock is most frequently seen in the San Juan Islands region with intermittent sightings in Puget Sound (Whale Museum 2012). In the fall and early winter months, the Southern Residents are seen more frequently in Puget Sound, where returning chum and Chinook salmon are concentrated (Osborne et al. 1988). By winter, they spend progressively less time in the inland marine waters and more time off the coast of Washington, Oregon, and California (Black 2011).

While both Southern Resident killer whales and transient killer whales are frequently sighted in the main basin of Puget Sound, their presence near Navy installations varies from not present at all to infrequent sightings, depending on the season (Orca Network 2012; Whale Museum 2012). Southern Resident killer whales have not been reported in Hood Canal or Dabob Bay since 1995 (National Marine Fisheries Service 2008). Southern Resident killer whales (J pod) were historically documented in Hood Canal by sound recordings in 1958 (Ford 1991), a photograph from 1973, sound recordings in 1995 (Unger 1997), and also anecdotal accounts of historical use, but these latter sightings may be transient whales (National Marine Fisheries Service 2008). Transient killer whales were last observed in Hood Canal in 2005 and prior to that in 2003, but they have not been observed since. Prior to these occurrences, transients were rarely seen. Near NAVBASE Kitsap Bremerton and Keyport, the Southern Resident killer whale is also rare, with the last confirmed sighting in Dyes Inlet in 1997. There was a more recent confirmed Southern Resident occurrence along the Washington State Ferries route between Bremerton and Seattle in December 2007, but the exact location of the sighting is not known (Orca Network 2012). Transient killer whales have been seen infrequently near NAVBASE Kitsap Bremerton (e.g., a sighting in 2013 at Dyes Inlet; Orca Network 2013). Both Southern Resident killer whales and transients have been observed in Saratoga Passage and Possession Sound near NASWI and Naval Station Everett, respectively. Transients and Southern Resident killer whales have also been observed in southern Puget Sound in the Carr Inlet area.

Western Behm Canal, Alaska – The Alaska Resident, Northern Resident, and West Coast Transient stocks of killer whale occur in waters of southeast Alaska; however, transients are considered rare in the SEAFAC region of the Study Area (Dahlheim et al. 2009). Northern Resident killer whales have been documented in southeast Alaska, although in the summer they are found primarily in central and northern British Columbia (Allen and Angliss 2014). Therefore, individuals belonging to the Alaska Resident stock are the killer whales most likely to occur in the SEAFAC region of the Study Area, and are more likely from spring through fall (Dahlheim et al. 2009). Southern Resident killer whales (L pod, 30 individuals) were photographically identified in Chatham Strait, Southeast Alaska (northwest of Behm Canal), in June 2007 (National Marine Fisheries Service 2012c). Southern Residents were previously thought to range as far north as the Queen Charlotte Islands, B. C.; however, this sighting extends their known range about 200 mi. to the north (National Marine Fisheries Service 2012c).

Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

Status and Management

Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. For MMPA SARs, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: (1) the California, Oregon, and Washington stock; and (2) the Hawaii stock (Carretta et al. 2014).

Abundance

The current abundance estimate for short-finned pilot whales found along the U.S. west coast is based on the mean of two ship surveys conducted in California, Oregon, and Washington waters in 2005 and 2008. The resulting abundance estimate of 760 (CV = 0.64) individuals is considered the best estimate for the California, Oregon, and Washington stock (Carretta et al. 2014).

Distribution

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. 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 (Hui 1985; Payne and Heinemann 1993; Bernard and Reilly 1999). Short-finned pilot whale distribution off Southern California changed dramatically after El Niño in 1982–1983, when squid did not spawn as usual in the area, and pilot whales virtually disappeared from the area for 9 years (Shane 1995). Pilot whales appear to have returned to California waters as evidenced by an increase in sighting records, as well as incidental fishery bycatch data (Carretta et al. 2004; Barlow 2010); however, current and historic sightings of this species in waters off Oregon and Washington are rare (Hamilton et al. 2009; Barlow 2010).

Offshore – Along the U.S. west coast, short-finned pilot whales are most abundant south of Point Conception, California (Reilly and Shane 1986; Carretta et al. 2014). Stranding records for this species from Oregon and Washington waters are considered to be beyond the normal range of this species rather than an extension of its range (Norman et al. 2004). The occurrence of a short-finned pilot whale within offshore waters of the Study Area is considered rare.

Inland Waters (Puget Sound) – Short-finned pilot whales are not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – Short-finned pilot whales are not expected to occur within the SEAFAC region of the Study Area.

Short-Beaked Common Dolphin (*Delphinus delphis*)

Status and Management

The short-beaked common dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA SARs, there is a single Pacific management stock including only animals found within the U.S. EEZ of California, Oregon and Washington (Carretta et al. 2014).

Abundance

The California, Oregon, and Washington stock of short-beaked common dolphin has a current population estimate of 411,211 individuals (CV = 0.21) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 3,312 short-beaked common dolphins (CV = 0.53) occur in waters off Washington and Oregon (Barlow 2010).

Distribution

Historically along the U.S. west coast, short-beaked common dolphins were sighted primarily south of Point Conception (Dohl et al. 1983), but now they are commonly encountered as far north as 42°N (Hamilton et al. 2009), and occasionally as far north as 48°N (Forney 2007). Although they are not truly migratory, the abundance of the short-beaked common dolphin off the U.S. west coast varies, with seasonal and year-to-year changes in oceanographic conditions; movements may be north-south or inshore-offshore (Forney and Barlow 1998; Barlow et al. 2009; Forney et al. 2012; Becker et al. 2012b). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s, along 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). In general, the northward extent of short-beaked common dolphin distribution appears to vary from year to year and with changing ocean conditions (Forney and Barlow 1998; Becker et al. 2012b).

Offshore – Short-beaked common dolphins are found off the U.S. west coast throughout the year, distributed between the coast and at least 345 mi. (556 km) from shore (Barlow et al. 2009; Carretta et al. 2014). The short-beaked common dolphin is the most abundant cetacean species off California (Forney et al. 1995; Carretta et al. 2014); however, their abundance decreases dramatically north of about 40°N (Barlow et al. 2009; Forney et al. 2012; Becker et al. 2012b). During summer and fall, the primary occurrence of the short-beaked common dolphin in the offshore region of the Study Area is along the outer coast in waters deeper than 656 ft. (200 m), south of 42°N. However, short-beaked common dolphins are occasionally sighted in waters off Oregon and Washington, and one group of approximately 40 short-beaked common dolphins was sighted off northern Washington in 2005 at about 48°N (Forney 2007).

Inland Waters (Puget Sound) – Short-beaked common dolphins are not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – Short-beaked common dolphins are not expected to occur within the SEAFAC region of the Study Area.

Common Bottlenose Dolphin (*Tursiops truncatus*)

Status and Management

The common bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA SARs, bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks: (1) the California coastal stock; (2) the California, Oregon, and Washington offshore stock; (3) the Kauai and Niihau stock; (4) the Oahu stock; (5) the 4-Islands region stock; (6) the Hawaii Island stock; and (7) the Hawaii pelagic stock (Carretta et al. 2014). The stock of California coastal bottlenose dolphins are found within about 0.62 mi. (1 km) of shore, generally from as far south as San Quintin, Mexico, north to Point

Conception, California (Carretta et al. 1998; Defran and Weller 1999). During El Niño events, when water temperatures increase, coastal bottlenose dolphins have been consistently sighted off central California and as far north as San Francisco, but are considered extralimital in all regions of the Study Area. The following discussion is therefore specific to the California, Oregon and Washington offshore stock.

Abundance

The California, Oregon, and Washington stock of common offshore bottlenose dolphin has a current population estimate of 1,006 (CV = 0.48) (Carretta et al. 2014).

Distribution

Bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. Off the U.S. west coast, individuals have been documented in offshore waters as far north as about 41°N; they may range into Oregon and Washington waters during warm-water periods (Carretta et al. 2014).

Offshore – During surveys off the U.S. west coast, offshore bottlenose dolphins were generally found at distances greater than 1.86 mi. (3 km) from the coast and were most abundant off southern California (Barlow 2010). Based on sighting data collected by SWFSC during systematic surveys in the Northeast Pacific between 1986 and 2005, there were few sightings of offshore bottlenose dolphins north of about 40°N (Hamilton et al. 2009). The occurrence of offshore bottlenose dolphins within offshore waters of the Study Area is considered rare.

Inland Waters (Puget Sound) – Bottlenose dolphins are considered extralimital in Washington inland waters; only three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound since 2004 (Cascadia Research 2011).

Western Behm Canal, Alaska – Common bottlenose dolphins are not expected to occur within the SEAFAC region of the Study Area.

Striped Dolphin (*Stenella coeruleoalba*)

Status and Management

The striped dolphin is protected under the MMPA and is not listed under the ESA. NMFS divides striped dolphin management stocks within the U.S. EEZ into two discrete areas: (1) the California, Oregon, and Washington stock; and (2) the Hawaii stock (Carretta et al. 2014).

Abundance

The current best abundance estimate of the California, Oregon, and Washington stock is 10,908 (CV = 0.34) striped dolphins (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 12 striped dolphins (CV = 1.05) occur in waters off Washington and Oregon (Barlow 2010).

Distribution

Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins also 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).

Offshore – During ship surveys conducted off the U.S. west coast in the summer and fall from 1991 to 2005, striped dolphins were sighted primarily from 100 to 300 nm offshore of the California coast (Barlow and Forney 2007). Striped dolphin encounters increase in deep, relatively warmer waters off the U.S. west coast (Becker et al. 2012b), and their abundance decreases north of about 42°N (Barlow et al. 2009; Forney et al. 2012; Becker et al. 2012b). Although striped dolphins typically do not occur north of California, there are a few sighting records off Oregon and Washington (Von Saunder and Barlow 1999; Barlow 2003; Barlow 2010). Strandings are documented along the coasts of Oregon, Washington, and British Columbia (Kellogg and Scheffer 1947; Kenyon and Scheffer 1949; Cowan and Guiguet 1952; Scheffer 1960). Occurrences north of California may be related to incidents of warm water moving northward (Baird et al. 1993; Norman et al. 2004). The occurrence of striped dolphins within the northwest offshore waters of the Study Area is considered rare.

Inland Waters (Puget Sound) – Striped dolphins are not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – Striped dolphins are not expected to occur within the SEAFAC region of the Study Area.

Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)

Status and Management

This species is protected under the MMPA but is not listed under the ESA. NMFS divides Pacific white-sided dolphin management stocks within the U.S. Pacific EEZ into two discrete areas: (1) the Alaska/North Pacific stock; and (2) the California, Oregon, and Washington stock (Allen and Angliss 2014; Carretta et al. 2014). Morphological studies and genetic analysis suggests existence of several populations of Pacific white-sided dolphins throughout their range (Lux et al. 1997; Hayano et al. 2004). Four populations have been suggested: in the offshore waters of Baja California, in the offshore waters of California to Oregon, offshore of British Columbia and Alaska, and in the offshore waters west of 160°W (Hayano et al. 2004). However, the population boundaries are dynamic, and there is no reliable way to distinguish animals reliably in the field. Thus, populations occurring in the U.S. Pacific EEZ are managed by NMFS as the two stocks noted above (Allen and Angliss 2014; Carretta et al. 2014).

Abundance

Using a portion of an estimate derived from sightings north of 45°N in the Gulf of Alaska, an estimate of 26,880 dolphins can be derived for the North Pacific stock (Allen and Angliss 2014). The current abundance estimate for the California, Oregon, and Washington stock is 26,930 individuals (CV = 0.28) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 11,250 Pacific white-sided dolphins (CV = 0.36) occur in waters off Washington and Oregon (Barlow 2010).

Distribution

The Pacific white-sided dolphin is found in cold temperate waters across the northern rim of the Pacific Ocean (Reeves et al. 2002; Jefferson et al. 2008). It is typically found in deep waters along the continental margins and outer shelf and slope waters. It is also known to inhabit inshore regions of southeast Alaska, British Columbia, and Washington, and occurs seasonally off Southern California (Forney and Barlow 1998; Brownell et al. 1999).

Offshore – Forney and Barlow (1998) found significant north/south shifts in the seasonal distribution of Pacific white-sided dolphin off California, with the animals moving north into Oregon and Washington waters during the summer, and showing increased abundance in the Southern California Bight in the winter. In late spring (May), Pacific white-sided dolphins can be found in shelf waters off the coast of Oregon and Washington (Tsutsui et al. 2001; Reeves et al. 2002). During ship surveys conducted off the U.S. west coast in the summer and fall from 1991 to 2005, the number of Pacific white-sided dolphin sightings showed no clear pattern with respect to geographic region, although they were consistently found in larger groups off central California (Barlow and Forney 2007). Acoustic detections of Pacific white-sided dolphin have been made consistently from June through March in waters off Washington, with a notable absence of detections in April and May (Oleson et al. 2009).

Based on habitat models developed with survey data collected during summer and fall from 1991 to 2008, Becker et al. (2012b) found that encounters of Pacific white-sided dolphin increased in shelf and slope waters and in relatively cooler waters in the study area. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of the 1991–2008 data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Pacific white-sided dolphins are thus likely to occur year-round in the offshore region of the NWTT Study Area, with increased abundance in the summer/fall.

Inland Waters (Puget Sound) – Pacific white-sided dolphins are known to enter the inshore passes of British Columbia and Washington, and have been encountered in the Strait of Juan de Fuca and the Strait of Georgia (Stacey and Baird 1991; Norman et al. 2004). Small groups have also been seen in Haro Strait off San Juan Island. Pacific white-sided dolphins are extremely rare in Puget Sound, with only one stranding in southern Puget Sound recorded in the 1980s (Osborne et al. 1988). Two incidental sightings were reported to Orca Network: one in April 2010 near Everett reported by a naturalist, and one in March 2011 near Seattle that was unverified (Orca Network 2012). Pacific white-sided dolphins are considered as occasional visitors to the inland waters region of the Study Area and occurrence is considered rare with the exception of southern Puget Sound where occurrence is considered extralimital.

Western Behm Canal, Alaska – Pacific white-sided dolphins are known to enter the inshore passes of Alaska, British Columbia, and Washington (Osborne et al. 1988; Ferrero and Walker 1996). During surveys conducted in the inland waters of southeast Alaska between 1991 and 2007, Pacific white-sided dolphins were only seen during the spring and summer surveys (Dahlheim et al. 2009). Because most sightings occur in water deeper than 656 ft. (200 m), and the SEAFAC area is at least this deep in many areas, the species may occasionally visit the SEAFAC area.

Northern Right Whale Dolphin (*Lissodelphis borealis*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. 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 the open sea waters of the central North Pacific. Although no evidence of separate populations was found, separate stocks are assumed to exist. Currently, the management stock in U.S. Pacific EEZ waters consists of a single California, Oregon, and Washington stock (Carretta et al. 2014).

Abundance

The current abundance estimate for the California, Oregon, and Washington stock of northern right whale dolphin is 8,334 individuals (CV = 0.40) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 4,152 northern right whale dolphins (CV = 0.38) occur in waters off Washington and Oregon (Barlow 2010).

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 oceanic species is distributed from approximately 30°N to 50°N, 145°W to 118° east and generally not as far north as the Bering Sea (Jefferson et al. 2008). Occasional movements south of 30°N are associated with unusually cold water temperatures (Leatherwood and Walker 1979; Jefferson and Lynn 1994). This species tends to occur along the outer continental shelf and slope, normally in waters colder than 68° Fahrenheit (F) (20° Celsius [C]) (Leatherwood and Walker 1979; Jefferson and Lynn 1994). 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). The species does not migrate, although seasonal shifts do occur.

Offshore – Survey data suggest that, at least in the eastern North Pacific, seasonal inshore-offshore and north-south movements are related to prey availability, with peak abundance in the Southern California Bight during winter and distribution shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Leatherwood and Walker 1979; Barlow 1995; Forney et al. 1995; Forney and Barlow 1998). Based on habitat models developed with survey data collected during summer and fall from 1991 to 2008, Becker et al. (2012b) found that encounters of northern right whale dolphin increased in shelf and slope waters in the study area, and encounters decreased substantially in waters warmer than approximately 64°F (18°C). These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of the 1991–2008 data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Northern right whale dolphins are thus likely to occur year-round in the offshore region of the NWTT Study Area, with increased abundance in the summer/fall.

Inland Waters (Puget Sound) – Northern right whale dolphins are relatively common off the Washington coast, but based on a lack of sighting records, this species is not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – Northern right whale dolphins are not expected to occur within the SEAFAC region of the Study Area.

Risso's Dolphin (*Grampus griseus*)

Status and Management

Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA SARs, Risso's dolphins within the Pacific U.S. EEZ are divided into two discrete areas: (1) a California, Oregon, and Washington stock; and (2) a Hawaii stock (Carretta et al. 2014).

Abundance

Risso's dolphin 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 abundance for the California, Oregon, and Washington stock, based on surveys between 2005 and 2008, is 6,272 individuals (CV = 0.30) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 3,607 Risso's dolphins (CV = 0.36) occur in waters off Washington and Oregon (Barlow 2010).

Distribution

Risso's dolphins are distributed worldwide in tropical to warm-temperate waters, roughly between 60°N and 60°S, where surface water temperature is usually greater than 50°F (10°C; Kruse et al. 1999). In the eastern North Pacific, Risso's dolphins extend north into Canadian waters (Reimchen 1980; Baird and Stacey 1991). They are most often found along the continental slope (Green et al. 1992; Kruse et al. 1999) and Baumgartner (1997) hypothesized that this distribution strongly correlates with cephalopod distribution. Water temperature appears to affect the distribution of Risso's dolphins in the Pacific (Leatherwood et al. 1980; Kruse et al. 1999). Risso's dolphin does not migrate, although schools may range over very large distances, and seasonal shifts in centers of abundance are known for some regions.

Offshore – Risso's dolphin exhibits apparent seasonal shifts in distribution off the U.S. west coast, with movements from California waters north into Oregon and Washington waters in spring and summer (Green et al. 1992; Forney and Barlow 1998; Soldevilla et al. 2008). They were the most commonly sighted odontocete in the northwest offshore waters of the Study Area during aerial surveys in the late 1980s (Green et al. 1992), and were sighted frequently off the Washington coast in summer and fall during ship surveys in 1996, 2001, and 2005 (Barlow and Forney 2007). However, they have been sighted infrequently during recent surveys (Oleson et al. 2009). Based on systematic survey data and acoustic studies conducted in offshore waters of the Study Area during the last 10 years, there appears to be high interannual variability in the occurrence of this species (Oleson et al. 2009; Barlow 2010). Acoustic detections of Risso's dolphins have been made year-round in the Study Area (Oleson et al. 2009).

Inland Waters (Puget Sound) – This species is not expected to occur within the inland waters region of the Study Area. Inland water stranding records for this species include a March 1975 report for Discovery Bay in the eastern Strait of Juan de Fuca (Everitt et al. 1979) and another near Port Angeles in October 1987 (Osborne et al. 1988). Two reported sightings of juvenile Risso's dolphins took place in late 2011 (Cascadia Research 2011), and a pair of Risso's dolphins was sighted in Puget Sound during

aerial surveys in 2013 (Smultea and Bacon 2013); however, these sightings are considered very unusual as the species is considered extralimital to the Study Area and occurrence is highly unlikely.

Western Behm Canal, Alaska – Risso's dolphins are not expected to occur within the SEAFAC region of the Study Area.

Harbor Porpoise (*Phocoena phocoena*)

Status and Management

The harbor porpoise is protected under the MMPA and is not listed under the ESA. Based on genetic differences and discontinuities identified from aerial surveys for populations off California, Oregon, and Washington, and based on somewhat arbitrary boundaries for Alaska populations, nine separate stocks are recognized within U.S. Pacific EEZ waters: (1) a Bering Sea stock, (2) a Gulf of Alaska stock, (3) a Southeast Alaska stock, (4) a Washington Inland Waters stock, (5) a Northern Oregon/Washington Coast stock, (6) a Northern California/Southern Oregon stock, (7) a San Francisco-Russian River stock, (8) a Monterey Bay stock, and (9) a Morro Bay stock (Carretta et al. 2014). Harbor porpoise from four of these stocks may occur in the Study Area, including the southeast Alaska, Washington Inland Waters, Northern Oregon/Washington Coast, and Northern California/Southern Oregon stocks.

Abundance

Abundance estimates for harbor porpoise stocks that may occur in the Study Area are as follows: Southeast Alaska stock = 11, 146 individuals (CV = 0.24); Northern Oregon/Washington Coast stock = 21,487 individuals (CV = 0.44); Northern California/Southern Oregon stock = 37,769 individuals (CV = 0.52); Washington Inland Waters stock = there are no recent data but 2002/03 estimates were 10,682 individuals (CV = 0.38) (Allen and Angliss 2014; Carretta et al. 2014).

Distribution

Harbor porpoise are generally found in cool temperate to subarctic waters over the continental shelf in both the North Atlantic and North Pacific (Read 1999). In the eastern North Pacific, harbor porpoise are found in nearshore coastal (generally within a mile or two of shore) and inland waters from Alaska south to Point Conception, California, which is considered the southern extent of this species normal range (Dohl et al. 1983; Carretta et al. 2009; Hamilton et al. 2009).

Offshore – The harbor porpoise is a common species in the nearshore coastal waters of the Study Area year-round (Barlow 1988; Green et al. 1992; Osmek et al. 1996, 1998; Forney and Barlow 1998; Carretta et al. 2009). Harbor porpoise was the most frequently sighted marine mammal (114 sightings) during 42 small boat surveys in waters off Washington from August 2004 through September 2008 (Oleson et al. 2009). The range of harbor porpoise habitat extends from the shore out to roughly the 656 ft. (200 m) isobath (Carretta et al. 2009). Based on aerial survey data collected off the coasts of California and southern Oregon in summer and fall from 2002 to 2007, higher densities of harbor porpoise were found between the coast and the 295 ft. (90 m) isobath as compared to densities in the region between the 295 ft. (90 m) and 656 ft. (200 m) isobaths (Carretta et al. 2009). Data from earlier studies suggest that peak abundance is in the fall off northern California (Dohl et al. 1983) and in fall and winter off Oregon and Washington (Green et al. 1992). Seasonal shifts in distribution have been documented, and it has been suggested that harbor porpoise may move to relatively deeper waters during late winter (Dohl et al. 1983; Barlow 1988), but such seasonal movement patterns are not well understood. Based on data

collected during surveys in waters off Washington from August 2004 through September 2008, Oleson et al. (2009) found a significant seasonal difference in harbor porpoise sighting locations; in fall, sightings were closest to the shore, furthest from the shelf edge, and in shallow water, while in summer they were farthest from the shore, closest to the shelf edge, and in deeper water.

Inland Waters (Puget Sound) – Harbor porpoise are known to occur in the Strait of Juan de Fuca and the San Juan Island area year-round (Calambokidis and Baird 1994; Osmek et al. 1995; Carretta et al. 2014).

Harbor porpoises were historically one of the most commonly observed marine mammals in Puget Sound (Scheffer and Slipp 1948); however, there was a significant decline in sightings beginning in the 1940s (Everitt et al. 1979; Calambokidis et al. 1992), but recent increased sightings may indicate a return to the area. Only a few sightings were reported between the 1970s and 1980s (Calambokidis et al. 1992; Osmek et al. 1995; Raum-Suryan and Harvey 1998), and no harbor porpoise sightings were recorded during multiple ship and aerial surveys conducted in Puget Sound (including Hood Canal) in 1991 and 1994 (Calambokidis et al. 1992; Osmek et al. 1995). Incidental sightings of marine mammals during aerial bird surveys conducted as part of the Puget Sound Ambient Monitoring Program (PSAMP) detected few harbor porpoises in Puget Sound between 1992 and 1999 (Nysewander et al. 2005). However these sightings may be negatively biased due to the low elevation of the plane which may have caused an avoidance behavior. The apparent decline in harbor porpoises observed since the 1940s may be due to by-catch from gill net fisheries coupled with the sharp decline of the herring fishery. Since 1999, PSAMP data and stranding data documented increasing numbers of harbor porpoise in Puget Sound, indicating that the species may be returning to the area (Nysewander 2008; Washington Department of Fish and Wildlife 2008; Jeffries 2013a). Sightings in northern Hood Canal (north of the Hood Canal Bridge) have increased in recent years (Calambokidis 2010). In 2011, harbor porpoise were documented in small numbers in Hood Canal near NAVBASE Kitsap Bangor and in the DBRC Site (U.S. Department of the Navy 2012). From 1999 to 2008 there were harbor porpoise seen in southern Puget Sound in and near Carr Inlet, but no sightings between Rich Passage and Agate Passage in the vicinity of NAVBASE Kitsap Bremerton and Keyport. There were no sightings in Saratoga Passage near NASWI, but there was one sighting in Port Susan north of Naval Station Everett.

Western Behm Canal, Alaska – In Alaskan waters, harbor porpoises inhabit nearshore areas and are common in bays, estuaries, and tidal channels. Harbor porpoises are often found in coastal waters in southeast Alaska, and occur most frequently in waters less than 328 ft. (100 m) deep (Hobbs and Waite 2010). Harbor porpoise was the second-most frequently observed species during surveys conducted in the inland waters of southeast Alaska between 1991 and 2007 (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, it is possible that harbor porpoises may be present in the winter.

Dall's Porpoise (*Phocoenoides dalli*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. Dall's porpoise is managed by NMFS within U.S. Pacific EEZ waters as two stocks: (1) an Alaska stock; and (2) a California, Oregon, and Washington stock (Allen and Angliss 2014; Carretta et al. 2014).

Abundance

Dall's porpoises are very abundant, probably one of the most abundant small cetacean in the cooler waters of the North Pacific Ocean. However, population structure within North American waters has not been well studied. The current estimate for the Alaska stock of Dall's porpoise is 83,400 animals (CV = 0.097), corrected for vessel attraction behavior (Allen and Angliss 2014). The abundance for the California, Oregon, and Washington stock is 42,000 individuals (CV = 0.33) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 27,010 Dall's porpoise (CV = 0.29) occur in waters off Washington and Oregon (Barlow 2010).

Distribution

Dall's porpoise is one of the most common odontocete species in North Pacific waters (Jefferson 1991; Ferrero and Walker 1999; Calambokidis and Barlow 2004; Zagzebski et al. 2006; Williams and Thomas 2007). Dall's porpoise is found from northern Baja California, Mexico, north to the northern Bering Sea and south to southern Japan (Jefferson et al. 1993). However, the species is only common between 32°N and 62°N in the eastern North Pacific (Morejohn 1979; Houck and Jefferson 1999). Dall's porpoise are found in outer continental shelf, slope, and oceanic waters, typically in temperatures less than 63°F (17°C) (Houck and Jefferson 1999; Reeves et al. 2002; Jefferson et al. 2008).

Offshore – Dall's porpoise distribution off the U.S. west coast is highly variable between years, most likely due to changes in oceanographic conditions (Forney and Barlow 1998; Barlow et al. 2009; Becker et al. 2010, 2012b; Forney et al. 2012). North-south movements in California, Oregon, and Washington have been observed, with Dall's porpoise shifting their distribution southward during cooler-water periods on both interannual and seasonal time scales (Forney and Barlow 1998). Seasonal movements have also been noted off Oregon and Washington, where higher densities of Dall's porpoises were sighted offshore in winter and spring and inshore in summer and fall (Green et al. 1992). Based on habitat models developed using 1991–2008 survey data collected during summer and fall, Becker et al. (2012b) found that encounters of Dall's porpoise increased in shelf and slope waters in the Study Area, and encounters decreased substantially in waters warmer than approximately 63°F (17°C). These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Forney 2000; Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of these data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Dall's porpoise was one of the most frequently sighted marine mammal (44 sightings of 206 animals) during 42 small boat surveys in waters off Washington from August 2004 through September 2008 (Oleson et al. 2009).

Inland Waters (Puget Sound) – Dall's porpoise occur in the inland waters year-round, but abundance and distribution varies between summer and winter (Calambokidis 2006). Dall's porpoise are most frequently observed in the Strait of Juan de Fuca and Haro Strait between San Juan Island and

Vancouver Island (Nysewander et al. 2005). Tagging studies suggest that Dall's porpoise seasonally move between Haro Strait and the Strait of Juan de Fuca or farther west (Hanson et al. 1998).

The most recent Dall's porpoise sightings in Puget Sound are from aerial surveys during winter (1993–2008) and summer (1992–1999) as part of the PSAMP (Nysewander et al. 2005; Washington Department of Fish and Wildlife 2008). During these surveys, Dall's porpoise were sighted in Puget Sound as far south as Henderson Bay in Carr Inlet (Nysewander et al. 2005; Washington Department of Fish and Wildlife 2008). Dall's porpoise may also occasionally occur in Hood Canal (Jeffries 2006); the last one was observed in deeper water near NAVBASE Kitsap Bangor in summer 2008 (Tannenbaum et al. 2009). In recent years, several vessel line-transect surveys and other monitoring efforts have been completed in Hood Canal (including Dabob Bay), and Dall's porpoise were not seen (U.S. Department of the Navy 2012). Dall's porpoise have not been documented in the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton or Keyport in either the summer or winter surveys (Washington Department of Fish and Wildlife 2008; Nysewander et al. 2005). Dall's porpoise have been documented in Possession Sound near Naval Station Everett and in Saratoga Passage near NASWI, with all but one sighting occurring in the winter (Washington Department of Fish and Wildlife 2008; Nysewander et al. 2005).

Western Behm Canal, Alaska – When inshore, Dall's porpoise are found most often in deep channels with strong currents (Dahlheim et al. 2009). Dall's porpoise was the most frequently observed species during surveys conducted in the inland waters of southeast Alaska between 1991 and 2007 (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, it is possible that Dall's porpoises may be present in the winter.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale is managed by NMFS within U.S. Pacific EEZ waters as three stocks: (1) an Alaska stock; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014).

Abundance

There is currently no reliable abundance estimate for the Alaska stock of Cuvier's beaked whale (Allen and Angliss 2014). The current best available abundance estimate for the California, Oregon, and Washington stock is 6,590 individuals (CV = 0.65) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 137 Cuvier's beaked whales (CV = 1.12) occur in waters off Washington and Oregon (Barlow 2010). A recent study using the 1991–2008 survey data provides evidence that the abundance of Cuvier's beaked whales has declined slightly off California, Oregon, and Washington since the early 1990s, although reasons for these apparent declines are unknown (Moore and Barlow 2013). In considering only data from 2001, 2005, and 2008 surveys, however, there appears to be little change in Cuvier beaked whale estimated populations.

Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Barlow and Gisner 2006; Ferguson et al. 2006; Jefferson et al. 2008; Pitman

et al. 1988). Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 656 ft. (200 m) and are frequently recorded in waters with bottom depths greater than 3,281 ft. (1,000 m) (Jefferson et al. 2008; Falcone et al. 2009). A single population likely exists in offshore waters of the eastern North Pacific, ranging from Alaska south to Mexico (Carretta et al. 2014). Little is known about potential migration.

Offshore – Cuvier's beaked whale is the most commonly encountered beaked whale off the U.S. west coast (Hamilton et al. 2009; Carretta et al. 2014). This species is found from Alaska to Baja California, Mexico, and there are no apparent seasonal changes in distribution (Pitman et al. 1988; Mead 1989; Carretta et al. 2014). 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). Line-transect analyses of data collected during summer and fall of 1991–2008 revealed that abundance estimates were lower off Oregon and Washington as compared to areas off central and southern California (Barlow 2010). One sighting of three Cuvier's beaked whales was recorded in June 2006 during surveys conducted from August 2004 through September 2008 off the Washington coast (Oleson et al. 2009). Acoustic analyses of data collected from a Navy-funded monitoring device in Washington offshore waters detected Cuvier's beaked whale pulses between January and November 2011 (Širović et al. 2012b).

Inland Waters (Puget Sound) – Cuvier's beaked whales are not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – In the North Pacific, Cuvier's beaked whales range from Canadian waters north to the northern Gulf of Alaska, the Aleutian Islands, and the Commander Islands off Russia (Rice 1998). Cuvier's beaked whales were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Due to their preference for shelf and pelagic waters, the occurrence of Cuvier's beaked whale in the SEAFAC region of the Study Area is considered rare.

Baird's Beaked Whale (*Berardius bairdii*)

Status and Management

Baird's beaked whale is protected under the MMPA and is not listed under the ESA. Baird's beaked whale is managed by NMFS within Pacific U.S. EEZ waters as two stocks: (1) an Alaska stock; and (2) a California, Oregon, and Washington stock (Allen and Angliss 2014; Carretta et al. 2014).

Abundance

There is currently no reliable abundance estimate for the Alaska stock of Baird's beaked whale (Allen and Angliss 2014). The population estimate for the California, Oregon, and Washington stock of Baird's beaked whale is 847 (CV = 0.81) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 380 Baird's beaked whales (CV = 0.48) occur in waters off Washington and Oregon (Barlow 2010).

Distribution

Baird's beaked whale occurs mainly in deep waters over the continental slope, near oceanic seamounts, and areas with submarine escarpments, although they may be seen close to shore where deep water

approaches the coast (Jefferson et al. 2008; Kasuya 2009). This species is generally found through the colder waters of the North Pacific, ranging from off Baja California, Mexico, to the Aleutian Islands of Alaska (MacLeod and D'Amico 2006; Jefferson et al. 2008).

Offshore – Baird's beaked whale is found mainly north of 28°N in the eastern Pacific (Kasuya et al. 1997; Reeves et al. 2002). Along the U.S. west coast, Baird's beaked whales are seen primarily along the continental slope, from late spring to early fall (Balcomb 1989; Green et al. 1992; Carretta et al. 2014). 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. 2014). Off Washington and British Columbia, Baird's beaked whales have been sighted in offshore waters with a bottom depth of 2,297 ft. (700 m) to 5,495 ft. (1,675 m) (Wahl 1977; Willis and Baird 1998b). Based on habitat models developed using 1991–2008 survey data collected during summer and fall, Becker et al. (2012b) found that encounters of Baird's beaked whale increased in waters near the 6,562 ft. (2,000 m) isobath. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of these data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Acoustic analyses of data collected from a Navy-funded monitoring device in Washington offshore waters detected Baird's beaked whale pulses between January and November 2011, with a peak in detections in February and July (Širović et al. 2012b).

Inland Waters (Puget Sound) – Baird's beaked whales are not expected to occur within the inland waters region of the Study Area.

Western Behm Canal, Alaska – In the North Pacific Ocean and along the U.S. west coast, Baird's beaked whales are seen primarily along the continental slope in deep waters (Balcomb 1989; Reeves and Mitchell 1993). Baird's beaked whales were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Due to their preference for shelf and pelagic waters, the occurrence of Baird's beaked whale in the SEAFAC region of the Study Area is considered rare.

Mesoplodont Beaked Whale (*Mesoplodon* spp.)

Status and Management

All of the beaked whales in the genus *Mesoplodon* are protected under the MMPA but none are listed under the ESA. Due to the difficulty in distinguishing different *Mesoplodon* species from one another, NMFS includes six species in a single California, Oregon, and Washington management stock (Carretta et al. 2014). The six species known to occur in this region are Blainville's beaked whale (*M. densirostris*), Hubbs' beaked whale (*M. carlhubbsi*), Perrin's beaked whale (*M. perrini*), pygmy beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), and gingko-toothed beaked whale (*M. gingkodens*). In addition to the California, Oregon, and Washington stock of *Mesoplodon* species, Stejneger's beaked whale is also recognized separately as an Alaska stock and Blainville's beaked whale separately as a Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014).

Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in the California, Oregon, and Washington stock is 694 (CV = 0.65) (Carretta et al. 2014). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 565 *Mesoplodon* beaked whales (CV = 0.72) occur in waters off Washington and Oregon (Barlow 2010). A recent study using the 1991–2008

survey data provides evidence that the abundance of *Mesoplodon* beaked whales have declined off California, Oregon, and Washington since the early 1990s, although reasons for these apparent declines are unknown (Moore and Barlow 2013). In considering only data from 2001, 2005, and 2008 surveys, however, there appears to be little change in Mesoplodont beaked whale estimated populations.

Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 656 ft. [200 m]) (Waring et al. 2001; Canadas et al. 2002; Ferguson et al. 2006; MacLeod and Mitchell 2006; Pitman 2008). They are occasionally reported in waters over the continental shelf (Pitman 2008). At least six species in this genus have been recorded off the U.S. west coast, but due to the rarity of records and the difficulty in identifying these animals in the field, very little species-specific information is available. In addition, the technology for identifying beaked whale species from acoustic detections is still rather new (Baumann-Pickering et al. 2013), and some species may not yet have been recorded. It is likely that new beaked whale species may be discovered in the future (Pitman 2008). As available, relevant species-specific distribution information is summarized below.

Blainville's beaked whales are one of the most widely distributed within the *Mesoplodon* genus (MacLeod et al. 2006b; Jefferson et al. 2008). 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 (Mead 1989; Leslie et al. 2005; MacLeod and Mitchell 2006). There are a handful of known records of Blainville's beaked whale from the U.S. west coast and Baja California, Mexico, but the species does not appear to be common in this region (Pitman et al. 1988; Mead 1989; Hamilton et al. 2009). Acoustic analyses of data collected between January and November 2011 from a Navy-funded monitoring device in Washington offshore waters detected Blainville's beaked whale pulses once, in March (Širović et al. 2012b).

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. (2006b) speculated that the distribution might be continuous across the North Pacific between about 30°N and 45°N, but this remains to be confirmed.

Perrin's beaked whale distribution generally includes deep waters off the Pacific coast of North America (MacLeod et al. 2006b). Perrin's beaked whale is known only from five stranded specimens along the California coastline (Dalebout et al. 2002; MacLeod et al. 2006b). 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 (Mead 1981; Mead and Baker 1987; Mead 1989; Dalebout et al. 2002). 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) (Mead 1981; Dalebout et al. 2002), 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 (Urban-Ramirez and Aurioles-Gamboa 1992; Aurioles and Urban-Ramirez 1993; Jefferson et al. 2008). 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 (Reyes et al.

1991; Pitman and Lynn 2001; Sanino et al. 2007). MacLeod et al. (2006b) suggested that the pygmy beaked whale occurs in the eastern Pacific from about 30°N to about 30°S. There were no confirmed sightings of pygmy beaked whale north of 30°N during SWFSC systematic ship surveys of the eastern North Pacific between 1986 and 2005 (Hamilton et al. 2009).

Stejneger's beaked whale appears to prefer cold temperate and subpolar waters (Loughlin and Perez 1985; MacLeod et al. 2006b). 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). 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. 2006b). Acoustic analyses of data collected from a Navy-funded monitoring device in Washington offshore waters detected Stejneger's beaked whale calls between January and June 2011, with an absence of calls from mid-July through November 2011 (Širović et al. 2012b).

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 is from strandings, one of which occurred in California (MacLeod and D'Amico 2006; Jefferson et al. 2008).

Offshore – There were a total of 12 sightings of species identified to the genus Mesoplodon during ship surveys conducted in the summer and fall from 1991 to 2008 off California, Oregon, and Washington (Barlow 2010). Line-transect analyses of these data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Based on habitat models developed using 1991–2008 survey data collected during summer and fall, Becker et al. (2012b) found that encounters of small beaked whales (including both *Mesplondon* spp. and Cuvier's beaked whale) increased in deeper waters with greatest slopes within the study area. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012).

Inland Waters (Puget Sound) – Mesoplodont beaked whales are not expected to occur within the inland waters region of the Study Area. Strandings from the east coast of Vancouver Island have been documented (Osborne et al. 1988) but they are considered extralimital in this region.

Western Behm Canal, Alaska – Mesoplodont beaked whales were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Due to their preference for shelf and pelagic waters, the occurrence of any of the *Mesoplodon* beaked whale species in the SEAFAC region of the Study Area is considered rare.

Steller Sea Lion (*Eumetopias jubatus*)

Status and Management

In the North Pacific, NMFS has designated two Steller sea lion stocks: (1) the western U.S. stock, consisting of populations at and west of Cape Suckling, Alaska (144°W longitude); and (2) the Eastern U.S. stock, consisting of populations east of Cape Suckling, Alaska. The western U.S. stock of Steller sea lions is listed as depleted under the MMPA and endangered under the ESA. Although there is evidence of mixing between the two stocks (Jemison et al. 2013), animals from the western U.S. stock are not present in the Study Area; Steller sea lions in the Study Area are from the eastern U.S. stock. The eastern U.S. stock of Steller sea lions is listed as depleted under the MMPA. Due to their recovery, the eastern

distinct population segment (the eastern U.S. stock) of Steller sea lion was recently removed from the List of Endangered and Threatened Wildlife (National Oceanic and Atmospheric Administration 2013).

Critical habitat has been defined for the western U.S. stock of Steller sea lions in the Aleutian Islands and Western Alaska, which are outside of the Study Area. Critical habitat has been defined for the eastern stock of Steller sea lions in coastal southeast Alaska, Oregon, and California. At this time, there has been no change in the designation of critical habitat despite the recent delisting (National Oceanic and Atmospheric Administration 2013). In southeast Alaska, there is no designated habitat near the Behm Canal or the SEAFAC portion of the Study Area. In Oregon and California, critical habitat includes six listed aquatic zones that extend 3,000 ft. (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery, and an air zone that extends 3,000 ft. (0.9 km) above the aquatic zones; however, these areas are inshore of the Study Area's southeastern boundary by approximately 25 km (16 mi.). There is thus no designated Steller sea lion critical habitat in the Study Area including the SEAFAC site in Southeast Alaska. Steller sea lion haulout sites in Washington, Oregon and California have not been identified as critical habitat and there are no rookeries for the species in Washington State Waters (National Marine Fisheries Service 1993b), although up to 25 Steller sea lion pups have been born at Washington haulout sites in recent years (Jeffries 2013a).

Abundance

The eastern stock of Steller sea lions breeds on rookeries located in southeast Alaska, British Columbia, Oregon, and California; there are no rookeries located in Washington. The most recent pup counts available by region were 7,462 in 2009 for southeast Alaska, 5,485 in 2010 for British Columbia, 1,418 in 2009 for Oregon, and 673 in 2011 for California as reported in Allen and Angliss 2014. Using pup multipliers (sea lion population can be estimated by multiplying pup counts by a factor based on the birth rate, sex and age structure, and growth rate of the population) of either 4.2 or 5.2, the population is estimated to be within the range of 63,160and 78,198. Counts in Oregon have shown a gradual increase since 1976, as the adult and juvenile state-wide count for that year was 1,486 compared to 4,169 in 2002. Unlike the observed decline in the western U.S. stock of Steller sea lion, there has been an overall increase in the eastern U.S. stock. The eastern U.S. stock is increasing throughout the northern portion of its range (southeast Alaska and British Columbia), and is stable or increasing slowly in the central portion (Oregon through central California) (Pitcher et al. 2007; National Oceanic and Atmospheric Administration 2013).

Distribution

Steller sea lions range along the North Pacific Rim from northern Japan to California, with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands. The species is not known to migrate, but individuals disperse widely outside of the breeding season.

Offshore – The Steller sea lion uses haulout sites primarily along the outer coast from the Columbia River to Cape Flattery, as well as along the Vancouver Island side of the Strait of Juan de Fuca. Steller sea lion numbers vary seasonally with peak counts of 1,000 animals present during the fall and winter months (Jeffries et al. 2000). Haulout sites are found on jetties, offshore rocks and coastal islands. During the breeding season, the majority of animals will be located at these rookeries, as well as at haulout sites off the northern Washington coast where up to 25 pups are born annually (Jeffries 2013a).

Outside of breeding season, Steller sea lions may be present throughout the northwest offshore area, following aggregations of prey. The occurrence of Steller sea lions in the northwest offshore area of the Study Area is considered likely.

Inland Waters (Puget Sound) – While Steller sea lions are occasionally observed in the Strait of Juan de Fuca, they are seasonally present in Puget Sound. Jeffries (2012) identified five winter haulout sites used by Steller sea lions, ranging from immediately south of Port Townsend (near Admiralty Inlet) to Olympia in southern Puget Sound. Numbers of animals observed at these sites ranged from a few animals to less than 100. Steller sea lions opportunistically haulout on various navigational buoys between Admiralty Inlet and southern Puget Sound near Olympia (Jeffries 2012). One or two animals occur on these buoys. Up to six individuals have been observed in Hood Canal hauled out on submarines at NAVBASE Kitsap Bangor (U.S. Department of the Navy 2012). Steller sea lions would be expected to forage within the area, following local prey availability. Steller sea lions have been seasonally documented at NAVBASE Kitsap Bangor in Hood Canal since 2008 during daily haulout surveys. Similar opportunistic surveys at NAVBASE Kitsap Bremerton have not identified any Steller sea lions, although one was apparently sighted on the Navy security fence during a vessel survey in November 2012 (Lance 2012) and during aerial surveys conducted by the Washington Department of Fish and Wildlife in spring 2013 (Jeffries 2013a). There is a large sea lion haulout (used by California and Steller sea lions) near Manchester, approximately 8 mi. from NAVBASE Kitsap Bremerton. There are no known occurrences of Steller sea lions at Keyport, Everett, or Crescent Harbor. Steller sea lions are seasonally present in large numbers in southern Puget Sound near Carr Inlet and off the mouth of the Nisqually River (Jeffries 2013a).

Adjacent to the Study Area in Canadian waters, Race Rocks, British Columbia, Canada (Canadian side of the Strait of Juan de Fuca) has also been identified as a major winter haulout site for Steller sea lions (Edgell and Demarchi 2012). During summer months and associated breeding periods, the inland waters would not be considered a high-use area by Steller sea lions. Specifically, Steller sea lions are not expected June through September. The occurrence of Steller sea lions in the inland waters portion of the Study Area is considered seasonal.

Western Behm Canal, Alaska – The most recent counts of pups and non-pups of Steller sea lions were 24,447 sea lions (7,462 pups) at rookery and haulout sites in southeast Alaska in 2009 (Allen and Angliss 2014). Womble et al. (2008) presented annual observation data which indicates that Steller sea lions are present year-round in the SEAFAC area, but their areas of concentration fluctuate through the year. During the winter, haulout locations were situated close to known over-wintering herring locations. In the spring, Steller sea lions hauled out near locations of spawning forage fish. During the summer and autumn months, haulout locations were located close to migrating salmon locations. The seasonal use of haulouts by sea lions and ultimately haulout-specific foraging patterns of Steller sea lions depend in part upon seasonally available prey species in each region. The occurrence of Steller sea lions in the SEAFAC portion of the Study Area is considered likely.

California Sea Lion (*Zalophus californianus*)

Status and Management

The California sea lion is protected under the MMPA and is not listed under the ESA. NMFS has defined one stock for the California sea lion (U.S. stock), with five genetically distinct geographic populations: (1) Pacific Temperate, (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California. The Pacific Temperate population includes rookeries within U.S. waters and the Coronados Islands just south of the U.S./Mexico border. Animals from the

Pacific Temperate population range north into Canadian waters, and movement of animals between U.S. waters and Baja California waters has been documented (Carretta et al. 2014).

Abundance

The current population estimate of California sea lions in the U.S. stock is 296,750 (Carretta et al. 2014). The entire population cannot be counted because all age and sex classes are not ashore at the same time during field surveys. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the population is then estimated from the number of births and the proportion of pups in the population (Carretta et al. 2014).

Distribution

During the summer, California sea lions breed on islands from the Gulf of California to the Channel Islands and seldom travel more than about 31 mi. (50 km) from the islands. The primary rookeries are located on the California Channel Islands of San Miguel, San Nicolas, Santa Barbara, and San Clemente. Their distribution shifts to the northwest in fall and to the southeast during winter and spring, probably in response to changes in prey availability. In the non-breeding season, adult and subadult males migrate northward along the coast to central and northern California, Oregon, Washington, and Vancouver Island, are occasionally sighted hundreds of miles offshore, and return south the following spring. Primarily male California sea lions migrate into northwest waters, with most adult females with pups remaining in waters near their breeding rookeries off the coast of California and Mexico. Females and juveniles tend to stay closer to the rookeries. They also enter bays, harbors, and river mouths and often haulout on man-made structures such as piers, jetties, offshore buoys, and oil platforms.

Offshore – The California sea lion is the most frequently sighted otariid found in Washington waters and uses numerous haulout sites along the coast. Sea lions are present along the coast of Oregon from October to April (National Marine Fisheries Service 1997). Main haulout sites include the Columbia River (South Jetty), Cascade Head, Cape Arago, and Orford and Rogue Reefs. Sea lions also use the northern coast of California mainly during May and June, and September and October (Bonnell et al. 1983). Main haulout sites include St. George Reef, Castle Rock, and Farallon and Año Nuevo Islands. California sea lions feed on a wide variety of prey, including many species of fish and squid, and typically feed over the continental shelf. The occurrence of California sea lions in the northwest offshore portion of the Study Area is considered likely.

Inland Waters (Puget Sound) – Jeffries et al. (2000) identified numerous haulout sites used by California sea lions throughout the Puget Sound region. California sea lions are present between August and June in the inland waters, with peak numbers between October and May (National Marine Fisheries Service 1997; Jeffries et al. 2000). Main haulout sites occur at NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton, and Naval Station Everett, as well as in Rich Passage near Manchester, Seattle (Silshole Bay), south Puget Sound (Commencement Bay, Budd Inlet) and numerous navigation buoys south of Whidbey Island to Olympia (Jeffries et al. 2000; Jeffries 2012). Adjacent to the Study Area in Canadian waters, Race Rocks, British Columbia, Canada (Canadian side of the Strait of Juan de Fuca) has been identified as a major winter haulout for California sea lions (Edgell and Demarchi 2012). Numbers of animals observed at these sites ranged between 10 and 100 animals. California sea lions would be expected to forage within the area, following local prey availability. During summer months and associated breeding periods, the inland waters would not be considered a high-use area by California sea lions, as they would

be returning to rookeries in California waters. However, information from sightings of opportunistic animals hauled out at Bangor indicates that a few California sea lions are present in Hood Canal almost year-round with the exception of July. The occurrence of California sea lions in the inland waters portion of the Study Area is considered seasonal.

Western Behm Canal, Alaska – A total of 52 (25 male, 5 female, and 22 undetermined) California sea lions have been reported in Alaskan waters between 1974 and 2004, with an increasing presence in recent years (Maniscalco et al. 2004). California sea lions in Alaska most often were seen alone and only occasionally in small groups of two or more, although hundreds have been found to haulout together along the Washington coast and in southern British Columbia. The relatively few California sea lions found in Alaska usually have been associated with Steller sea lions at their haulouts and rookeries. The occurrence of California sea lions in the SEAFAC portion of the Study Area is considered rare.

Northern Fur Seal (*Callorhinus ursinus*)

Status and Management

NMFS has identified two stocks of northern fur seals based on high natal site fidelity, as well as substantial differences in population dynamics between Pribilof Islands (located in the Bering Sea) and San Miguel Island (California Channel Islands) populations. Animals from the Pribilof Islands are recognized as the Eastern Pacific stock, and those from San Miguel Island and Farallon Islands are the Californiastock (Allen and Angliss 2014; Carretta et al. 2014). Both stocks may be present in the Study Area. The Eastern Pacific stock of northern fur seals is listed as depleted under the MMPA and not listed under the ESA. The California stock of northern fur seals is not listed as depleted under the MMPA and not listed under the ESA.

Abundance

The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups counted at rookeries in the eastern Bering Sea multiplied by a series of different expansion factors determined from a life table analysis to estimate the number of yearlings, 2-year-olds, 3-year-olds, and animals 4 or more years old. The most recent estimate for the number of fur seals in the Eastern Pacific stock, based on pup counts from 2008 on Sea Lion Rock, St. Paul and St. George Islands, and from 2007 on Bogoslof Island, is 653,171 (Allen and Angliss 2014).

The smaller San Miguel Island population estimate is calculated in a similar manner as for the Eastern Pacific stock. Based on the 2011 count and the expansion factor, and including counts of fur seals at the Farallon islands (476), the most recent population estimate of the California stock is 12,844 northern fur seals (Carretta et al. 2014).

Estimated stock size for all northern fur seals in the United States in 2010 was approximately 671,000 (Testa 2012).

Distribution

The northern fur seal is endemic to the North Pacific Ocean, and it occurs from southern California to the Bering Sea, the Okhotsk Sea, and Honshu Island, Japan. Most northern fur seals are highly migratory and annually move from the high latitude breeding areas in the Bering Sea and Sea of Okhotsk they occupy in the warm season to more southern at-sea feeding areas in cold season (Olesiuk 2012). During

the breeding season (June–September), most of the world's population of northern fur seals occurs on the Pribilof and Bogoslof islands. Males are present in the Pribilof Island rookeries from around mid-May until August; females are present in the rookeries from mid-June to late October. Nearly all fur seals from the Pribilof Island rookeries are foraging at sea from fall through late spring. In November, females and pups leave the Pribilof Islands and migrate through the Gulf of Alaska to feeding areas primarily off the coasts of British Columbia, Washington, Oregon, and California before migrating north again to the rookeries in spring (Ream et al. 2005). Immature seals can remain in southern foraging areas year-round until they are old enough to mate (National Marine Fisheries Service 2012). Adult males migrate only as far south as the Gulf of Alaska.

The northern fur seal is a highly oceanic species, spending all but 35–45 days per year at sea. They are usually sighted 44 mi. (70 km) to 81 mi. (130 km) from land along the continental shelf and slope, seamounts, submarine canyons, and sea valleys, where upwelling of nutrient-rich water occurs (Kajimura 1984). The subpolar continental shelf and shelf break from the Bering Sea to California provides suitable feeding habitat (National Marine Fisheries Service 1993a). Although rookeries are typically composed of a rocky substrate, northern fur seals use sandy beaches for breeding on San Miguel Island (Bonnell et al. 1983; Baird and Hanson 1997). Both the Eastern Pacific and the San Miguel Island stocks occur within the Study Area.

Offshore – Northern fur seals are present in the northwest offshore region year-round (Bonnell et al. 1992), but are most abundant between January and May. Sightings are more common off the northern Washington and Vancouver Island coasts in winter, and off central and southern Oregon in spring (Bonnell et al. 1992). Adult females and juveniles from the California stock are found in offshore waters of northern California, Oregon, and Washington from October through May or early June. They return to the rookery islands to pup and breed in June and July (DeLong 2006). These fur seals are commonly found in deep waters (> 6,562 ft. [> 2,000 m]) offshore Oregon and Washington (Bonnell et al. 1992), and they rarely haulout on land during migrations (Bonnell et al. 1983). Given the highly pelagic nature of northern fur seals, the occurrence of northern fur seals in the northwest offshore portion of the Study Area is considered likely (National Marine Fisheries Service 2007; Davis et al. 2008; Lee et al. 2014; Sterling et al. 2014).

Inland Waters (Puget Sound) – As mentioned earlier, the northern fur seal is a highly oceanic species. Some individuals, mostly juveniles, make their way into the Strait of Juan de Fuca and Puget Sound each year (Everitt et al. 1979), albeit not in large numbers or with any regularity. Inland waters of the Puget Sound are an area of rare occurrence for this species.

Western Behm Canal, Alaska – The Eastern Pacific stock spends May–November in northern waters and at northern breeding colonies (north of the Gulf of Alaska). Peak abundance near SEAFAC should occur between March and June during the annual migration north to the Pribilof Islands breeding grounds (Fiscus et al. 1976). However, tagging data presented by Ream et al. (2005) indicate the main foraging areas and the main migration route through the Gulf of Alaska are located far to the west of SEAFAC. There are no rookeries or haulout sites in the vicinity of SEAFAC. Some northern fur seals, particularly juvenile males and nonpregnant females, remain in the region throughout the summer and have been documented in the nearshore waters of southeastern Alaska and Prince William Sound (Fiscus et al. 1976). The occurrence of northern fur seals in the SEAFAC portion of the Study Area is considered likely.

Guadalupe Fur Seal (*Arctocephalus townsendi*)

Status and Management

The Guadalupe fur seal is listed as depleted under the MMPA and threatened under the ESA. The primary breeding rookery of Guadalupe fur seals is at Isla de Guadalupe, Mexico, and a second breeding population has been established at Islas San Benito, Baja California, Mexico (Maravilla-Chavez and Lowry 1999; Esperon-Rodriguez and Gallo-Reynoso 2012), and are considered a single stock (Carretta et al. 2014).

Abundance

Carretta et al. (2014) report a population estimate of 7,408 for Guadalupe fur seals based on results from Gallo (1994). From earlier data, Gallo (1994) reported an average annual growth rate of 13.7%. A more recent population estimate for the entire stock of Guadalupe fur seals was 14,000–15,000 animals and based on surveys conducted in 2008 (Hernandez-Montoya 2009; Esperon-Rodriguez and Gallo-Reynoso 2012).

Distribution

Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa and Camacho-Ríos 2007), but have occasionally been identified from strandings (Northwest Region Stranding Database; Wilkinson 2013) or in archaeological contexts as far north as northern California, Oregon, and Washington (Etiner 2002; Rick et al. 2009). Between 1989 and 2011, a total of 118 dead stranded animals were found along the Washington and Oregon coastline (Northwest Region Stranding Database; Wilkinson 2013). Between 20 June and 1 November 2007, 19 Guadalupe fur seals stranded on the Washington and Oregon outer coasts, prompting NOAA to declare an Unusual Mortality Event on 19 October 2007 (Lambourn et al. 2012). The Unusual Mortality Event was officially closed on 11 December 2009. In 2012, approximately 58 Guadalupe fur seals were stranded on the outer coasts of Washington and Oregon (Lambourn 2013). This is three times the number strandings that prompted the Unusual Mortality Event in 2007. Of all the strandings reported off Washington and Oregon (1989–2012), most occurred from mid-May through August with occasional reports between October and December (Lambourn et al. 2012; Northwest Region Stranding Database). Sightings of live animals off Washington and Oregon are more limited, although there is photo documentation of apparently healthy Guadalupe fur seals in offshore waters of Washington and British Columbia in recent years during summer and early autumn (Lambourn et al. 2012). Given the increased number of strandings in the Pacific Northwest, coupled with their increasing population, it is possible that Guadalupe fur seals are returning to their historic pelagic migration range suggested by the archaeological findings (Eitner 2002; Rick et al. 2009; Lambourn et al. 2012).

Offshore – Based on their rookeries occurring in Baja California, Mexico, the species predominant distribution off Mexico, but with annual strandings in Oregon and Washington, Guadalupe fur seals are considered “seasonal” migrants within the offshore portion of the Study Area. Given the lack of at-sea sightings by the National Marine Fisheries Service and their documented coastal standings (Lambourn et al. (2012), it would be anticipated Guadalupe fur seals would be more coastal and near-shore in distribution in the Study Area as compared to other more pelagic pinnipeds such as northern fur seals.

Inland Waters (Puget Sound) – Guadalupe fur seals are not expected to occur within the inland waters region of the Study Area. Strandings from the offshore portion of the study area have been documented as noted above, but they are considered extralimital in the inland waters.

Western Behm Canal, Alaska – Guadalupe fur seals are not expected to occur in the SEAFAC portion of the Study Area.

Northern Elephant Seal (*Mirounga angustirostris*)

Status and Management

The northern elephant seal is protected under the MMPA and is not listed under the ESA. NMFS has defined one stock for the northern elephant seal, the California Breeding stock, which is geographically distinct from a population in Baja California.

Abundance

A complete population count of elephant seals is not possible because all age classes are not ashore at the same time. Instead, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the population is then estimated from the number of births and the proportion of pups in the population. Based on the estimated 35,549 pups born in California in 2005, the California stock was approximately 124,000 in 2005 (Carretta et al. 2014). Based on trends in pup counts, northern elephant seal colonies were continuing to grow in California through 2005.

Distribution

The northern elephant seal occurs almost exclusively in the eastern and central North Pacific. Rookeries are located from central Baja California, Mexico, to northern California (Stewart and Huber 1993). In California, they include the Channel Islands, Piedras Blancas, Cape San Martin, Año Nuevo Island and Peninsula, the Farallon Islands, and Point Reyes (Stewart et al. 1994; Carretta et al. 2014).

Adult elephant seals engage in two long northward migrations per year, one following the breeding season, and another following the annual molt (Stewart and DeLong 1995; Robinson et al. 2012). Between the two foraging periods, they return to land to molt, with females returning earlier than males (March–April versus July–August). After the molt, adults then return to their northern feeding areas until the next winter breeding seasons. Breeding occurs from December to March (Stewart and Huber 1993). Juvenile elephant seals typically leave the rookeries in April or May and head north, traveling an average of 559–621 mi. (900–1,000 km). Most elephant seals return to their natal rookeries when they start breeding (Huber et al. 1991). The foraging range extends thousands of miles offshore into the central North Pacific. Adults tend to stay offshore, but juveniles and subadults are often seen along the coasts of Oregon, Washington, and British Columbia (Condit and Le Boeuf 1984; Stewart and Huber 1993).

Offshore – Adult male elephant seals migrate north via the California current to the Gulf of Alaska during foraging trips, and could potentially be passing through the area off Washington in May and August (migrating to and from molting periods) and November and February (migrating to and from breeding periods) (Stewart and DeLong 1995), but their presence there is transient and short-lived. Bonnell et al. (1992) reported that northern elephant seals were distributed equally in shelf, slope, and offshore

waters during surveys conducted off Oregon and Washington, as far as 93 mi. (150 km) from shore, in waters less than 6,562 ft. (2,000 m) deep. Most elephant seal sightings at sea were during June, July, and September off Washington; sightings recorded from November through May were off southern Oregon (Bonnell et al. 1992). The occurrence of elephant seals in the northwest offshore portion of the Study Area would be considered seasonal.

Inland Waters (Puget Sound) – There are regular haulout sites at Smith and Minor Islands, Dungeness Spit, and Protection Island in the Strait of Juan de Fuca that are thought to be used year-round (Jeffries et al. 2000; Jeffries 2012). Pupping has also occurred at these sites, as well as Race Rocks on the British Columbia side of the Strait of Juan de Fuca (Jeffries 2012). Typically these sites have small numbers of 2–10 individuals present.

No haulout sites occur in Puget Sound, with the exception of individual elephant seals occasionally hauling out for 2–4 weeks to molt, usually during the spring and summer and typically on sandy beaches (Calambokidis and Baird 1994; Norberg 2012). These animals are usually yearlings or subadults, and their haulout locations are unpredictable (Norberg 2012). The National Stranding Network database reported one male subadult elephant seal hauled out to molt at Manchester Fuel Depot in February 2004.

The Whale Museum (www.thewhalemuseum.com) occasionally reports incidental observations of northern elephant seal individuals throughout Puget Sound. Rat Island across the bay from the Port Townsend ferry terminal is occasionally used by juvenile elephant seals. Given that the reported haulout sites are in the Strait of Juan de Fuca, the occurrence of elephant seals in the Puget Sound region would occur infrequently and be associated with the molting season.

Western Behm Canal, Alaska – Elephant seals prefer offshore areas but occasionally visit southeast Alaska. The species breeds off the California coast, but the nonbreeding distribution extends to the Gulf of Alaska. From April through June the species can be found in Alaska waters. Elephant seals feed in deep water, an average of 590 ft. (180 m), on fish and squid. While occasional sightings have occurred near Ketchikan, the species favors offshore areas and is not expected to be found near SEAFAC (U.S. Department of the Navy 1991). The occurrence of elephant seals in the SEAFAC portion of the Study area is considered to be extralimital.

Harbor Seal (*Phoca vitulina*)

Status and Management

For management purposes, differences in mean pupping date, movement patterns, pollutant loads, and fishery interactions have led NOAA to recognize 17 stocks along the U.S. west coast including Alaska (Carretta et al. 2014; Allen and Anglis 2012). There are 12 stocks that are present in Alaskan waters, of which only the Clarence Strait stock is within the NWTT Study Area at SEAFAC. Within U.S. West Coast waters (excluding Alaska), five stocks of harbor seals are recognized: 1) Oregon/Washington Coast; 2) California; 3) Washington Northern Inland Waters (including Puget Sound north of the Tacoma Narrows Bridge, the San Juan Islands, and the Strait of Juan de Fuca); 4) Southern Puget Sound (south of the Tacoma Narrows Bridge); and 5) Hood Canal (Carretta et al. 2014). All five of these harbor seal stocks are expected to be in the NWTT Study Area, they are protected under the MMPA, and are not listed under the ESA.

Abundance

The current statewide abundance estimate for Alaskan harbor seals is 152,602, based on aerial survey data collected during 1998–2007 (Allen and Angliss 2014). For the stock that covers the SEAFAC region (Clarence Strait), the latest stock abundance for harbor seals is 23,289 animals.

Aerial surveys were conducted offshore in Oregon and Washington during the 1999 pupping season along with radio-tagging studies in1991 and 1992. After applying a correction factor to account for animals in the water during the time of the survey, the population of the Oregon/Washington Coast stock of harbor seals is estimated to be 24,732 (Carretta et al. 2014). Based on the analyses of Jeffries et al. (2003) and Brown et al. (2005), both the Washington and Oregon portions of this stock were reported as reaching carrying capacity.

The California stock of harbor seals is estimated to be 30,196 seals (CV = 0.157) (Carretta et al. 2014) based on the most recent harbor seal counts (19,608 in May–July 2009) and a correction factor to compensate for the number of animals in the water during the time of the survey.

Aerial surveys of harbor seals in Washington were conducted during the pupping season in 1999, during which time the total numbers of hauled-out seals (including pups) were counted. In addition radio-tagging studied where conducted in 1991 and 1992. In pooling these two data sets as well as using a correction factor to account for animals in the water which are missed during the aerial surveys (Huber et al. 2001) the Washington Northern Inland Water stock harbor seal population is estimate to be 11,036 (CV = 0.15); the Southern Puget Sound harbor seal population estimated to be 1,568 (CV = 0.15); and the Hood Canal harbor seal population estimated to be 1,088 (CV = 0.15)[5] (Carretta et al. 2014). The most recent abundance estimates are >8 years old (based on the 1999 data) and there are no current estimates of abundance for these stocks (Carretta et al.2014). Jeffries et al. (2003) reported that the annual rate of increase in the population in Washington up until 1999 had slowed indicating that the population was near or at carrying capacity.

Distribution

Harbor seals are a coastal species, rarely found more than 12 mi. (20 km) from shore, and frequently occupy bays, estuaries, and inlets (Baird 2001). Individual seals have been observed several miles upstream in coastal rivers (Baird 2001). Ideal harbor seal habitat includes haulout sites, shelter during the breeding periods, and sufficient food (Bjørge 2002). Haulout areas can include intertidal and subtidal

[5] The Navy's LOA application differs from the Navy's Draft EIS/OEIS for NWTT in that it contains updated information on the Washington Inland Waters stocks of harbor seals (Carretta et al. 2014) and their abundance in Hood Canal based on a new application of London et al. (2012). The NWTT Draft EIS/OEIS analysis relied on NMFS' Stock Assessment Reports through 2013 (Carretta et al. 2014), which did not incorporate the London et al. findings. London et al. (2012) reported the variability of harbor seal haulout behavior (or time spent out of the water) in a sub-portion of Hood Canal, covering five months of the year (July-November). The paper provided a range of haulout probabilities in Hood Canal that differed from the single value (65%-Huber et al. 2001) previously used by NMFS and Navy to calculate harbor seal abundance. Recently, in discussions with NMFS, they have determined that it is now appropriate to incorporate London et al. (2012) for the Hood Canal stock only. This resulted in increasing the population estimate of the Hood Canal stock of harbor seals by a factor of approximately 3, resulting in a new abundance estimate of 3,555. There have been no published data from new harbor seal surveys as of this application.

rock outcrops, sandbars, sandy beaches, peat banks in salt marshes, and manmade structures such as log booms, docks, and recreational floats (Wilson 1978; Prescott 1982; Schneider and Payne 1983, Gilbert and Guldager 1998; Jeffries et al. 2000; Lambourn et al. 2010). Harbor seals do not make extensive pelagic migrations, though some long distance movement of tagged animals in Alaska (108 mi. [174 km]) and along the U.S. west coast (up to 342 mi. [550 km]) have been recorded (Brown and Mate 1983; Womble and Gende 2013). Harbor seals have also displayed strong fidelity to haulout sites.

Offshore – Harbor seals haulout on rocks, reefs, beaches, and offshore islands along the U.S. west coast (Carretta et al. 2014). Jeffries et al. (2000) documented several harbor seal rookeries and haulouts along the Washington coastline. This is the only pinniped species that breeds in Washington State. Pupping in Oregon and Washington occurs from April to July (Brown 1988). Bonnell et al. (1992) noted that most harbor seals sighted off Oregon and Washington were 12.4 mi. (20 km) from shore, with the farthest sighting 57 mi. (92 km) from the coast. During surveys off the Oregon and Washington coasts, 88 percent of at-sea harbor seals occurred over shelf waters < 656 ft. (200 m) deep, with a few sightings near the 6,562 ft. (2,000 m) contour, and only one sighting over deeper water (Bonnell et al. 1992). The occurrence of harbor seals in the northwest offshore portion of the Study Area is considered likely.

Inland Waters (Puget Sound) – The harbor seal is the most common, widely distributed pinniped found in Washington waters, and is frequently observed by recreational boaters, ferry passengers and other users of the marine environment. Harbor seals are the most abundant marine mammal in Hood Canal, where they can occur anywhere in Hood Canal waters year-round (U.S. Department of the Navy 2012a). London et al. (2012) identified five locations in Hood Canal (including Dabob Bay) the authors termed "major haulout sites" and noted these were locations having documented human (non-Navy) disturbance. London et al. (2012) report that disturbance occurs on a regular basis and described that disturbance for four of the five sites as follows: Quilcene Bay—operational salmon net-pen floats and oyster rafts; Dosewallips—state park and marina with motorized boats, kayakers, and canoers; Hamma Hamma—working oyster farm; and Skokomish—a kayak rental facility and a tribal and commercial fisheries site.

In southern Puget Sound, harbor seals haulout on a variety of substrate materials including intertidal beaches, reefs, sandbars, log booms and floats. There are five main harbor seal haulout areas including: mouth of the Nisqually River, Cutts Island, Gertrude Island, Eagle Island, and Woodard Bay. Based on periodic aerial and boat surveys, each of these sites regularly supports a population of over 100 seals (Lambourn et al. 2010). The harbor seal is the only pinniped species which is found year-round and breeds in Washington waters. Pupping seasons vary by geographic region, with pups born in coastal estuaries (Columbia River, Willapa Bay and Gray Harbor) from mid-April through June; Olympic Peninsula coast from May through July; San Juan Islands and eastern bays of Puget Sound from June through August; southern Puget Sound from mid-July through September; and Hood Canal from August through January (Jeffries et al. 2000). The occurrence of harbor seals in the inland waters portion of the Study area is considered likely.

Western Behm Canal, Alaska – Surveys from 1983 through 1999 revealed a stable and increasing population of harbor seals in the Ketchikan, Sitka, and Kodiak areas. Between 1983 and 1999, the population near Ketchikan rose from approximately 1,059 animals to 3,149 animals (Small et al. 2001). The latest stock abundance estimate for harbor seals in the SEAFAC region (Clarence Strait) is 23,289 animals (Allen and Angliss 2014). The occurrence of harbor seals in the SEAFAC region of the Study Area is considered likely.

Northern Sea Otter (*Enhydra lutris kenyoni*)

Status and Management

The USFWS recognizes five northern sea otter stocks in U.S. waters under MMPA guidelines. These include three stocks in Alaska that are designated southeast, southcentral, and southwest; a single stock in Washington (the northern sea otter [*Enhydra lutris kenyoni*]); and a single stock in California (the southern sea otter [*Enhydra lutris nereis*]). The southeast Alaska stock is not likely to be present in the western Behm Canal portion of the Study Area. Only the Washington stock of sea otter occurs in the Study Area.

Sea otters that occur along the coast of Washington (which have no formal federal designation) are the results of reintroduction efforts of the northern sea otter (from Amchitka Alaska) in 1969 and 1970 (Lance et al. 2004). The Washington stock is not classified as strategic because the population is growing and is not listed as depleted under the MMPA or threatened or endangered under the ESA. A federal species recovery plan for the northern sea otter population has not been developed; however, the State of Washington developed a recovery plan to address the northern sea otter population in its waters (Lance et al. 2004).

Abundance

Based on a 2013 survey (actual count), the minimum population estimate of the Washington sea otter population is 1,272 individuals (Jameson and Jeffries 2014). No correction factor for missed animals has been applied to count data to determine a total population estimate from survey counts for Washington.

Distribution

Sea otters occupy nearly all coastal marine habitats, from bays and estuaries to rocky shores exposed to oceanic swells (Riedman and Estes 1990; U.S. Fish and Wildlife Service 2003, 2008; Washington Department of Fish and Wildlife 2004). Although sea otters prefer rocky shoreline and relatively shallow water (< 131 ft. [< 40 m] deep) with kelp beds, this is not an essential habitat requirement, and some individuals use soft-sediment areas where kelp is absent (Riedman and Estes 1990, Washington Department of Fish and Wildlife 2004). Sea otters seldom range more than 1.2 mi. (2 km) from shore, although some individuals, particularly juvenile males, travel farther offshore (Riedman and Estes 1990; Ralls et al. 1995, 1996; Lance et al. 2004; Washington Department of Fish and Wildlife 2004). Sea otters move seasonally to areas where there is food or where sheltered water offers protection from storms and rough seas (Kenyon 1975; Riedman and Estes 1990). Individual sea otters in Washington show such shifts (Lance et al. 2004), but the population as a whole does not migrate, and otters range along the Washington coast from Pt. Grenville to Neah Bay year-round.

Offshore – The 2011 Washington sea otter survey was conducted in July 2011 and included the inshore area from the South Jetty at the mouth of the Columbia River on the outer Washington coast to Pillar Point in the Strait of Juan de Fuca. Survey results for 2013 indicate growth of the Washington sea otter population continues to remain positive, with a total of 1,272 sea otters observed (Jameson and Jeffries 2014). As sea otters seldom range more than 1.2 mi. (2 km) from shore and are not known to migrate, it is not anticipated that they would be present in the offshore portion of the Study Area, where their occurrence is considered rare. However, their occurrence in the nearshore waters of Washington would overlap with portions of the NUWC Division, Keyport Range Complex where their occurrence is considered likely.

Inland Waters (Puget Sound) – Although the sea otter is not usually seen in the Inland Waters, there are confirmed sightings and movements of tagged individuals in the eastern Strait of Juan de Fuca, around the San Juan Islands, and within the Puget Sound near Olympia (Calambokidis et al. 1987; Lance et al. 2004;Jeffries and Jameson 2014). Prior to recent sightings, the Strait of Juan de Fuca had not been occupied by sea otters for over 100 years (Jeffries et al. 2005). One sea otter was sighted about 6 mi. (9 km) inland up McAllister Creek in south Puget Sound (Jeffries and Allen 2001). Recent sea otter surveys have not covered the Inland Waters east of Tongue Point; however, there have been confirmed sightings of scattered individuals in the San Juan Islands and Puget Sound (Jameson and Jeffries 2014). Most of these sightings have been of one or two animals, with no sightings of multiple animals reported (Jeffries and Jameson 2014). Based on the low numbers of sightings in the Inland Waters portion of the Study Area, the occurrence of sea otters is considered rare.

Western Behm Canal, Alaska – Based on surveys conducted in 2003, there are common sightings in southeast Alaska along the western portions of Prince of Wales Islands and throughout the Chatham and Summer Strait. The closest sea otter populations, as determined by these surveys, are approximately 32–43 nm west of the SEAFAC area along the Pacific coast (Esslinger and Bodkin 2009). As sea otters seldom range more than 1.2 mi. (2 km) from shore and are not known to migrate, it is not anticipated that they would be present in the SEAFAC area. The presence of sea otters in the SEAFAC portion of the Study Area is considered extralimital.

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5 TAKE AUTHORIZATION REQUESTED

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

In this application, the Navy requests one 5-year LOA for the take of marine mammals incidental to proposed training activities in the Study Area for the period from October 2015 through October 2020, and one 5-year LOA for the take of marine mammals incidental to proposed testing activities in the Study Area for the period from October 2015 through October 2020. 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 Study Area constitute 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 does the following:

- 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 NWTT EIS/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 stressor categories associated with these activities included the following:

- Acoustic (sonar and other active non-impulsive sources; explosives; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance or strikes (vessels, in-water devices, military expended materials, seafloor devices)
- Entanglement (fiber optic cables and guidance wires, parachutes)
- Ingestion (military expended materials from munitions, military expended materials other than munitions)
- Secondary stressors (sediments and water quality)

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), 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 or mortality.

5.1 INCIDENTAL TAKE REQUEST FOR TRAINING ACTIVITIES

A detailed analysis of effects due to marine mammal exposures to impulsive and non-impulsive sources in the 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 a year (a 12-month period) and the summation over a 5-year period (annual events occurring five times and the non-annual event occurring three times). The Civilian Port Defense exercise is a non-annual event and is analyzed as occurring every other year, or three times during the 5-year period considered in this analysis. Annual totals presented in the tables are the summation of all annual events plus all the proposed non-annual events occurring in a 12-month period as a maximum year.

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	Vessel strike	None	None
Level A	Impulsive and Non-Impulsive	11 – Species specific data shown in Tables 5-2 and 5-3	55 – Species specific data shown in Tables 5-2 and 5-3
Level B	Impulsive and Non-Impulsive	107,459– Species specific data shown in Tables 5-2 and 5-3	533,543– Species specific data shown in Tables 5-2 and 5-3

* The effects analysis for this LOA application differs from the Navy's Draft EIS/OEIS for NWTT in that it contains updated information on the Washington Inland Waters stocks of harbor seals (Carretta et al. 2014) and their abundance in Hood Canal based on a new application of London et al. (2012). This resulted in increasing the population estimate of the Hood Canal stock of harbor seals by a factor of approximately 3, resulting in a new abundance estimate of 3,555. In addition, in calculating its exposure estimates, the Navy also applied the haulout probability of 20 percent derived from London et al. (2012) which changed the percentage of harbor seals in the water from 35% (Huber et al. 2001) to 80%. These changes in assumptions result in a corresponding increase in estimated exposures because the Navy is assuming that there are more harbor seals present in Hood Canal and more of the animals will be in the water at any given time compared to the analysis presented in the NWTT Draft EIS/OEIS. There are no indications that these calculated take estimates have affected Hood Canal harbor seal survival by altering population growth over the last 10 years, or behavior patterns such as breeding, nursing, feeding, or sheltering.

5.1.1 IMPULSIVE AND NON-IMPULSIVE SOURCES

Table 5-2 provides the Navy's take request for training activities by species from the acoustic effects modeling estimates. The numbers provided in the annual columns are the totals for a maximum year (i.e. , a year in which a Civilian Port Defense Occurs). Table 5-3 provides the contribution to the maximum year total (1,783 Level B exposures) resulting from the biennial Civilian Port Defense exercise. The 5-year totals presented assume the biennial event would occur three times over the 5-year period (in the first, third, and fifth years). Derivations of the numbers presented in Tables 5-2 and 5-3 are described in more detail within Chapter 6. There are no mortalities predicted for any training activities resulting from the use of impulsive or non-impulsive sources. Values shown in Table 5-2 also include Level B values from non-annual Civilian Port Defense training events.

5.1.2 VESSEL STRIKE TAKE REQUEST FOR TRAINING ACTIVITIES

There has never been a vessel strike to a whale during any training activities in the Study Area (see Figure 1 1). A detailed analysis of strike data is contained in Section 6.7 (Estimated Take of Large Whales by Navy Vessel Strike). The Navy does not anticipate vessel strikes to marine mammals within the Study Area.

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

Species	Stock	Max. Annual		5-Year	
		Level B	Level A	Level B	Level A
North Pacific right whale	Eastern North Pacific	0	0	0	0
Humpback whale	Central North Pacific	0	0	0	0
	California, Oregon, & Washington	12	0	60	0
Blue whale	Eastern North Pacific	5	0	25	0
Fin whale	Northeast Pacific	0	0	0	0
	California, Oregon, & Washington	25	0	125	0
Sei whale	Eastern North Pacific	0	0	0	0
Minke whale	Alaska	0	0	0	0
	California, Oregon, & Washington	18	0	90	0
Gray whale	Eastern North Pacific	6	0	30	0
	Western North Pacific	0	0	0	0
Sperm whale	North Pacific	0	0	0	0
	California, Oregon, & Washington	81	0	405	0
Kogia (spp.)	California, Oregon, & Washington	73	0	365	0
Killer whale	Alaska Resident	0	0	0	0
	Northern Resident	0	0	0	0
	West Coast Transient	9	0	39	0
	East North Pacific Offshore	13	0	65	0
	East N. Pacific Southern Resident	2	0	6	0
Short-finned pilot whale	California, Oregon, & Washington	0	0	0	0
Short-beaked common dolphin	California, Oregon, & Washington	734	0	3,670	0
Bottlenose dolphin	California, Oregon, & Washington	0	0	0	0
Striped dolphin	California, Oregon, & Washington	22	0	110	0
Pacific white-sided dolphin	North Pacific	0	0	0	0
	California, Oregon, & Washington	3,482	0	17,408	0
Northern right whale dolphin	California, Oregon, & Washington	1,332	0	6,660	0
Risso's dolphin	California, Oregon, & Washington	657	0	3,285	0
Harbor porpoise	Southeast Alaska	0	0	0	0
	Northern Oregon/Washington Coast	35,006	0	175,030	0
	Northern California/Southern Oregon	52,509	0	262,545	0
	Washington Inland Waters	1,417	1	4,409	5
Dall's porpoise	Alaska	0	0	0	0
	California, Oregon, & Washington	3,730	4	18,650	20
Cuvier's beaked whale	Alaska	0	0	0	0
	California, Oregon, & Washington	353	0	1,765	0
Baird's beaked whale	Alaska	0	0	0	0
	California, Oregon, & Washington	591	0	2,955	0
Mesoplodon beaked whales	California, Oregon, & Washington	1,417	0	7,085	0
Steller sea lion	Eastern U.S.	404	0	1,986	0
Guadalupe fur seal	Guadalupe Island	7	0	35	0
California sea lion	U.S. Stock	814	0	4,038	0
Northern fur seal	Eastern Pacific	2,495	0	12,475	0
	California	37	0	185	0
Northern elephant seal	California Breeding	1,271	0	6,353	0
Harbor seal *	Southeast Alaska (Clarence Strait)	0	0	0	0
	OR/WA Coastal	0	0	0	0
	California	0	0	0	0
	WA Northern Inland Waters	427	4	1,855	20
	Southern Puget Sound	58	0	252	0
	Hood Canal	452	2	2,054	10
Northern sea otter	Southeast Alaska	0	0	0	0
	Washington	0	0	0	0
	TOTALS	**107,459**	**11**	**533,543**	**55**

* The increase in exposures over those presented in the DEIS and the previous LOA request are a result of the changes to the harbor seal abundance and haulout assumptions for the Hood Canal stock. The combination of these two changes in best available science results in an additional 4 Level A takes and 417 Level B takes for training activities per year to the Hood Canal stock. There are no indications that these calculated take estimates have affected Hood Canal harbor seal survival by altering population growth over the last 10 years, or behavior patterns such as breeding, nursing, feeding, or sheltering.

Table 5-3: Training Exposures Specific To the Biennial Civilian Port Defense Exercise
(Values provided for informational purposes and are included in Table 5-2 species-specific totals)

Species	Stock	Biennial	
		Level B	Level A
North Pacific right whale	Eastern North Pacific	0	0
Humpback whale	Central North Pacific	0	0
	California, Oregon, & Washington	0	0
Blue whale	Eastern North Pacific	0	0
Fin whale	Northeast Pacific	0	0
	California, Oregon, & Washington	0	0
Sei whale	Eastern North Pacific	0	0
Minke whale	Alaska	0	0
	California, Oregon, & Washington	0	0
Gray whale	Eastern North Pacific	0	0
	Western North Pacific	0	0
Sperm whale	North Pacific	0	0
	California, Oregon, & Washington	0	0
Kogia (spp.)	California, Oregon, & Washington	0	0
Killer whale	Alaska Resident	0	0
	Northern Resident	0	0
	West Coast Transient	3	0
	East N. Pacific Offshore	0	0
	East N. Pacific Southern Resident	2	0
Short-finned pilot whale	California, Oregon, & Washington	0	0
Short-beaked common dolphin	California, Oregon, & Washington	0	0
Bottlenose dolphin	California, Oregon, & Washington	0	0
Striped dolphin	California, Oregon, & Washington	0	0
Pacific white-sided dolphin	North Pacific	0	0
	California, Oregon, & Washington	1	0
Northern right whale dolphin	California, Oregon, & Washington	0	0
Risso's dolphin	California, Oregon, & Washington	0	0
Harbor porpoise	Southeast Alaska	0	0
	Northern OR/WA Coast	0	0
	Northern CA/Southern OR	0	0
	WA Inland Waters	1,338	0
Dall's porpoise	Alaska	0	0
	California, Oregon, & Washington	236	0
Cuvier's beaked whale	Alaska	0	0
	California, Oregon, & Washington	0	0
Baird's beaked whale	Alaska	0	0
	California, Oregon, & Washington	0	0
Mesoplodon beaked whales	California, Oregon, & Washington	0	0
Steller sea lion	Eastern U.S.	17	0
Guadalupe fur seal	Guadalupe Island	0	0
California sea lion	U.S. Stock	16	0
Northern fur seal	Eastern Pacific	0	0
	California	0	0
Northern elephant seal	California Breeding	1	0
Harbor seal *	Southeast Alaska (Clarence Strait)	0	0
	OR/WA Coastal	0	0
	California	0	0
	WA Northern Inland Waters	140	0
	Southern Puget Sound	19	0
	Hood Canal	103	0
Northern sea otter	Southeast Alaska	0	0
	Washington	0	0
	TOTALS	**1,876**	**0**

* The increase in exposures over those presented in the DEIS and the previous LOA request are a result of the changes to the harbor seal abundance and haulout assumptions for the Hood Canal stock. The combination of these two changes in best available science results in an additional 64 Level B takes for training activities per year to the Hood Canal stock as provided in summation in Table 5-2 above. There are no indications that these calculated take estimates have affected Hood Canal harbor seal survival by altering population growth over the last 10 years, or behavior patterns such as breeding, nursing, feeding, or sheltering.

5.2 INCIDENTAL TAKE REQUEST FOR TESTING ACTIVITIES

A detailed analysis of effects due to marine mammal exposures to impulsive and non-impulsive sources in the Study Area is presented in Chapter 6 (Number and Species Taken). Based on the model and post-model analysis described in Chapter 6, Table 5-4 summarizes the Navy's final take request for testing activities for an annual (12-month) period and the summation over a 5-year period. There are no non-annual testing events.

Table 5-4: Summary of Annual and 5-Year Take Request for Testing Activities *

MMPA Category	Source	Testing Activities	
		Annual Authorization Sought	5-Year Authorization Sought
Level A	Impulsive and Non-Impulsive	176 – Species specific data shown in Table 5-5	880 – Species specific data shown in Table 5-5
Level B	Impulsive and Non-Impulsive	139,815 – Species specific data shown in Table 5-5	699,075 – Species specific data shown in Table 5-5

* The effects analysis for this LOA application differs from the Navy's Draft EIS/OEIS for NWTT in that it contains updated information on the Washington Inland Waters stocks of harbor seals (Carretta et al. 2014) and their abundance in Hood Canal based on a new application of London et al. (2012). This resulted in increasing the population estimate of the Hood Canal stock of harbor seals by a factor of approximately 3, resulting in a new abundance estimate of 3,555. In addition, in calculating its exposure estimates, the Navy also applied the haulout probability of 20 percent derived from London et al. (2012) which changed the percentage of harbor seals in the water from 35% (Huber et al. 2001) to 80%. These changes in assumptions result in a corresponding increase in estimated exposures because the Navy is assuming that there are more harbor seals present in Hood Canal and more of the animals will be in the water at any given time compared to the analysis presented in the NWTT Draft EIS/OEIS. There are no indications that these calculated take estimates have affected Hood Canal harbor seal survival by altering population growth over the last 10 years, or behavior patterns such as breeding, nursing, feeding, or sheltering.

5.2.1 IMPULSIVE AND NON-IMPULSIVE SOURCES

Table 5-5 summarizes the Navy's take request for testing activities by species. There are no non-annual testing events. Derivation of these values is described in more detail within Chapter 6. There are no mortalities predicted for any testing activities based on the analysis of impulsive and non-impulsive sources.

5.2.2 VESSEL STRIKE ANALYSIS FOR TESTING ACTIVITIES

There has never been a vessel strike to a whale during any testing activities in the Study Area. A detailed analysis of strike data is contained in Section 6.7 (Estimated Take of Large Whales by Navy Vessel Strike). Testing activities involving vessel movement could mainly occur in the Inland Waters and in Western Behm Canal with some additional testing activities in the offshore region. The majority of vessels used in the Inland Waters and Western Behm Canal are smaller vessels, which are less likely to be involved in a whale strike. Under the three alternatives, the proposed actions would not result in any appreciable changes in locations or frequency of vessel activity and there have been no whale strikes during any previous testing activities in the Study Area. The manner in which the Navy has tested would remain consistent with the range of variability observed over the last decade so the Navy does not anticipate vessel strikes would occur within the Study Area during testing events.

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

Species	Stock	Annual		5-Year	
		Level B	Level A	Level B	Level A
North Pacific right whale	Eastern North Pacific	0	0	0	0
Humpback whale	Central North Pacific	1	0	5	0
	California, Oregon, & Washington	44	0	220	0
Blue whale	Eastern North Pacific	6	0	30	0
Fin whale	Northeast Pacific	2	0	10	0
	California, Oregon, & Washington	34	0	170	0
Sei whale	Eastern North Pacific	2	0	10	0
Minke whale	Alaska	0	0	0	0
	California, Oregon, & Washington	18	0	90	0
Gray whale	Eastern North Pacific	11	0	55	0
	Western North Pacific	0	0	0	0
Sperm whale	North Pacific	0	0	0	0
	California, Oregon, & Washington	78	0	390	0
Kogia (spp.)	California, Oregon, & Washington	106	1	530	5
Killer whale	Alaska Resident	2	0	10	0
	Northern Resident	0	0	0	0
	West Coast Transient	202	0	1,010	0
	East North Pacific Offshore	22	0	110	0
	East N. Pacific Southern Resident	0	0	0	0
Short-finned pilot whale	California, Oregon, & Washington	0	0	0	0
Short-beaked common dolphin	California, Oregon, & Washington	1,628	0	8,140	0
Bottlenose dolphin	California, Oregon, & Washington	0	0	0	0
Striped dolphin	California, Oregon, & Washington	14	0	70	0
Pacific white-sided dolphin	North Pacific	3	0	15	0
	California, Oregon, & Washington	4,869	0	24,345	0
Northern right whale dolphin	California, Oregon, & Washington	2,038	0	10,190	0
Risso's dolphin	California, Oregon, & Washington	1,154	0	5,770	0
Harbor porpoise	Southeast Alaska	926	0	4,630	0
	Northern Oregon/Washington Coast	17,212	15	86,060	75
	Northern California/Southern Oregon	25,819	23	129,095	115
	Washington Inland Waters	5,336	6	26,680	30
Dall's porpoise	Alaska	1,200	0	6,000	0
	California, Oregon, & Washington	10,139	43	50,695	215
Cuvier's beaked whale	Alaska	15	0	75	0
	California, Oregon, & Washington	91	0	455	0
Baird's beaked whale	Alaska	25	0	125	0
	California, Oregon, & Washington	149	0	745	0
Mesoplodon beaked whales	California, Oregon, & Washington	369	0	1,845	0
Steller sea lion	Eastern U.S.	504	0	2,520	0
Guadalupe fur seal	Guadalupe Island	3	0	15	0
California sea lion	U.S. Stock	2,073	0	10,365	0
Northern fur seal	Eastern Pacific	1,830	0	9,150	0
	California	27	0	135	0
Northern elephant seal	California Breeding	1,325	2	6625	10
Harbor seal*	Southeast Alaska (Clarence Strait)	22	0	110	0
	OR/WA Coastal	1,655	4	8275	20
	California	0	0	0	0
	WA Northern Inland Waters	1,448	14	7,240	70
	Southern Puget Sound	196	1	980	5
	Hood Canal	59,217	67	296,085	335
Northern sea otter	Southeast Alaska	0	0	0	0
	Washington	0	0	0	0
	TOTALS	**139,815**	**176**	**699,075**	**880**

* The increase in exposures over those presented in the DEIS and the previous LOA request are a result of the changes to the harbor seal abundance and haulout assumptions for the Hood Canal stock. The combination of these two changes in best available science results in an additional 61 Level A takes and 52,970 Level B takes for testing activities per year to the Hood Canal stock. There are no indications that these calculated take estimates have affected Hood Canal harbor seal survival by altering population growth over the last 10 years, or behavior patterns such as breeding, nursing, feeding, or sheltering.

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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 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. The 30 marine mammal species with possible or confirmed presence within the Study Area (see Table 3-1) are managed by NMFS with the exception of the sea otter, which is managed by the USFWS. 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.

6.2 STRESSORS

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

- Sonar (sound navigation and ranging) and other active sound sources (non-impulsive sources)
- Explosives (impulsive sources)

There are no exposures predicted by the Navy Acoustic Effects Model (NAEMO) resulting in mortality for the activities in the Study Area.

In the analysis of the impacts from the estimated Level B or Level A exposures, 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, some stressors species are grouped based on their taxonomic relationship and discussed as follows: mysticetes (baleen whales), odontocetes (toothed whales), and pinnipeds (seals and sea lions).

Non-Impulsive and Impulsive Sound Sources – As summarized by the National Research Council of the National Academies, the possibility that human-generated sound could harm marine mammals or significantly interfere with their normal activities is an issue of concern (National Research Council of the National Academies 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council of the National Academies 2003, 2005), there are many unknowns in assessing the specific effects and significance of responses by marine mammals to sound exposures, such as what activity the animal is engaged in at the time of the exposure (Nowacek et al. 2007; Southall et al. 2007, 2009a). Furthermore, many other factors besides just the received level of sound may affect an animal's reaction such as the animal's physical condition, prior experience with the sound, and proximity to the source of the sound (Ellison et al. 2012).

6.3 Analysis Background and Framework

Sound sources can potentially result in behavioral changes or injury to a marine mammal. A discussion of these various types of impacts follows.

6.3.1 Direct Injury

The potential for direct injury in marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993). Additionally, non-injurious effects on marine mammals (e.g., Temporary Threshold Shift [TTS]) are extrapolated to injurious effects (e.g., Permanent Threshold Shift [PTS]) based on data from terrestrial mammals to derive the criteria serving as the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ from terrestrial animals 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 non-auditory direct injury from non-impulse sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious impulse sources such as explosives. Non-impulse sources also lack the strong shock wave such as that associated with an explosion. Therefore, primary blast injury and barotrauma (i.e., injuries caused by large pressure changes, discussed below) would not occur due to exposure to non-impulse sources such as sonar. Even for the most sensitive auditory tissues and although there have been strandings associated with use of sonar (see U.S. Department of the Navy 2013b), as Ketten (2012) has recently summarized, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result of anthropogenic noise exposures, including sonar." The theories of sonar induced acoustic resonance and sonar induced bubble formation are discussed below. These phenomena, if they were to occur, would require the co-occurrence of a precise set of circumstances that in the natural environment under real-world conditions are unlikely to occur.

6.3.2 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 impulse 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 (Office of the Surgeon General 1991; Craig and Hearn 1998a; Craig Jr. 2001). 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 pulmonary contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Office of the Surgeon General 1991). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct 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 and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera. 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 impulse sources occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a NEW of 8.76 lb. (3.97 kg) placed at a depth of 48 ft. (14.6 m). Approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered 3 days later stranded dead 42 nm to the north of the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011).

6.3.2.1 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 sonar or other non-impulse sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulse sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993).

6.3.2.2 Acoustic Resonance

Acoustic resonance has been proposed as a hypothesis suggesting that acoustically-induced vibrations (sound) from sonar or sources with similar operating characteristics could be damaging tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the issue (National Oceanic and Atmospheric Administration 2002). They 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 the Navy 2013b). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (National Oceanic and Atmospheric Administration 2002). The frequencies at which resonance was predicted to occur were below the frequencies utilized by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance is not likely under realistic conditions during training and testing activities and this type of impact is not considered further in this analysis.

6.3.2.3 Bubble Formation (Acoustically Induced)

A suggested 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 (see Section 3.4.3.1.8, Stranding, regarding strandings that gave rise to the debate about bubble formation). The process is dependent upon a number of factors including the sound pressure level (SPL) and duration. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles 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 (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 upon 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 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 supersaturation (Houser et al. 2001, 2010). If rectified diffusion were possible in marine mammals exposed to high level 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.

It is unlikely that the short duration of sonar or explosion sounds would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, 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 the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become a problematic size. Recent research with *ex vivo* supersaturated bovine tissues suggested that, for a 37 kHz signal, a sound exposure of approximately 215 dB referenced to (re) 1 micropascal (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 at 1 m, a whale would need to be within 10 m (33 ft.) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400–700 kilopascals 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 400–700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001; Saunders et al. 2008). It is improbable that this mechanism is 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 this phenomenon (Piantadosi and Thalmann 2004; Evans and Miller 2003). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al. 2005; Jepson et al. 2003), 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 (Moore et al. 2009; Dennison et al. 2011; Bernaldo de Quiros et al. 2012). Prior experimental work has also demonstrated the post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980).

6.3.2.4 Nitrogen Decompression

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular and tissue bubble formation (Jepson et al. 2003; Saunders et al. 2008; Hooker et al. 2012); nitrogen off-gassing occurring in human divers is called decompression sickness. The mechanism for bubble formation from saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the

scientific community (Saunders et al. 2008; Hooker et al. 2012). 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 (Jepson et al. 2003; Fernández 2005; Hooker et al. 2012). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Previous modeling suggested 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. (2006) suggested that emboli observed in animals exposed to mid-frequency active sonar (Jepson et al. 2003; Fernández 2005) 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. 2010).

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 (Saunders et al. 2008; 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 by-catch 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. 2010).

Recent research with ex vivo supersaturated bovine tissues suggested 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 at 1 m, a whale would need to be within 10 m (33 ft.) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400–700 kilopascals 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 400–700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001; Saunders et al. 2008). It is improbable that this mechanism is 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.

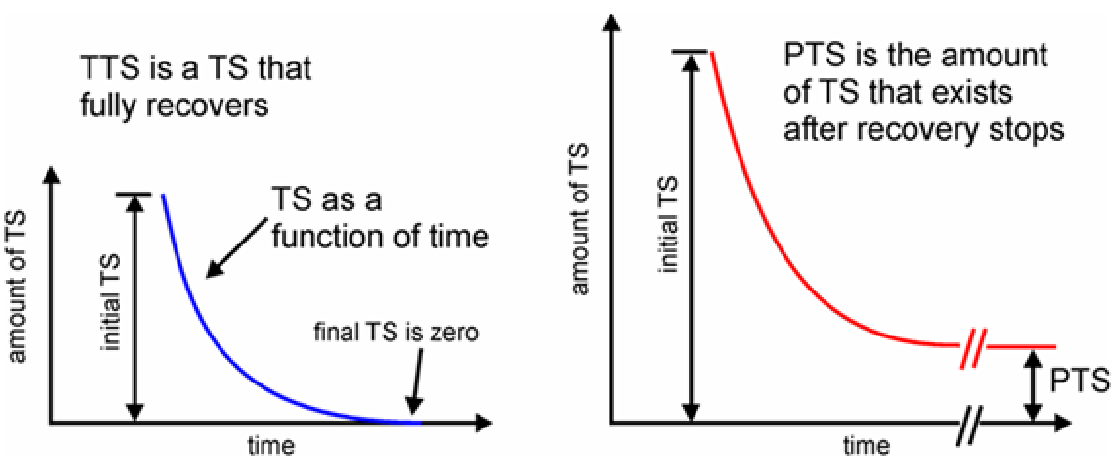
A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possibly arise from the formation of bubbles in 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 2 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 tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim et al. (2012) determined that while behavioral and physiological responses to sonar have the potential to result in bubble formation, the actually observed behavioral responses of cetaceans to sonar did not imply any significantly increased risk of over what may otherwise occur normally in individual marine mammals. As a result, no marine mammals addressed in this analysis are given differential treatment due to the possibility for acoustically mediated bubble growth.

6.3.2.5 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term “hearing loss” does not equate to “deafness.” This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1994). If high-intensity sound overstimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound’s frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a 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.

For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Finneran et al. 2005, 2010a; Nachtigall 2004). The recovery time is related to the exposure duration, sound exposure level (SEL), and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005, 2010a; Mooney et al. 2009a, 2009b). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). 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. Again for clarity, PTS, as discussed in this document, is not the loss of hearing, but instead is the loss of hearing sensitivity over a particular range of frequency. Figure 6-1 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.



TS = threshold shift, TTS = temporary threshold shift, PTS = permanent threshold shift

Figure 6-1: Two Hypothetical Threshold Shifts

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (i.e., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and possibly 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. Note that the term "auditory fatigue" is often used to mean "temporary threshold shift"; however, in this EIS/OEIS a more general meaning is used to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure). The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure.

Hearing loss, or auditory fatigue, in marine mammals has been studied by a number of investigators (Schlundt et al. 2000; Finneran et al. 2000, 2002; Finneran et al. 2005, 2007; Nachtigall et al. 2003, 2004; Mooney et al. 2009a, 2009b; Lucke et al. 2009). 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 indicated the amount of TTS. Species studied include the bottlenose dolphin (total of 9 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 (Schlundt et al. 2000). The criteria for onset-TTS are very conservative, and it is not clear that this level of threshold shift would have a functional effect on the hearing of a marine mammal in the ocean.

The primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS shift 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 SPL 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).
- SEL 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, b). However, for longer duration sounds—beyond 16–32 seconds—the relationship between TTS and SEL 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 (Schlundt et al. 2000; Finneran et al. 2007). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range.
- For bottlenose dolphins, sounds with frequencies above 10 kHz are more hazardous than those at lower frequencies (i.e., lower SELs required to affect hearing) (Finneran 2010a).
- The amount of observed TTS tends to decrease with increasing time following the 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 intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL. This means that predictions based on total, cumulative SEL 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 their similarities with terrestrial mammals with respect to features such as TTS, age-related hearing loss (called Presbycusis), ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS shift exposure levels may be estimated by assuming some upper limit of TTS that equates 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.

6.3.3 AUDITORY MASKING

Auditory masking occurs when a sound, or noise in general, limits the perception of another sound. 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 have been determined for pinnipeds (Southall et al. 2000; Southall et al. 2003) and bottlenose dolphins (Johnson 1967) and detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Johnson 1971; Au and Pawloski 1989; Erbe 2000). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology 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 North Atlantic right whale's optimal communication space (estimated as a sphere of water with a diameter of 20 km), that space is decreased by 84 percent. This methodology 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. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been 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 have been observed to increase the length of their 'songs' (Miller et al. 2000; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low frequency active sonar. North Atlantic right whales have been 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 (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 responding in marine mammals has been documented in the presence of seismic survey noise. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Iorio and Clark 2010), indicative of a potentially compensatory response to the increased noise level. Melcon et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when simulated 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. Controlled exposure experiments in 2007 and 2008 in the Bahamas recorded responses of false killer whales, short-finned pilot whales, and melon-headed whales to simulated mid-frequency active sonar (DeRuiter et al. 2013a). The responses to exposures between species were variable. After hearing each MFA signal, false killer whales were found to "increase their whistle production rate and made more-MFA-like whistles" (DeRuiter et al. 2013a). In contrast, melon-headed whales had "minor transient silencing" after each MFA signal, while pilot whales had no apparent response. Consistent with the findings of other previous research (see for example Southall et al. 2007), DeRuiter et al. (2013a) found the responses were variable by species and with the context of the sound exposure.

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 or not 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. Allen et al. (2014) documented Blainville's beaked whale response to playbacks of killer whale vocalizations.

6.3.4 Physiological Stress

Marine mammals may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. 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), has been 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 above and beyond those that occur naturally. Various efforts have been undertaken to investigate the impact from vessels (both whale-watching and general vessel traffic noise) and demonstrated impacts do occur (Bain 2002; Erbe 2002; Williams et al. 2006, 2009, 2011b, 2013, 2014a; Noren et al. 2009; Read et al. 2014; Rolland et al. 2012; Pirotta et al. 2015). This body of research for the most part has investigated impacts associated with the presence of chronic stressors, which differ significantly from generally intermittent Navy training and testing activities. For example, in an analysis of energy costs to killer whales, Williams et al. (2009) suggested that whale-watching in the Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance, which could carry higher costs than other measures of behavioral change might suggest. Ayres et al. (2012) recently reported on research in the Salish Sea involving the measurement of Southern Resident killer whale fecal hormones to assess two potential of threats to the species recovery: lack of prey (salmon) and impacts to behavior from vessel traffic. Ayres et al. (2012) suggested that the lack of prey overshadowed any population-level physiological impacts on Southern Resident killer whales from vessel traffic.

Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulse 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 that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin and Geraci 1989; St. Aubin and Dierauf 2001). 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 multisystemic harm 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 be mediated by the over activation of the animal’s normal physiological adaptations to diving or escape. Pursuit, capture and short-term holding of belugas have been observed

to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al. 1996; Ortiz and Worthy 2000; St. Aubin 2002). Male grey 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/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.

6.3.5 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 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. 1995). More recent reviews (Nowacek et al. 2007; Southall et al. 2007, 2009a; Ellison et al. 2012) 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 that may be compensating for 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 ecology of individual species is unlikely to completely overlap.

Southall et al. (2007) 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. 2007). 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 dependent 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-impulse 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 3 playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB re 1 µPa (Tyack et al. 2011).

6.3.5.1 Behavioral Reactions to Sonar and Other Active Acoustic Sources

6.3.5.1.1 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) including changes in vocal activity and avoidance of the source vessel (Clark 2001; Miller et al. 2000; Croll et al. 2001; Fristrup et al. 2003; 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. 2004). Although the animal's received SPL was similar in the latter two studies (133–150 dB re 1 µPa), 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 SPL of approximately 110–120 dB re 1 µPa (Melcón et al. 2012). Preliminary results from the 2010–2011 field season of an 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). Blue whales responded to a mid-frequency sound source, with a source level between 160 and 210 dB re 1 µPa at 1 m and a received sound level up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during controlled exposure experiments (CEE) (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during CEEs, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Distances of the sound source from the whales during CEEs were sometimes less than a mile. These preliminary findings from Melcón et al. (2012) and Goldbogen et al. 2013 are consistent with the Navy’s criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other non-impulse sources used in the quantitative acoustic effects analysis (Section 6.4.2, Behavioral Responses). The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received SPL of 120 dB re 1 µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

6.3.5.1.2 Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, 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; Southall et al. 2009b; 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 2011). DeRuiter et al. (2013b) presented results from two Cuvier’s beaked whales that were tagged and exposed to simulated mid-frequency active sonar during the 2010 and 2011 field seasons of the southern California behavioral response study. The 2011 whale was also incidentally exposed to mid-frequency active sonar from a distant naval exercise. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square (rms), respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. 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 (Defence Science and Technology Laboratory 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 1–2 kHz and 6–7 kHz ranges) (Miller et al. 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed on one occasion (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 (Defence Science and Technology Laboratory 2007; Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; 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; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011).

As presented in more detail in Section 3.4.3.1.8 (Stranding), in May 2003, killer whales in Haro Strait, Washington were observed exhibiting what were believed by some observers to be aberrant behaviors while the USS SHOUP was in the vicinity and using mid-frequency active sonar. Sound fields modeled for the USS SHOUP sonar transmissions (National Marine Fisheries Service 2011b; U.S. Department of the Navy 2004; Fromm 2004a) estimated a mean received SPL of approximately 169.3 dB re 1 µPa at the location of the killer whales during the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 µPa).

In the Caribbean, research on sperm whales near the Grenadines in 1983 coincided with the U.S. intervention in Grenanda where sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals since the source was not visible (Watkins and Schevill 1975; Watkins et al. 1985). The authors did not provide any sound levels associated with these observations although they did note getting a similar reaction from 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 as had been demonstrated previously on another occasion in which sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins et al. 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 (Schlundt et al. 2000; Finneran et al. 2001; Finneran et al. 2003a; Finneran and Schlundt 2004; Finneran et al. 2010b). 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 (Schlundt et al. 2000; Finneran et al. 2002). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178–193 dB re 1 µPa rms, 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. 2001, 2006a) and emissions for underwater data transmission (Kastelein et al. 2005b). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006b), again highlighting the importance in understanding species differences in the tolerance of underwater noise (Southall et al. 2007).

6.3.5.1.3 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 SPL, 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, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2010).

6.3.5.1.4 Sea Otters

Sea otters depend on visual acuity to forage and their eyes are able to focus both in air and underwater (Riedman and Estes 1990). Davis et al. (1988) conducted a study of southern sea otter's reactions to various underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to purposefully move sea otters from a location in the event of an oil spill. Anthropogenic sound sources used in this behavioral response study included truck air horns and an acoustic harassment device (10–20 kHz at 190 dB; designed to keep dolphins and pinnipeds from being caught in fishing nets). The authors found that the sea otters often remained undisturbed, quickly became tolerant of the various sounds, and even when the desired response occurred (chased from a location) by the presence of a harassing sound, they generally moved only a short distance (109–219 yd. [100–200 m]) before resuming normal activity.

6.3.5.2 Behavioral Reactions to Impulsive Sound Sources

6.3.5.2.1 Mysticetes

Baleen whales have shown a variety of responses to impulse sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Richardson et al. 1995; Gordon et al. 2003; Southall 2007). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995), 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 1986, 1988). 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 (Yazvenko et al. 2007; Gailey 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 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 micropascal squared second (μPa^2-s) 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.

6.3.5.2.2 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 SPL re 1 µPa with energy content greatest between 0.3 and 3.0 kHz (Madsen 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 impulse sound from a seismic watergun (Finneran et al. 2010a).

6.3.5.2.3 Pinnipeds

A review of behavioral reactions by pinnipeds to impulse noise can be found in Richardson et al. (1995) and Southall et al. (2007). 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 rms 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 impulse source at levels of 165–170 dB re 1 µPa (Finneran et al. 2003b).

Experimentally, 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 non-startling 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 non-startling 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.

6.3.5.2.4 Sea Otters

Sea otters depend on visual acuity to forage and their eyes are able to focus both in air and underwater (Riedman and Estes 1990). Davis et al. (1988) conducted a study of southern sea otter's reactions to various underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to purposefully move sea otters from a location in the event of an oil spill. Anthropogenic sound sources used in this behavioral response study included truck air horns and an acoustic harassment device The authors found that the sea otters often remained undisturbed, quickly became tolerant of the various sounds, and even when the desired response occurred (chased from a location) by the presence of a harassing sound, they generally moved only a short distance before resuming normal activity. While there are no known studies of sea otter reactions to impulse sound, it is assumed sea otter would react in a manner similar to the various stimuli reported by Davis et al. (1988).

6.3.5.3 Behavioral Reactions to Vessels

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Richardson et al. 1995; Foote et al. 2004; Hildebrand 2005; Hatch and Wright 2007; Holt et al. 2008; Melcon et al. 2012; May-Collado and Quinones-Lebron 2014; NOAA 2014b). As noted previously, in the inland waters of Puget Sound, Erbe et al. (2012) estimated the maximum underwater SEL from vessel traffic near Seattle was 215 dB re 1 μPa^2-s and Bassett et al. (2010) measured mean SPLs at Admiralty Inlet from commercial shipping at 117 dB re 1 µPa with a maximum exceeded 135 dB re 1 µPa on some occasions.

In short-term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels (Acevedo 1991; Aguilar de Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000; Christiansen et al. 2010; Erbe 2002; Williams et al. 2009; Noren et al. 2009; Stensland and Berggren 2007; Stockin et al. 2008; Christiansen et al. 2013; Williams et al. 2014). Noren et al. (2009) conducted research in the San Juan Islands in 2005 and 2006 and their findings suggested that close approaches by vessels impacted the whales' behavior and that the whale-watching guideline minimum approach distance of 100 m may be insufficient in preventing behavioral responses. Most studies of this type are opportunistic and have only examined the short-term response to vessel sound and vessel traffic (Watkins 1981; Richardson et al. 1995; Magalhães et al. 2002; Noren et al. 2009). Long-term and cumulative implications of vessel sound on marine mammals remains largely unknown (National Marine Fisheries Service 2012a, b). Clark et al. (2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in one Atlantic setting and with the noise from the passage of two vessels, the optimal communication space for North Atlantic right whale could be decreased by 84 percent (e.g., Hatch et al. 2012).

Williams et al. (2014) documented some behavioral reactions by northern resident killer whales to ship presence, but these sometimes subtle responses were conditional on both behavioral state, shipping activity and time of day, and the subjective nature of the severity score the authors used. Christiansen et al. (2013) also documented whale watching vessel impacts to minke whales.

Bassett et al. (2012) recorded vessel traffic over a period of just under a year as large vessels passed within 20 km of a hydrophone site located at Admiralty Inlet in Puget Sound. During this period there were 1,363 unique Automatic Identification System transmitting vessels recorded. Navy vessels, given they are much fewer in number, are a small component of overall vessel traffic and vessel noise in most areas where they operate and this is especially the case in the Study Area (see Mintz and Filadelfo [2011] concerning a general summary for the U.S. EEZ). In addition, Navy combatant vessels have been

designed to generate minimal noise and use ship quieting technology to elude detection by enemy passive acoustic devices (Southall et al. 2005; Mintz and Filadelfo 2011).

6.3.5.3.1 Mysticetes

Fin whales may alter their swimming patterns by increasing speed and heading away from a vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study in an area where whale watching activities are common (Watkins 1981). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Richter et al. 2003; Williams et al. 2002).

Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

In the Watkins (1981) study, humpback whales did not exhibit any avoidance behavior but did react to vessel presence. In a study of regional vessel traffic, (Baker et al. 1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi. (2,000 and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were within approximately 1.2 mi. (2,000 m; Baker et al. 1983). Similar findings were documented for humpback whales when approached by whale watch vessels in Hawaii and having responses that including increased speed, changed direction to avoid, and staying submerged for longer periods of time (Au and Green 2000).

Recently, Gende et al. (2011) reported on observations of humpback whale in inland waters of Southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for predicting and understanding behavioral reactions as concluded by Southall et al. (2007a, b) and Ellison et al. (2012).

Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (National Marine Fisheries Service 1993). In the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing, but otherwise do not exhibit strong reactions (Calambokidis et al. 2009b). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al. 1982).

Although not expected to be in the Study Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004). North Atlantic right whales continue to use habitats

in high vessel traffic areas (Nowacek et al. 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Terhune and Verboom 1999, Nowacek et al. 2004). Although this may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to potential ship strike. The regulated approach distance for North Atlantic right whales is 500 yd. (457 m) (National Oceanic and Atmospheric Administration 1997).

Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more 'uninterested' reactions towards the end of the study. Finback [fin] whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 98.4 ft. (30 m). Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters was associated with vessel noise (Doyle et al. 2008); Melcón et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity by humpback whales have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place in Hawaii, however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2014).

6.3.5.3.2 Odontocetes

Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Würsig et al. 1998; Magalhães et al. 2002). One study showed that after diving, sperm whales showed a reduced timeframe from when they emitting the first click than before vessel interaction (Richter et al. 2006). The smaller whale-watching and research vessels generate more noise in higher frequency bands and are more likely to approach odontocetes directly, and to spend more time near the individual whale. Reactions to Navy vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns.

Würsig et al. (1998) reported most *Kogia* species and beaked whales react negatively to vessels by quick diving and other avoidance maneuvers. Cox et al. (2006) noted very little information is available on the behavioral impacts of vessels or vessel noise on beaked whales. A single observation of vocal disruption of a foraging dive by a tagged Cuvier's beaked whale documented when a large noisy vessel was opportunistically present, suggests that vessel noise may disturb foraging beaked whales (Aguilar de Soto et al. 2006). Tyack et al. (2011) noted the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise and at similar received levels to those noted previously and for mid-frequency sonar.

Most delphinids react neutrally to vessels, although both avoidance and attraction behavior is known (Hewitt 1985; Würsig et al. 1998). Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Incidence of attraction includes harbor porpoises approaching a vessel and common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris and Prescott 1961; Shane et al. 1986; Würsig et al. 1998; Ritter 2002). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner and common dolphins) show evasive behavior when approached; however populations that live closer to shore (within 100 nm; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010a, b).

Killer whales, the largest of the delphinids, are targeted by numerous small whale-watching vessels in the Pacific Northwest and from 1998 to 2012 during the viewing season have had an annual monthly average of nearly 20 vessels of various types within 0.5 mi. of their location from between the hours of 9 a.m. and 6 p.m. (Eisenhardt 2012). For the 2012 season, it was reported that 1,590 vessel incidents were possible violations of the federal vessel approach regulations or MMPA and ESA laws as well (Eisenhardt 2012). Research suggests that whale-watching guideline distances may be insufficient to prevent behavioral disturbances due to vessel noise (Noren et al. 2009). In 2012, there were 79 U.S. and Canadian commercial whale watch vessels in the Haro Strait region (Eisenhardt 2012).These vessels have measured source levels that ranged from 145 to 169 dB re 1 µPa at 1 m and the sound they produce underwater has the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing (Erbe 2002). Killer whales foraged significantly less and traveled significantly more when boats were within 328 ft. (100 m) of the whales (Kruse 1991; Trites and Bain 2000; Williams et al. 2002; Williams et al. 2009; Lusseau et al. 2009). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; Noren et al. 2009). The reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them, rather than to the noise of the vessel itself, or to the number of vessels in their proximity.

Similar behavioral changes (increases in traveling and other stress-related behaviors) have been documented in Indo-Pacific bottlenose dolphins in Zanzibar (Englund and Berggren 2002; Stensland and Berggren 2007; Christiansen et al. 2010). Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/sustained displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007; Miksis-Olds et al. 2007). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (Acevedo 1991; Janik and Thompson 1996; Berrow and Holmes 1999; Scarpaci et al. 2000; Gregory and Rowden 2001; Lusseau 2004; Mattson et al. 2005; Arcangeli and Crosti 2009).

Both finless porpoises (Li et al. 2008) and harbor porpoises (Polacheck and Thorpe 1990) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise in the Study Area, 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.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al. 2008) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple

vocalization parameters has been shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales off the northwestern coast of the United States have been observed to increase the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al. 2004; NOAA 2014b). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. For example, the source level of killer whale vocalizations has been shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect; see Hotchkin and Parks 2013). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2008).

6.3.5.3.3 Pinnipeds

Little is known about pinniped reactions to underwater non-impulse sounds (Southall et al. 2007a, b) including vessel noise. In a review of reports on reactions of pinnipeds to small craft and ships, Richardson et al. (1995) note that information is on pinniped reactions is limited and most reports are based on anecdotal observations. Specific case reports in Richardson et al. (1995) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007a, b), pinniped responses to vessels are affected by the context of the situation and by the animal’s experience. In summary, pinniped’s reactions to vessels are variable and reports include a wide entire spectrum of possibilities from avoidance and alert to cases where animals in the water are attracted and cases on land where there is lack of significant reaction suggesting “habituation” or “tolerance” of vessels (Richardson et al. 1995).

A study of reactions of harbor seals hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska revealed that animals are more likely to flush and enter the water when cruise ships approach within 1,640 ft. (500 m) and four times more likely when the cruise ship approaches within 328 ft. (100 m) (Jansen et al. 2010). Navy vessels would generally not operate in vicinity of nearshore natural areas that are pinniped haulout or rookery locations.

6.3.5.3.4 Sea Otters

Sea otters depend on visual acuity to forage and their eyes are able to focus both in air and underwater (Riedman and Estes 1990). Davis et al. (1988) conducted a study of southern sea otter’s reactions to visual and underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to purposefully move sea otters from a location in the event of an oil spill. There was no reaction to an oil boom placed across the forage area of the test animals. The authors found that the sea otters often remained undisturbed, quickly became tolerant of the stimuli, and even when the desired exclusion response occurred, they generally moved only a short distance before resuming normal activity.

6.3.5.4 Behavioral Reactions to Aircraft and Missile Overflights

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft helicopters and missiles. Thorough reviews of the subject and available information are presented in Richardson et al. (1995), Efroymson et

al. (2001), Luksenburg and Parsons (2009), and Holst et al. (2011). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Manci et al. 1988; Holst et al. (2011). Richardson et al. (1995) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition it was suggested that variations in the responses noted were due to generally other undocumented factors associated with overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

6.3.5.4.1 Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998; Efroymson et al. 2001). Richardson et al. (1995) reported that while data on the reactions of mysticetes is meager and largely anecdotal, there is no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 1,000 ft. (305 m) do not cause a reaction.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft. (305 m) above sea level, infrequently observed at 1,500 ft. (457 m), and not observed at 2,000 ft. (610 m) above sea level (Richardson et al. 1995). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 492 ft. (150 m) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals since these animals are often presented with limited egress due to limited open water between ice floes. Additionally many of these animals may be hunted by Native Alaskans, which could lead to animals developing additional sensitivity to human noise and presence.

6.3.5.4.2 Odontocetes

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react (Richardson et al. 1995).

During standard marine mammal surveys at an altitude of 750 ft. (229 m), some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Green et al. 1992; Würsig et al. 1998; Richter et al. 2003; Richter et al. 2006; Smultea et al. 2008). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft. [244 to 335 m]) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003).

Navy aircraft do not fly at low altitude, hover over, or follow whales and so are not expected to evoke this type of response.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Würsig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Würsig et al. 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 492 ft. (150 m).

6.3.5.4.3 Pinnipeds

Richardson et al. (1995) noted that data on pinniped reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations. Richardson et al.'s (1995) summary of this variable data note that responsiveness generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). Hauled out pinnipeds exposed to aircraft sight or sound often react by becoming alert and in many cases rushing into the water. Stampedes resulting in mortality to pups (by separation or crushing) have been noted in some cases although it is rare. Holst et al. (2011) provides an up-to-date review of this subject.

Helicopters are used in studies of several species of seals hauled out and is considered an effective means of observation (Gjertz and Børset 1992; Bester et al. 2002; Bowen et al. 2006), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). In other studies, harbor seals showed no reaction to helicopter overflights (Gjertz and Børset 1992).

Ringed seals near an oil production island in Alaska reacted to approaching Bell 212 helicopters generally by increasing vigilance, although one seal left its basking site for the water after a helicopter approached within approximately 328 ft. (100 m) (Blackwell et al. 2004). Seals in the study near an oil production platform were thought to be habituated and showed no reactions to industrial noise in water or in air, including impact pile-driving, during the rest of the observations.

For California sea lions and Steller sea lions at a rocky haulout off Crescent City in northern California, helicopter approach to landing typically caused the most severe response (National Oceanic and Atmospheric Administration 2010). Responses were also dependent on the species with Steller sea lions being more "skittish" and California sea lions more tolerant. Depending on the spacing between subsequent approaches, animals hauled out in between and fewer animals reacted upon subsequent exposures (National Oceanic and Atmospheric Administration 2010).

Pinniped reactions to rocket launches and overflight at San Nicolas Island, California were studied for the time period of August 2001–October 2008 (Holst et al. 2011). Consistent with other reports, behavioral reactions were found to differ between species. California sea lions startled and increased vigilance for up to 2 minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 2.5 mi. (4 km) of the rocket trajectory leaving their haulout sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the increasing populations of pinnipeds on San Nicolas Island (Holst et al. 2011).

6.3.5.4.4 Sea Otters

There is no specific information available indicating that overflights of any kind have an impact on sea otters. Fixed-wing aerial surveys are often recommended as a means to monitor populations of sea otter. As of 2011, USFWS stated that they had no evidence that defense-related activities have had any adverse effects on the well-monitored experimental population of southern sea otters at San Nicolas Island or in the Southern California Range Complex (U.S. Fish and Wildlife Service 2011).

6.3.5.5 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. (2006) 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 tolerate the disturbance and remain in the area. 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. However, animals that remain in the area throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. 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 (Blackwell et al. 2004; Bejder et al. 2006; Teilmann et al. 2006). Gray whales in Baja California abandoned an 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 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blaineville'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.

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for that analysis, as well as oceanographic and species assemblage changes not thoroughly addressed in Moore and Barlow (2013), although the authors suggest Navy sonar as one possible explanation for the apparent decline in beaked whale numbers over that broad area. In the small portion of the Pacific coast overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and documented higher densities of beaked whales provide indications that the proposed decline in numbers elsewhere along the Pacific coast is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using sonar more than 60 years ago, there is no data available to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred. As Moore and Barlow (2013) point out, it remains clear that the Navy range in Southern California continues to support high densities of beaked whales. When considering data from Moore and Barlow (2013), however, in considering only data from 2001, 2005, and 2008 surveys, there appears to be little change in Cuvier or Mesoplodont beaked whale estimated populations.

6.3.6 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 "an event in the wild in which (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 in apparent 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 U.S.C. § 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 (Geraci et al. 1999; Culik 2004; Perrin and Geraci 2002; Hoelzel 2003; Geraci and Lounsbury 2005; Walker et al. 2005; Bradshaw et al. 2006; National Research Council of the National Academies 2003). Anthropogenic factors include, for example, pollution (Jepson et al. 2005; Hall et al. 2006a, b; Tabuchi et al. 2006; Commission 2010; Elfes et al. 2010), vessel strike (Laist et al. 2001; Jensen and Silber 2003; Geraci and Lounsbury 2005; de Stephanis and Urquiola 2006; Douglas et al. 2008; Berman-Kowalewski et al. 2010), fisheries interactions (Read et al. 2006; Look 2011), entanglement (Baird and Gorgone 2005; Johnson and Allen 2005; Saez et al. 2012), and noise (Richardson et al. 1995; National Research Council of the National Academies 2003; Cox et al. 2006).

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year

(National Marine Fisheries Service 2011a, b, c, d). 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 U.S. Department of the Navy (2013b). For the general environment around the Study Area in particular, see, for example, Barbieri et al. (2013), Calambokidis and Huggins (2008), Cascadia Research (2010a, b, 2012a, b, 2013), Engelhard et al. (2012), Norman et al. (2004), Osborne (2003), Rice et al. (1986), Saez et al. (2013), and Willis and Baird et al. (1998).

Sonar use during exercises involving the 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 2006). These five mass stranding events have resulted in about 40 known stranding deaths among cetaceans, consisting mostly of beaked whales, with a potential link to sonar (International Council for the Exploration of the Sea 2005a, b, c). The U.S. Navy-funded research involving Behavioral Response Studies in Southern California and the Bahamas discussed previously were motivated by the desire to understand any links between the use of mid-frequency sonar and cetacean behavioral responses, including the potential for strandings. Although these events have served to focus attention on the issue of impacts resulting from the use of sonar, as Ketten (2012) recently pointed out, "ironically, to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result anthropogenic noise exposures, including sonar."

In these previous strandings, 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. 2003; 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. 2010; 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; Bernaldo de Quiros et al. 2012).

As additional background and specific to the NWTT Study Area, in May 2003 there was an incident involving the use of mid-frequency sonar by the USS SHOUP, which was portrayed in some media reports at the time as having potentially causing harbor porpoise strandings in the region. On 5 May 2003, in the area of Admiralty Inlet, the USS SHOUP began the use of mid-frequency sonar as part of a training event which continued until later that afternoon and ended as the USS SHOUP transited Haro Strait heading north. Between 2 May and 2 June 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and 1 Dall's porpoise (*Phocoenoides dalli*) had been reported to the Northwest Marine Mammal Stranding Network and allegations were made that these strandings had been caused by the USS SHOUP's use of sonar. A comprehensive review of all strandings and the events involving USS SHOUP on 5 May 2003 were subsequently presented in a report by U.S. Department of Navy (2004).

Additionally, NMFS undertook an series of necropsy analyses on the stranded animals to determine the cause of the strandings (National Marine Fisheries Service 2005b, Norman et al. 2004). Necropsies were performed on 10 of the porpoises and two heads were selected for computed tomographic imaging (Norman et al. 2004).

None of the 11 harbor porpoises demonstrated signs of acoustic trauma. A putative cause of death was determined for five of the porpoises based only on the necropsy results; two animals had blunt trauma injuries and three animals had indication of disease processes. A cause of death could not be determined in the remaining animals, which is consistent with the expected percentage of marine mammal necropsies conducted within the northwest region. It is important to note that these determinations were based only on the evidence from the necropsy to avoid bias with regard to determinations of the potential presence or absence of acoustic trauma. For example, the necropsy investigators had no knowledge of other potential external causal factors, such as Specimen 33NWR05005 having been found tangled in a fishing net which may have otherwise assisted in their determination regarding the likely cause of death for that animal. Additionally, seven of the porpoises collected and analyzed died prior to SHOUP departing to sea on 5 May 2003. Of these seven, one, discovered on 5 May 2003, was in a state of moderate decomposition, indicating it died before 5 May; the cause of death was determined, most likely, to be Salmonella septicemia. Another porpoise, discovered at Port Angeles on 6 May 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to 5 May. One stranded harbor porpoise discovered fresh on 6 May is the only animal that could potentially be linked in time to the USS SHOUP's 5 May active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered 1–3 weeks after the USS SHOUP's 5 May use of sonar. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al. 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS SHOUP use of sonar was higher than expected based on annual strandings of harbor porpoises (Norman et al. 2004). This conclusion in the NMFS report also conflicts with data from The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne, 2003). According to The Whale Museum, the number of strandings as of 15 May 2003 was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992, the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997, there were 12 strandings in the San Juan Islands with more than 30 strandings throughout the general Puget Sound area. In reporting their findings, NMFS acknowledged that the intense level of media attention to the 2003 strandings likely resulted in increased reporting effort by the public over that which is normally observed (Norman et al. 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings." It was also clear that in 2003, the number of strandings in the May–June timeframe that year was also higher for the outer coast, indicating much wider phenomena than use of sonar by USS SHOUP in Puget Sound for one day in May. It was in fact later determined by NMFS that the

<u>Criteria for Estimating Mortality Reflects a Conservative Overestimate:</u>

Navy's metric for modeling and quantifying "mortality" provides a conservative overestimate of the mortalities likely to occur. The onset mortality threshold is the minimum impulse exposure level predictive of extensive lung injury likely to result in one percent mortality of animals in a population; 99 percent would be expected to recover from the injury.

number of harbor porpoise strandings in the northwest had been increased beginning in 2003 and continued through 2006. On 3 November 2006, an Unusual Mortality Event in the Pacific Northwest was declared by NMFS (see U.S. Department of the Navy [2013b], Cetacean Stranding Report for more detail on this Unusual Mortality Event).

The speculative association of the harbor porpoise strandings to the use of sonar by the USS SHOUP was inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events, strandings shortly after the use of sonar (less than 36 hours), stranded individuals were spatially co-located. Although mid-frequency active sonar was used by the USS SHOUP, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that mid-frequency active sonar was a cause of harbor porpoise strandings. Rather, a lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, supports the conclusion that harbor porpoise strandings in 2003 in the Pacific Northwest were unrelated to the sonar activities by the USS SHOUP.

As the International Council for the Exploration of the Sea (2005b) 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; Hildebrand et al. 2011; 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, four long-beaked common dolphins were killed by the detonation of an underwater explosive (Danil and St. Leger 2011). This area has been used for underwater demolitions training for at least 3 decades without incident. During this underwater detonation training event, a pod of 100–150 long-beaked common dolphins were observed moving towards the explosive event’s 700 yd. (640 m) exclusion zone monitored by a personnel in a safety boat and participants in a dive boat. Within the exclusion zone, approximately 5 minutes remained on a time-delayed firing device connected to a single 8.76 lb. (3.8 kg) explosive charge weight (C-4 and detonation cord) set at a depth of 48 ft. (14.6 m), approximately 0.5–0.75 nm from shore. 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 died as a result of being in proximity to the explosion. In addition, to the three dolphins found dead on 4 March at the event site, the remains of a fourth dolphin were discovered on 7 March (3 days later and approximately 42 mi. (68 km) from the location where the training event occurred), which was assessed as being related to this event (Danil and St. Leger 2011). Details such as the dolphins’ depth and distance from the explosive at the time of the detonation could not be estimated from the 250 yd. (229 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 event involving impulse energy (underwater detonation with timed delayed firing) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, Navy has reviewed training requirements, safety procedures, and potential mitigation measures and, along with NMFS, is determining appropriate changes to implement 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, which details

all mitigations. It is also important to note that there are no activities proposed in the NWTT Study Area that make use of a time-delayed firing device.

In comparison to strandings, serious injury, and death from non-Navy human activities affecting the oceans, major causes include commercial vessel strikes (e.g., Berman-Kowalewski et al. 2010; Silber et al. 2010), impacts from urban pollution (e.g., O'Shea & Brownell 1994; Hooker et al. 2007), and annual fishery-related entanglement, bycatch, injury, and mortality (e.g., Baird and Gorgone 2005; Forney and Kobayashi 2007; Saez et al. 2012), which have been estimated worldwide to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals; Culik 2004, International Council for the Exploration of the Sea 2005b, Read et al. 2006) than the few potential injurious impacts that could be possible as a result of Navy activities. This does not negate the potential influence of mortality or additional stress to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distributions, but overall the Navy's impact in the oceans and inland water areas where training and testing occurs is small by comparison to other human activities.

6.3.7 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). 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 (PCAD) model (National Research Council 2005) proposed 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 from 2009 until mid-2012 by independent scientists and Navy observers in the Southern California Range Complex and Hawaii Range Complex 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.

6.3.8 Summary of Observations During Previous Navy Activities

Since 2006, the Navy, non-Navy marine mammal scientists, and research institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS[6] and these reports may be informative to the analysis of impacts to marine mammals in general 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, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship ASW sonar system.

Monitoring results from two locations where intensive training and testing occurs in the Pacific:

From 2009 to 2012 in the Navy's Hawaii and Southern California training and testing ranges, Navy-funded marine mammal monitoring research completed (in addition to other marine mammal research efforts) over 5,000 hours of visual survey effort covering over 65,000 nm, and resulted in the sighting of over 256,000 individual marine mammals. This monitoring effort is consistent with other research from these areas in that there has been no direct evidence demonstrating that routine Navy training and testing has negatively impacted marine mammal populations inhabiting these Navy ranges.

The majority of the training and testing activities Navy is proposing for the next 5 years are similar, if not identical, to activities that have been occurring in the same locations for decades. For example, the

[6] Navy monitoring reports are available at the Navy website, www.navymarinespeciesmonitoring.us/, and also at the NMFS website, www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

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 the Pacific, the vast majority of scientific field work, research, and monitoring efforts have occurred in Southern California and Hawaii where Navy has historically concentrated training and testing activities. In the Study Area, because there have been no Major Training Events and training and testing events are by comparison, small in scope, the majority of Navy's research effort has been focused elsewhere.

In the NWTT Study Area since 2011, there have been eight annual exercise reports and six monitoring reports (e.g., Department of the Navy 2011a, b, 2012a, b, 2013d; see also Table 6-1) submitted to NMFS since issuance of the current authorizations under the MMPA (National Marine Fisheries Service 2010, 2011). Research undertaken by Navy in the Pacific Northwest includes the following:

- Deployment of two autonomous passive acoustic monitoring buoys (High-frequency Acoustic Recording Package) in the waters of Washington State
- Analysis of 17,417 hours of passive acoustic data as of July 2013 (e.g., Kerosky et al. 2013)
- Deployment of satellite tracking tags on fin and humpback whales off the Washington coast by Cascadia Research Collective in cooperation with Washington Department of Fish and Wildlife (e.g., Schorr et al. 2013)
- Tagging of gray whales off Oregon and Northern California by researchers at Oregon State University (e.g., Mate 2013)
- Surveys of pinnipeds at Puget Sound Navy installations (Everett, Bangor, Bremerton)
- Marine mammal small boat line transect surveys in Hood Canal and Dabob Bay
- Aerial pinniped haulout surveys in inland waters (e.g., Jeffries 2013b)
- Aerial cetacean line-transect surveys in the inland Puget Sound waters (Smultea and Bacon 2013)
- Monitoring of Explosive Ordinance Demolition/Underwater Detonation training

Table 6-1: Navy Exercise and Monitoring Report Submissions for the Pacific from 2011 through 1 December 2013

Year Submitted	Range	Document
2011	Southern California Range Complex and Hawaii Range Complex	Annual Range Complex Exercise Report, August 2010–August 2011
		Marine Mammal Monitoring, 2011 Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, August 2010–February 2011
		Marine Species Monitoring, Annual Report, 2011
	Keyport Range Complex	Annual Range Complex Exercise Report, Year 1, April 2011–September 2011
		Annual Range Complex Monitoring Report, Year 1, April 2011–November 2011
	Northwest Training Range Complex	Annual Range Complex Exercise Report, Year 1, November 2010–May 2011
		Annual Range Complex Monitoring Report, Year 1, November 2010 –May 2011
	Gulf of Alaska	Annual Monitoring Report, 2011, Year 1

		Annual Exercise Report, 17 May 2011–31 October 2011
2012	Southern California Range Complex	Annual Range Complex Exercise Report, 2 August 2011–1 August 2012
		Marine Species Monitoring, 2012 Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 16 February 2011–15 February 2012
		Marine Species Monitoring, 2012
	Keyport Range Complex	Annual Range Complex Exercise Report, Year 2
		Annual Range Complex Monitoring Report, Year 2

Table 6-1: Navy Exercise and Monitoring Report Submissions for the Pacific from 2011 through 1 December 2013 (continued)

Year Submitted	Range	Document
2012 (continued)	Northwest Training Range Complex	Annual Range Complex Unclassified Exercise Report, Year 2
		Annual Range Complex Monitoring Report, Year 2
		Environmental Monitoring Report, EOD/UNDET, 17 December 2012
	Hawaii Range Complex	Marine Species Monitoring, 2012 Annual Report
	Gulf of Alaska	Annual Monitoring Report, 2012, Year 2
2013	Southern California Range Complex	Comprehensive Exercise and Monitoring Report For the U.S. Navy's Southern California Range Complex 2009–2012
	Keyport Range Complex	Annual Range Complex Exercise Report, Year 3
		Annual Range Complex Monitoring Report, Year 3
	Northwest Training Range Complex	Annual Range Complex Unclassified Exercise Report, Year 3
		Annual Marine Species Monitoring Report, Year 3
		Environmental Monitoring of Explosive Ordnance Disposal, Underwater Detonation Training in the Northwest Training Range Complex (22 November 2013)
	Hawaii Range Complex	Comprehensive Exercise and Monitoring Report For the U.S. Navy's Hawaii Range Complex 2009–2012
	Gulf of Alaska	Annual Monitoring Report, 2013, Year 3

Notes: (1) These reports are publically available at the Navy website (www.navymarinespeciesmonitoring.us/) and from the NMFS Office of Protected Resources website (www.nmfs.noaa.gov/pr/permits/incidental.htm#applications). (2) EOD = Explosive Ordnance Disposal, UNDET = Underwater Detonation, U.S. = United States, Navy = United States Department of the Navy

These efforts have added to the baseline marine mammal data for the Washington Coast and Puget Sound along and with other previously funded baseline data gathering (i.e., Olsen et al. 2009; Olsen and Hildebrand 2012). Analysis of data from the deployed acoustic buoys confirmed detection of four baleen whale species, including blue whales, fin whales, gray whales, and humpback whales; nine toothed whale species; and anthropogenic sounds dominated by shipping noise (Širović et al. 2012a, 2012b; Kerosky et al. 2013). Between May 2010 and May 2013, satellite tracking tags were placed on 3 gray whales, 11 fin whales, 5 humpback whales, and 2 killer whales off the Washington coast (Schorr et al. 2013). One tag, on an Eastern North Pacific Offshore stock killer whale in a pod encountered off Washington at Grays Harbor Canyon, remained attached and continued to transmit for approximately 3 months. In this period, the animal transited a distance of approximately 4,700 nm, which included time spent in the Gulf of Alaska. In 2012–2013, tags were attached to 11 Pacific Coast Feeding Group gray whales near Crescent City, California; in general, the tag-reported positions indicated these whales were moving southward at this time of year (Mate 2013). The Navy's 2013 annual monitoring report for the

NWTT Range contains the details of the findings from this research (U.S. Department of the Navy 2013d).

Additional survey efforts around Navy installations in Puget Sound (for which follow-up investigations are ongoing) provide a more focused documentation of the continued presence of marine mammals in locations where Navy has continued training and testing for decades (e.g., Jeffries [2013b] and detailed comprehensive presentation in Chapter 13, Section 13.4).

Since 2006 across all Navy Range Complexes (in the Atlantic, Gulf of Mexico, and the Pacific), there have been more than 80 reports; Major Exercise Reports, Annual Exercise Reports, and Monitoring Reports. For the Pacific since 2011, there have been 29 monitoring and exercise reports (as shown in Table 6-1) submitted to NMFS to further research goals aimed at understanding the Navy's impact on the environment as it carries out its mission to train and test. For example, the Comprehensive Exercise and Monitoring Report for the U.S. Navy's Southern California Range Complex 2009–2012 provides 3 years of data from one of the most intensively used Navy range complexes (U.S. Department of the Navy 2013c).

In addition to this multi-year record of reports from across the Navy, there have also been ongoing Behavioral Response Study research efforts (in Southern California and the Bahamas) specifically focused on determining the potential effects from Navy mid-frequency sonar (Southall et al. 2011, 2012, Tyack et al. 2011; DeRuiter et al. 2013b; Goldbogen et al. 2013). This multi-year compendium of monitoring, observation, study, and broad scientific research is informative with regard to assessing the effects of Navy training and testing in general. Given that this record involves many of the same Navy training and testing activities being considered for the Study Area and because it includes all the marine mammal taxonomic families and many of the same species, this compendium of Navy reporting is directly applicable to the Study Area. For example, In the Hawaii and Southern California Navy training and testing ranges from 2009 to 2012, Navy-funded marine mammal monitoring research completed over 5,000 hours of visual survey effort covering over 65,000 nm, 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. In Hawaii alone between 2006 and 2012, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises.

Based on the findings from surveys in Puget Sound and research efforts and monitoring before, during, and after training and testing events across the Navy since 2006, the Navy's assessment is that it is unlikely there would be impacts to populations of marine mammals (such as whales, dolphins and pinnipeds) 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 including the Study Area. 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) 6 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.[7] Citations to

[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 (RIMPAC 2006) exercise. Monitoring has continued to the present for Major Training Events

evidence indicative of increases 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 Hawaii or Southern California suggesting Navy training and testing has had or may have any long-term consequences to marine mammals. Barring any evidence to the contrary, therefore, what limited and preliminary evidence there is from the Navy's 80-plus reports and other focused scientific investigations 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, would 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 can be found throughout the literature.

Work by Moore and Barlow (2011) indicates that, since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes offshore waters of the Study Area up to the Canadian border. They predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching "current ecosystem limits." Research by Falcone and Shorr (2012) suggests that fin whales may have population sub-units with higher than expected residency to the Southern California Bight, which includes part of the Navy's Southern California Range Complex. For the portion of the blue whale population in the Pacific (along the U.S. west coast) that includes Southern California as part of its range, there has been a significant upward trend in abundance (Calambokidis et al. 2009a). Berman-Kowalewski et al. (2010) report that, in 2007, the number of blue whales in the Santa Barbara Channel (just north of the Navy's Southern California Range Complex) was the highest count since 1992. Similar findings have also documented the season range expansion and increasing presence of Bryde's whales south of Point Conception in the Southern California (Kerosky et al. 2012; Smultea et al. 2013). 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).

As presented in detail in Section 3.4.3.1.6.2 (Behavioral Reactions to Sonar and Other Active Acoustic Sources), Goldbogen et al. (2013) reported on the results of an ongoing Navy funded behavioral response study in the waters of Southern California.[8] Goldbogen et al. (2013) suggested that, "frequent exposure to mid-frequency anthropogenic sounds may pose significant risks to the recovery rates of endangered blue whale populations." In actuality, while there is no data indicating any trend in the entire Eastern North Pacific population towards recovery since the end of whaling (e.g., Barlow and Forney 2007), research along the U.S. west coast and Baja California reported by Calambokidis et al. (2009a) based on mark-recapture estimates "indicated a significant upward trend in abundance of blue whales" at a rate of increase just under 3 percent per year for the portion of the blue whale population in the Pacific that includes Southern California as part of its range. The Eastern North Pacific stock (population), which is occasionally present in Southern California, is known to migrate from the northern Gulf of Alaska to the eastern tropical Pacific at least as far south as the Costa Rica Dome (Carretta et al. 2014). Given this population's vast range and absent discussion of any other documented impacts, such as commercial ship strikes (Berman-Kowalewski et al. 2010), the suggestion by Goldbogen et al. (2013) that, since the end of commercial whaling, sonar use (in the fraction of time and area represented by

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in the Pacific and Atlantic as well as other monitoring and research conducted as part of coordinated efforts under the Navy's Integrated Comprehensive Monitoring Plan developed in consultation with NMFS and others.

[8] The Navy is continuing funding the behavioral response study research, which has for the first time in Southern California in Fall of in 2013, exposed marine mammals to actual U.S. Navy mid-frequency sonar. The results from that most recent fieldwork are pending.

the Navy's training and testing in the Southern California Range Complex) may be a significant risk to the blue whale's recovery in the Pacific is speculative at this stage. Furthermore, the suggestion is contradicted by the upward trend in abundance and counts (Calambokidis et al. 2009a; Berman-Kowalewski et al. 2010) of blue whales in the area where sonar use has been occurring for decades.

In addition, Goldbogen et al. (2013) do not account for interannual changes in oceanographic conditions within the California Current from the 1990s as compared to the 2000s and the resulting likely effects on blue whale distribution nor do they account for the fact that population assessments are derived from infrequent surveys (Baumann and Doherty 2013; Goericke et al. 2007; Hazen et al. 2012; Miller et al. 2013; Salvadeo et al. 2011; Sydeman et al. 2013; Venrick 2012). Blue whale distribution is likely influenced by oceanographic impacts to distributions of zooplankton including krill. Rowmmich and McGowan (1995) and Venrick (2012) documented overall declining trends in zooplankton displacement volumes off California since the 1950s that would have significant effect on blue whale distributions along the U.S. west coast. Bjorkstedt et al. (2010, 2011) noted that, in contrast to the consistently warm conditions that dominated the California Current prior to the strong 1997–1998 El Niño, the Pacific Decadal Oscillation index suggests that the North Pacific has since been in a generally cooler state since that time. Areas outside of Southern California are not heavily or frequently surveyed by NMFS or other research programs for blue whale occurrence. However, it has been reported by Carretta et al. (2013) that blue whales from the U.S. west coast have been increasingly found feeding to the north and south of the U.S. west coast during summer and fall. In summary, given the documented environmental variability along the U.S. west coast and lack of data needed to make a complete assessment of the blue whale population, there can be no definitive statements regarding the recovery of the blue whale population in the Pacific or inferences then drawn based on a trend in the species recovery in the Pacific from sightings along the U.S. west coast. It is, however, important to note that for the blue whale population along the U.S. west coast (which includes Southern California where the Navy has been training and testing for decades) there has been a significant upward trend in abundance (Calambokidis et al. 2009a), despite an increasingly found likely redistribution beyond that area (Carretta et al. 2014).

The Hawaiian Islands, where the Hawaii Range Complex has been utilized for decades, continue to function as a critical breeding, calving, and nursing area for humpback whales. 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 haulout and nursing area for endangered Hawaiian Monk Seals. While there has been a decline in the population of Hawaiian monk seals in the northwestern Hawaiian Islands, in the main Hawaiian Islands the numbers have continued to increase (Littnan 2010). In similar findings and after years of recovery, surveys of harbor seals in Hood Canal in recent decades show a fairly stable population, suggesting the area’s carrying capacity may have been reached (Jeffries et al. 2003) in this area where many of the same Navy training and testing activities have been occurring for decades.

As increases in population would seem to indicate, evidence for the presence 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 ASW training (including relatively intense choke point or 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 monitoring effort during the 2006 Rim of the Pacific Exercise. 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 mid-frequency 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 mid-frequency sonar transmissions and the training activity, in general, did not appear to affect the presence of other detected species on or near the range.

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for this analysis, as well as oceanographic and species assemblage changes on the U.S. west coast not thoroughly addressed. Interestingly, however, in the small portion of that area overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and higher densities provide indications that the proposed decline noted elsewhere is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. In Southern California, based on a series of surveys from 2006 to 2008 and a 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 given the number of animals encountered there. Follow-up research (Falcone and Schorr 2012) in this same location seems to suggest that Cuvier's beaked whales may have population sub-units with higher than expected residency to the Navy's instrumented Southern California Anti-Submarine Warfare Range in particular. Photo identification methods in the Southern California Range Complex has identified approximately 100 individual Cuvier's beaked whale individuals with 15 percent having been seen in more than 1 year, with sighting spans up to 4 years (Falcone and Schorr 2012). This finding is also consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009). For over three decades, this 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. The Navy's use of the area has not precluded beaked whales from also continuing to inhabit the area, nor has there been documented declines or beaked whale mortalities associated with Navy training and testing activities. Navy funding for monitoring of beaked whale and other marine species (involving visual survey, passive acoustic recording, and tagging studies) will continue in Southern California to develop additional data towards a clearer understanding of marine mammals inhabiting the Navy's range complexes.

To summarize, while the evidence covers most marine mammal taxonomic suborders, it is limited to a few species and only suggestive of the general viability of those species in intensively used Navy training and testing areas. There is no direct evidence that routine Navy training and testing spanning decades has negatively impacted marine mammal populations at any Navy Range Complex. Although there have been a few strandings associated with use of sonar in other locations (see U.S. Department of the Navy 2013b), Ketten (2012) has recently summarized, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result of anthropogenic noise exposures, including sonar." Therefore, based on the best available science (Barlow et al. 2011; Falcone et al. 2009; Falcone and Schorr 2012; Littnan 2011; Martin and Kok 2011; McCarthy et al. 2011; McSweeney et al. 2007; McSweeney et al. 2009; Moore and Barlow 2011; Tyack et al. 2011;

Southall et al. 2012), including data developed in the series of 71 reports submitted to NMFS, the Navy believes that long-term consequences for individuals or populations are unlikely to result from Navy training and testing activities in the Study Area.

6.4 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.

6.4.1 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 impulsive 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 1998a) and WINSTON S. CHURCHILL surface ship (Craig Jr. 2001). These criteria and thresholds were also adopted by NMFS in several Final Rules issued under the MMPA (63 Federal Register [FR] 230; 66 FR 87; 73 FR 121; 73 FR 199). These criteria and thresholds were revised as necessary based on new science and used for the shock trial of the U.S. Navy amphibious transport dock ship MESA VERDE (Finneran and Jenkins 2012) and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the MESA VERDE shock trial (73 FR 143). 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 Finneran and Jenkins (2012), who cover the development of the thresholds and criteria for assessment of impacts.

Species-specific minimal animal masses are used for determining impulse-based thresholds because they most closely represent effects on individual species. The Navy's Thresholds and Criteria 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. The scaling of lung volume to depth is conducted for all species since data are from experiments with terrestrial animals held near the water's surface. 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 all newborn, or calf, weights rather than representative adult weights results in an overestimate of effects to animals near an explosion. 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 are based on the impulse at which these effects are predicted for 1 percent of animals; the portion of animals affected would increase closer to the explosion. As discussed above, due to these conservative criteria used to predict these effects, it is likely that fewer animals would be affected than predicted under the Navy's acoustic analysis. Therefore, these criteria conservatively overestimate the number of animals that could be killed or injured.

6.4.1.1 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 impulsive of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton et al. 1973, 1975; Yelverton and Richmond 1981). Therefore, impulsive was used as a metric upon which internal organ injury could be predicted.

Impulsive (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 impulsive 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 impulsive 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 impulsive level predictive of extensive lung injury, the exposure level likely to result in 1 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 impulsive 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 percent 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 impulsive delivery time to experience an effect decreases (Goertner 1982).

Species-specific calf masses are used for determining impulsive-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 all newborn, or calf, weights rather than representative adult weights results in an overestimate of effects to animals near an explosion. 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. Although these criteria conservatively overestimate the number of

animals that could be killed or injured, no mortality or slight lung injury was predicted in the analysis of the modeling resulting from the use of explosives during training and testing in the Study Area.

6.4.1.2 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, equivalent to a SPL of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by the Navy and NMFS for ship shock trials (National Marine Fisheries Service; 63 FR 230; 66 FR 87; 73 FR 143). However, no gastrointestinal injuries were predicted in the analysis of the modeling resulting from the use of explosives during training and testing in the Study Area.

6.4.1.3 Frequency Weighting

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. 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. These M-weighting functions were derived for each marine mammal hearing group based on an algorithm using the range of frequencies that are within 80 dB of an animal or group's best hearing. The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of noise (Figure 6-2). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions. Otariid seal thresholds and weighting functions were applied to sea otter as described in Finneran and Jenkins (2012).

While all data published since 2007 were reviewed to determine if any adjustments to the weighting functions were required, only two published experiments suggested that modification of the mid-frequency cetacean auditory weighting function was necessary (see Finneran and Jenkins [2012] for more details on that modification not otherwise provided below). The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3 to 28 kHz (Finneran et al. 2010a). 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).

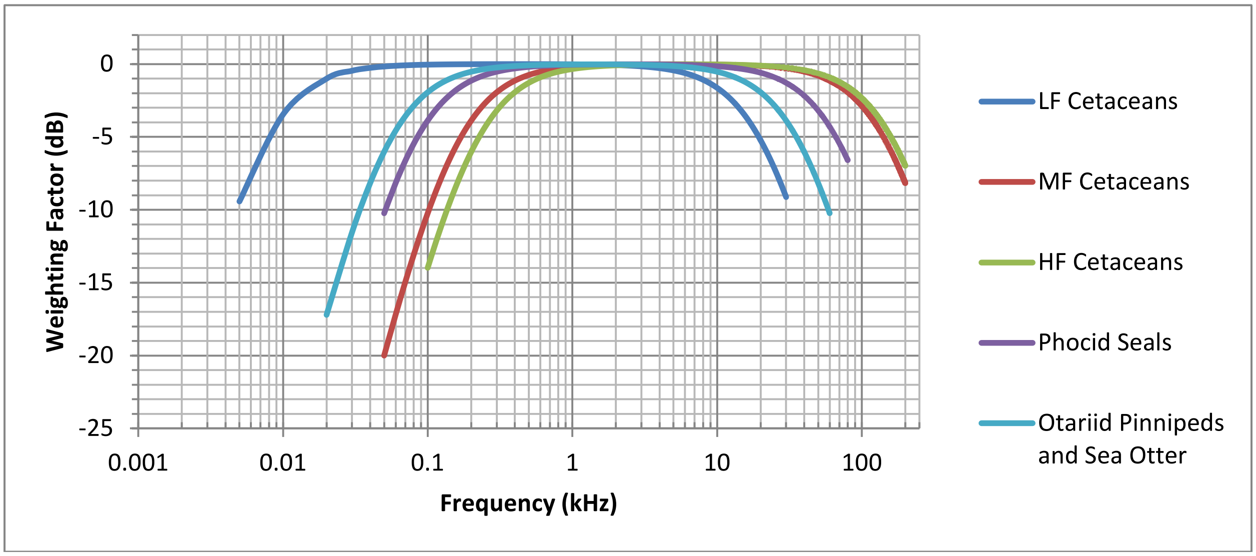

Figure 6-2: Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

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 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 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. Similar type II weighting curves were not developed for pinnipeds since their hearing is markedly different from cetaceans, and because they do not hear as well at higher frequencies. Their weighting curves do not require the same adjustment (see Finneran and Jenkins 2012 for additional details).

The Type II auditory weighting functions (Figure 6-3) are applied to the received sound level before comparing it to the appropriate SEL thresholds for TTS or PTS, or the explosive behavioral response threshold (note that for pinnipeds and sea otters, the Southall et al. (2007) weighting functions (see Figure 6-2) are used in lieu of any new weighting functions). 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 impulsive metrics used to predict onset-mortality and slight lung injury from underwater explosions; and the thresholds used to predict behavioral responses from harbor porpoise and beaked whales from sonar and other active acoustic sources.

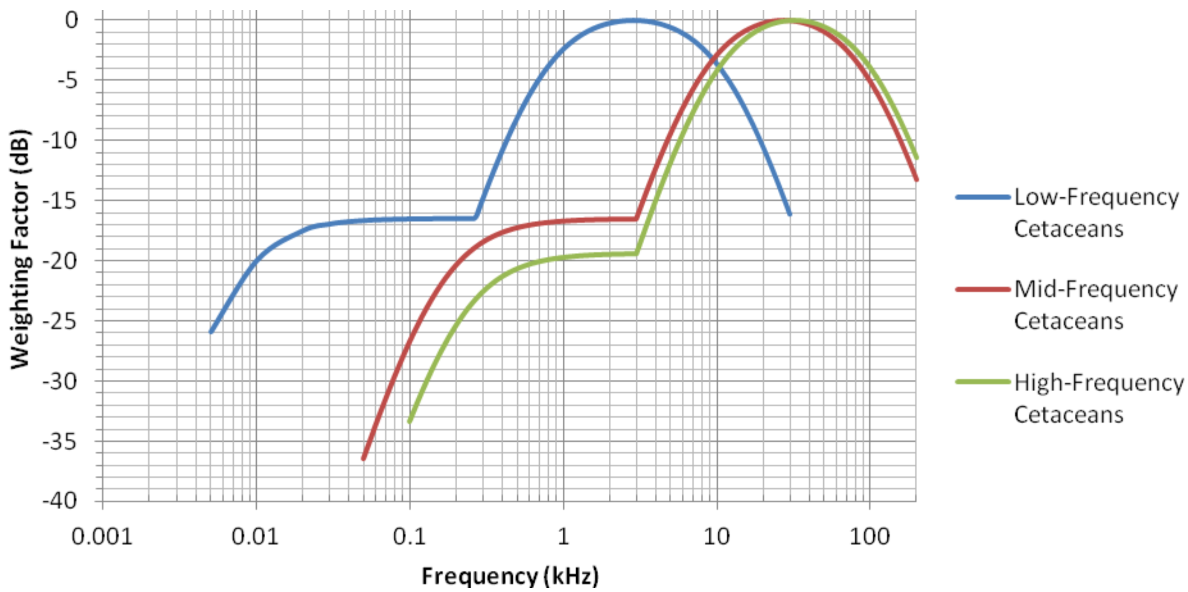

Figure 6-3: New Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans, Pinniped, and Sea Otter

6.4.1.4 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 of similar source types. For sonar, including use of multiple systems within any scenario, energy will be summed for all exposures within a cumulative exposure band, with the cumulative exposure bands defined in four bands: 0–1.0 kHz (low-frequency sources); 1.1–10.0 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. After the energy has been summed within each frequency band, the band with the greatest amount of energy is used to evaluate the onset of PTS or TTS. For explosives, including use of multiple explosives in a single scenario, energy is summed across the entire frequency band.

6.4.1.5 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 SELs (Table 6-2). The onset of TTS or PTS from exposure to impulsive sources is predicted using a SEL-based threshold in conjunction with a peak pressure threshold (Table 6-3). 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 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 have been estimated using empirical TTS data obtained from marine mammals and relationships between TTS and PTS established in terrestrial mammals.

Table 6-2: Acoustic Criteria and Thresholds for Predicting Physiological Effects to Marine Mammals Underwater from Sonar and Other Active Acoustic Sources

Group	Species	Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB re 1 μPa^2-s SEL (Type II weighting)	198 dB re 1 μPa^2-s SEL (Type II weighting)
Mid-Frequency Cetaceans	Most delphinids, beaked whales, medium and large toothed whales	178 dB re 1 μPa^2-s SEL (Type II weighting)	198 dB re 1 μPa^2-s SEL (Type II weighting)
High-Frequency Cetaceans	Porpoises, *Kogia* spp.	152 dB re 1 μPa^2-s SEL (Type II weighting)	172 dB re 1 μPa^2-s SEL (Type II weighting)
Phocidae (underwater)	Elephant seal and harbor seal	183 dB re 1 μPa^2-s SEL (Type I weighting)	197 dB re 1 μPa^2-s SEL (Type I weighting)
Otariidae (underwater)	Sea lions and Fur seal	206 dB re 1 μPa^2-s SEL (Type I weighting)	220 dB re 1 μPa^2-s SEL (Type I weighting)
Mustelidae (underwater)	Sea Otter		

Notes: Notes: dB = decibels, SEL = Sound Exposure Level, dB re 1 μPa^2-s = decibels referenced to 1 micropascal squared second (see Finneran and Jenkins 2012)

Temporary and permanent threshold shift thresholds are based on TTS onset values for impulse and non-impulse 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 Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis Technical Report provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals (Finneran and Jenkins 2012).

6.4.1.6 Temporary Threshold Shift for Sonar and Other Active Acoustic Sources

TTS involves no tissue damage, is by definition temporary, and therefore is not considered injury. TTS values for mid-frequency cetaceans exposed to non-impulse sound are derived from multiple studies (Schlundt et al. 2000; Finneran et al. 2005; Mooney et al. 2009a; Finneran et al. 2010b; Finneran and Schlundt 2010) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010; Finneran 2011). This difference in TTS onset at higher frequencies is incorporated into the weighting functions.

Previously, there were no direct measurements of TTS from non-impulse sound in high-frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic air gun and those results are reflected in the current impulse sound TTS thresholds described below. The beluga whale, which had been the only species for which both impulse and non-impulse TTS data exist has a non-impulse TTS onset value about 6 dB above the (weighted) impulse threshold (Schlundt et al. 2000; Finneran et al. 2002). Therefore, 6 dB was added to the harbor porpoise's impulse TTS threshold demonstrated by Lucke et al. (2009) to derive the non-impulse TTS threshold used in the current Navy modeling for high-frequency cetaceans. Report on the first direct measurements of TTS from non-impulse sound has been recently presented by Kastelein et al. (2012a) for harbor porpoise. These new data are fully consistent with the current harbor porpoise thresholds used in the modeling of effects from non-impulse sources.

Table 6-3: Impulsive Sound and Explosive Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals

Group	Species	Onset TTS	Onset PTS	Onset Slight GI Tract Injury	Onset Slight Lung Injury	Onset Mortality
Low Frequency Cetaceans	All mysticetes	172 dB re 1 µPa²-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)	187 dB re 1 µPa²-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)	237 dB re 1 µPa (unweighted)	Note 1	Note 2
Mid-Frequency Cetaceans	Most delphinids, medium and large toothed whales	172 dB re 1 µPa²-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)	187 dB re 1 µPa²-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)			
High Frequency Cetaceans	Porpoises and *Kogia* spp.	146 dB re 1 µPa²-s SEL (Type II weighting) or 195 dB re 1 µPa Peak SPL (unweighted)	161 dB re 1 µPa²-s SEL (Type II weighting) or 201 dB re 1 µPa Peak SPL (unweighted)			
Phocidae	Northern elephant seal and harbor seal	177 dB re 1 µPa²-s (Type I weighting) or 212 dB re 1 µPa Peak SPL (unweighted)	192 dB re 1 µPa²-s (Type I weighting) or 218 dB re 1 µPa Peak SPL (unweighted)			
Otariidae	Steller and California Sea Lion, Guadalupe and Northern fur seal	200 dB re 1 µPa²-s (Type I weighting) or 212 dB re 1 µPa Peak SPL (unweighted)	215 dB re 1 µPa²-s (Type I weighting) or 218 dB re 1 µPa Peak SPL (unweighted)			
Mustelidae	Sea Otter					
Note 1	$= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$		Note 2	$= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$		

[1] Impulse calculated over a delivery time that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for animal size and depth.
Notes: GI = gastrointestinal, M = mass of animals in kilograms, D_{Rm} = depth of receiver (animal) in meters, SEL = Sound Exposure Level, SPL = Sound Pressure Level (re 1 µPa), dB = decibels, re 1 µPa = referenced to one micropascal, dB re 1 µPa²-s = decibels referenced to one micropascal squared second

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy uses mid-frequency cetacean thresholds to assess PTS and TTS for low-frequency cetaceans, since

mid-frequency cetaceans are the most similar to the low-frequency group (see Finneran and Jenkins (2012) on the development of the thresholds and criteria).

Pinniped TTS criteria are based on data provided by Kastak et al. (2005) for representative species of both of the pinniped hearing groups: harbor seals (Phocidae) and California sea lions (Otariidae). Kastak et al. (2005) used octave band noise centered at 2.5 kHz to extrapolate an onset TTS threshold. More recently Kastelein et al. (2012b) used octave band noise centered at 4 kHz to obtain TTS thresholds in the same two species resulting in similar levels causing onset-TTS as those found in Kastak et al. (2005). For sea otters, the otariid TTS threshold and weighting function are applied due to similarities in taxonomy and auditory performance.

The appropriate frequency weighting function for each species group is applied when using the SEL-based thresholds to predict TTS.

6.4.1.7 Temporary Threshold Shift for Explosives

The TTS SEL thresholds for cetaceans are consistent with the USS MESA VERDE ship shock trial that was approved by NMFS (73 FR 143) and are more representative of TTS induced from impulses (Finneran et al. 2002) rather than pure tones (Schlundt et al. 2000). In most cases, a total weighted SEL is more conservative than greatest SEL in 1/3-octave bands, which was used prior to the USS MESA VERDE ship shock trials. There are no data on TTS obtained directly from low-frequency cetaceans, so mid-frequency cetacean impulse threshold criteria from Finneran et al. (2002) have been used. High frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single air gun.

Pinniped criteria were not included for prior ship shock trials, as pinnipeds were not expected to occur at the shock trial sites, and TTS criteria for previous Navy EIS/OEISs also were not differentiated between cetaceans and pinnipeds (National Marine Fisheries Service 2008). TTS values for impulse sound criteria have not been obtained for pinnipeds, but there are TTS data for octave band sound from representative species of both major pinniped hearing groups (Kastak et al. 2005). Impulse sound TTS criteria for pinnipeds were estimated by applying the difference between mid-frequency cetacean TTS onset for impulse and non-impulse sounds to the pinniped non-impulse TTS data (Kastak et al. 2005), a methodology originally developed by Southall et al. (2007). Therefore, the TTS criteria for impulse sounds from explosions for pinnipeds is 6 dB less than the non-impulse onset-TTS criteria derived from Kastak et al. (2005).

For sea otters, the otariid TTS and PTS thresholds and weighting function are applied due to similarities in taxonomy and the likely hearing ability of sea otters when underwater.

6.4.1.8 Permanent Threshold Shift for Sonar and Other Active Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well understood relationships between terrestrial mammalian TTS and PTS have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Ward et al. 1958, 1959a, b; Miller et al. 1963). These data would suggest that a PTS criteria of 40 dB would be reasonable for conservatively predicting (overestimating) PTS in marine mammals. Data from terrestrial mammal testing (Ward et al. 1958, 1959a, b) show growth of TTS by 1.5–1.6 dB for every 1 dB increase in exposure level. The difference between measureable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6,

indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism we have rounded that number down to 20 dB (Southall et al. 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are assumed to produce a PTS. For example, an onset-TTS criteria of 195 dB re 1 μPa^2-s would have a corresponding onset-PTS criteria of 215 dB re 1 μPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method overestimates or predicts greater effects than have actually been observed in tests on a bottlenose dolphin (Schlundt et al. 2006; Finneran et al. 2010a) and is therefore protective.

Kastak et al. (2007) obtained different TTS growth rates for pinnipeds than Finneran and colleagues obtained for mid-frequency cetaceans. NMFS recommended reducing the estimated PTS criteria for both groups of pinnipeds, based on the difference in TTS growth rate reported by Kastak et al. (2007) (14 dB instead of 20 dB).

The appropriate frequency weighting function for each species group (Table 6-4) is applied when using the SEL-based thresholds to predict PTS.

6.4.1.9 Permanent Threshold Shift for Explosions

Since marine mammal PTS data from impulse exposures do not exist, onset PTS levels for these animals are estimated by adding 15 dB to the SEL-based TTS threshold and by adding 6 dB to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied when using the resulting SEL-based thresholds, as shown in Table 6-5, to predict PTS.

6.4.2 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 NAEMO) 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.

6.4.2.1 Non-Impulsive Sound from Sonar and Other Active Acoustic Sources

Potential behavioral effects to marine mammals from in-water sound from sonar and active acoustic sources were predicted using the behavioral response function for most animals. The received sound level is weighted with the Type I auditory weighting functions (Southall et al. 2007, see Figure 6-2) before the behavioral response function is applied. The harbor porpoise and beaked whales are the exception. They have unique criteria based on specific data that show these animals to be especially sensitive to sound. Harbor porpoise and beaked whale non-impulsive behavioral criteria are used unweighted—without weighting the received level before comparing it to the threshold (see Finneran and Jenkins 2012).

Behavioral Response Functions – The Navy worked with NMFS to define a mathematical function used to predict potential behavioral effects to odontocetes and pinnipeds (Figure 6-4) and mysticetes (Figure 6-5) from mid-frequency sonar (National Marine Fisheries Service 2008a).

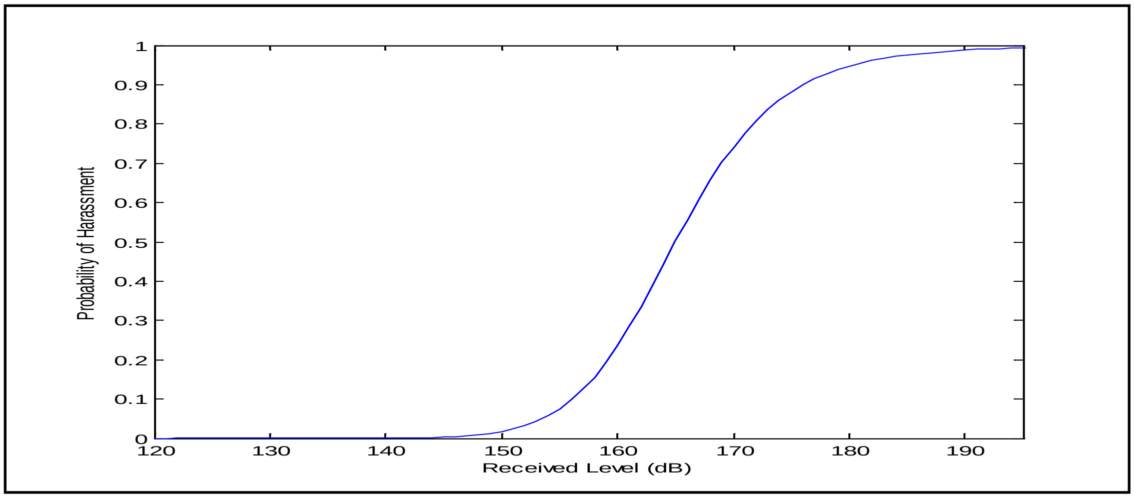

Figure 6-4: Behavioral Response Function Applied to Odontocetes and Pinnipeds

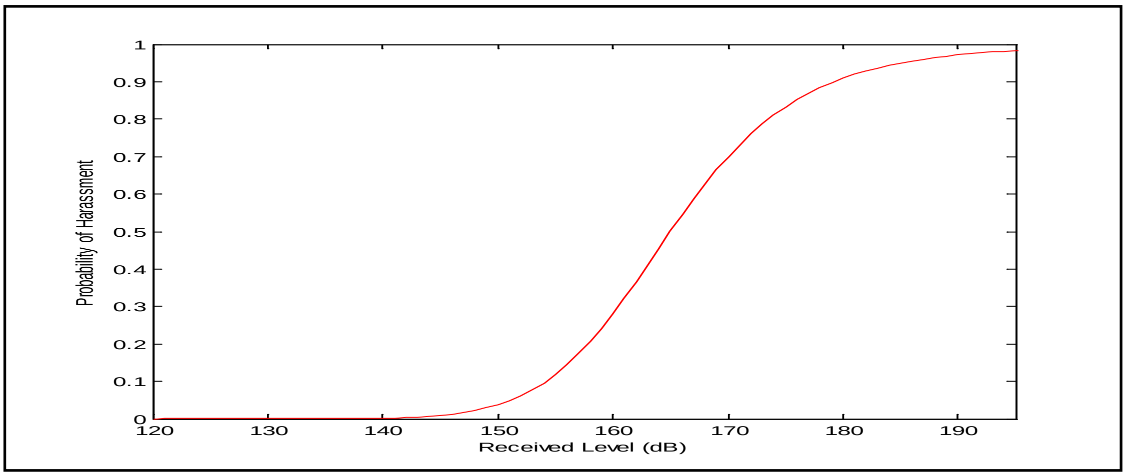

Figure 6-5: Behavioral Response Function Applied to Mysticetes

These analyses assume that the probability of eliciting a behavioral response to sonar and other active acoustic sources on individual animals would be a function of the received SPL (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 received levels, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). Although the response functions differ, the intercepts on each figure highlight that each function has a 50 percent probability of harassment at a received level of 165 dB SPL. These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to SPLs below a certain basement value.

The values used in this analysis are based on three sources of data: TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003b, and 2005a; 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 (National Marine Fisheries Service 2005c; U.S. Department of the Navy 2004), 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).

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 response functions represent a relationship that is deemed to be generally true, but may not be true in specific circumstances.

Specifically, the behavioral response 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). At present, available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the response 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.

The behavioral response 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 with mid-frequency active sonar) at a given received level of sound. For example, at 165 dB SPL (dB re 1 μPa rms), 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.

6.4.2.1.1 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 actual naval mid-frequency sonar in real anti-submarine training scenarios as well as playbacks of killer whale vocalizations, and other anthropogenic sounds. Tyack et al. (2011) report that, in reaction to sonar playbacks, most beaked whales stopped echolocating, made long slow ascent, and moved away from the sound. During an exercise using mid-frequency sonar, beaked whales avoided the sonar acoustic footprint at a distance where the received level was "around 140 dB" (SPL) and once the exercise ended, beaked whales re-inhabited the center of exercise area within 2–3 days (Tyack et al. 2011). The Navy has therefore adopted an unweighted 140 dB re 1 μPa SPL threshold for significant behavioral effects for all beaked whales (family: Ziphiidae).

Since the development of the criterion, analysis of the data the 2010 and 2011 field seasons of the southern California Behavioral Responses Study have been published. The study, DeRuiter et al. (2013b), provides similar evidence of Cuvier's beaked whale sensitivities to sound based on two controlled exposures. Two whales, one in each season, were tagged and exposed to simulated mid-frequency active sonar at distances of 3.4–9.5 km. The 2011 whale was also incidentally exposed to mid-frequency active sonar from a distant naval exercise (approximately 118 km away). Received levels from the mid-frequency active sonar signals during the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa rms, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Because the sample size was limited (controlled exposures during a single dive in both 2010 and 2011) and baseline behavioral data was obtained from different stocks and geographic areas (i.e., Hawaii and Mediterranean Sea), and the responses exhibited to controlled exposures were not exhibited by an animal exposed to some of the same received levels of real sonar exercises, the Navy relied on the studies at the Atlantic Undersea Test and Evaluation Center that analyzed beaked whale responses to actual naval exercises using mid-frequency active sonar to evaluate potential behavioral responses by beaked whales to proposed training and testing activities using sonar and other active acoustic sources.

6.4.2.1.2 Harbor Porpoises

The information currently available regarding this species suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (Kastelein et al. 2000; Kastelein et al. 2005) and wild harbor porpoises (Johnston 2002) responded to sound (e.g., acoustic harassment devices, acoustic deterrent devices, or other non-impulsive sound sources) are very low (e.g., approximately 120 dB re 1 µPa). Therefore, a SPL of 120 dB re 1 µPa is used in this analysis as a threshold for predicting behavioral responses in harbor porpoises.

6.4.2.2 Impulsive Sound from Explosions

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, the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in SEL). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulsive 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, the consequence of the reaction is likely trivial and no Level B takes or significant harm as defined under ESA is considered to have occurred. 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 impulsive events can be quite short, it may be possible to accumulate multiple received impulses at SPLs 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 SEL for multiple impulsive events. For example, five air gun impulses, each 0.1 second long, received at a Type II weighted SPL of 167 dB SPL would equal a 164 dB SEL, and would

not be predicted as leading to a significant behavioral response in MF or HF cetaceans. However, if the five 0.1-second pulses are treated as a 5-second exposure, it would yield an adjusted SEL of approximately 169 dB, exceeding the behavioral threshold of 167 dB SEL. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on SEL metrics such as TTS, 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 SEL value. For impulse behavioral criteria, the new weighting functions (see Figure 6-3) are applied to the received sound level before being compared to the threshold.

Table 6-4 summarizes behavioral thresholds by marine mammal hearing group.

Table 6-4: Behavioral Thresholds for Impulsive Sound

Hearing Group	Impulsive Behavioral Threshold for > 2 pulses/24 hours	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

Notes: (1) LF_{II}, MF_{II}, HF_{II} are New compound Type II weighting functions; P_{WI}, O_{WI} = Original Type I (Southall et al. 2007) for pinniped and mustelid in water (see Finneran and Jenkins 2012). (2) SEL = re 1 µPa^2-s; SPL = re 1 µPa, SEL = Sound Exposure Level, dB = decibel, SPL = Sound Pressure Level.

6.5 Quantitative Modeling for Impulsive and Non-Impulsive Sources

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during Navy training and testing activities. Inputs to the quantitative analysis include 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 sonar, 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 potential effects due to Navy training and testing.

Various 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 influence the result. Assumptions in

previous and current 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. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold 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 variable bathymetry and an animal's likely presence at various depths.

- NAEMO accounts for the variability of the sound propagation data in both distance and depth when computing the received sound level on the animals. Previous models captured the variability in sound propagation over range and used a conservative approach to account for only the maximum received sound level within the water column.
- NAEMO bases the distribution of animats (virtual representation of an animal) over the operational area on density maps which provides a more natural distribution of animals. Previous models assumed a uniform distribution of animals over the operational area.
- NAEMO distributes animats throughout the three dimensional water space proportional to the known time that animals of that species spend at varying depths. Previous models assumed animals were placed at the depth where the maximum sound received level occurred for each distance from a source.
- NAEMO conducts a statistical analysis to compute the estimated effects on animals. Previous models assumed all animals within a defined distance would be affected by the sound.

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 the 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 mitigation zone 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. 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. This final step in the modeling process is meant to better quantify the predicted effects by accounting for likely animal avoidance behavior and implementation of standard Navy mitigations.

6.5.1 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 described as the number of animals present per unit area.

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in NMFS providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the 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, adopted a protocol to select the best available data sources based on species, area, and season (see the Navy's Pacific Marine Species Density Database Technical Report; U.S. Department of the Navy 2014b). The resulting Geographic Information System (GIS) database includes one single spatial and seasonal density value for every marine mammal and sea turtle species present within the Study Area.

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. EEZ. NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. EEZ. NMFS publishes annual SARs for various regions of U.S. waters and covers all stocks of marine mammals within those waters. The majority of species that occur in the Study Area are covered by the Pacific Region Stock Assessment Report (Carretta et al. 2014), with a few species (e.g., Steller sea lions) covered by the Alaska Region Stock Assessment Report (Allen and Angliss 2014). 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). Where the data supports habitat based density modeling, the Navy's database uses those density predictions. 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). 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 cetacean 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 or Relative Environmental Suitability 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).

Methods used to estimate pinniped at-sea density are generally quite different than those described above for cetaceans. Pinniped abundance is generally estimated via shore counts of animals at known rookeries and haulout sites. For example, for species such as the California sea lion, population estimates are based on counts of pups at the breeding sites (Carretta et al. 2014). However, this method is not appropriate for other species such as harbor seals, whose pups enter the water shortly after birth. Population estimates for these species are typically made by counting the number of seals ashore and applying correction factors based on the proportion of animals estimated to be in the water (Carretta et al. 2014). Population estimates for pinniped species that occur in the Study Area are provided in the

Pacific Region Stock Assessment Report (Carretta et al. 2014). Translating these population estimates to in-water densities presents challenges because the percentage of seals or sea lions at sea compared to those on shore is species-specific and depends on gender, age class, time of year (molt and breeding/pupping seasons), foraging range, and for species such as harbor seal, time of day and tide level. These parameters were identified from the literature and used to establish correction factors which were then applied to estimate the proportion of pinnipeds that would be at sea within the Study Area for a given season.

6.5.1.1 North Pacific Right Whale

For North Pacific right whales, as presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), the population is so low (n=31), they are generally found only in the Bering Sea, and the square kilometer area of potential occurrence is very large (including the Bering Sea and much of the North Pacific). Given these factors, any derived density would be too low to be informative in acoustic modeling; predicting estimated effects much less than one (1.0) based on the low number of predicted effects for species that are much more numerous (e.g., blue whale). Given overall the low number of animals in the population and that a North Pacific right whale has not been seen in the Study Area since 1992 (indicating a highly unlikely presence), the Navy has determined possible effects to North Pacific right whale from Navy training and testing in the Study Area are discountable and a density for the North Pacific right whale is therefore not required for the impact analyses which follow.

6.5.1.2 Northern Sea Otter

For sea otters, as presented in detail in Section 3.4.3.34 (Northern Sea Otter [*Enhydra lutris kenyoni*]), the presence of sea otters in the Western Behm Canal (Alaska) portion of the Study Area is considered extralimital. There have been confirmed sightings of scattered individuals in the inland waters portion of the Study Area where they are considered rare, and given that sea otters seldom range more than 1.2 mi. (2 km) from shore and are not known to migrate, their occurrence is also considered rare in the offshore portion of the Study Area. Sea otters are likely to be in the coastal margin of the offshore area (e.g., Quinault Range; see Section 2.1.1.2, Sea and Undersea Space), which is used for some testing activities. Almost all the proposed activities would occur far from any likely sea otter presence. Additionally, sea otters inhabit acoustically complex shallow water environments where acoustic modeling is very imprecise and therefore not representative and they spend little time underwater (see Watwood and Buonantony 2012) thus very much limiting the potential for exposure in any case. Even if exposed to sound from Navy activities, research indicates sea otters often remained undisturbed, quickly become tolerant of various sounds, and even when purposefully harassed they generally moved only a short distance (100–200 m) before resuming normal activity (Davis et al. 1988). Therefore, the Navy has determined that possible effects to Northern sea otter from Navy training and testing in the Study Area are discountable and a density for the sea otter was therefore not required for the impact analyses which follow.

For a six stocks involving three marine mammal species in the Study Area (killer whale, harbor porpoise, and Northern fur seal), there is insufficient data for a stock specific density to be derived; each of these two stocks was represented in the modeling by a single density. Therefore, as detailed in the following paragraphs, to quantify the likely number of effects to these stocks/species, the modeling based on a common species density were prorated to the stocks, and in the case of Guadalupe fur seal a surrogate species was assumed to provide an appropriate conservative estimate of effects.

6.5.1.3 Killer Whale (Alaska Resident and Northern Resident Killer Whale Stocks)

In the Western Behm Canal (Alaska) portion of the Study Area, there is overlap of the Alaska Resident and Northern Resident killer whale stocks, with each stock at the limit of its known range. There is no density available for the small number of Northern Resident animals that may be present in the Western Behm Canal. Consistent with the procedure used previously to derive the number of predicted exposures for a stock for which there is no density information available, the Navy derived a ratio based on the abundance estimates for Alaska Resident and Northern Resident) stocks of killer whales. The ratio of the Alaska Resident stock (0.89) to that of the Northern Resident stock (0.11) was then used to prorate the total modeled killer whale acoustic exposures in Western Behm Canal to each of those two stocks.

6.5.1.4 Harbor Porpoise (Northern Oregon/Washington Coast and Northern California/Southern Oregon Stocks)

For harbor porpoise in the offshore portion of the Study Area, there is overlap of the Northern Oregon/Washington Coast stock and the Northern California/Southern Oregon stock but there is only a single density available for acoustic impact modeling. Modeled effects to harbor porpoise in the offshore portion of the Study Area were therefore assigned to the appropriate stock using a derived a ratio based on the abundance estimates for the two stocks as reported in NMFS' Stock Assessment Report (Carretta et al. 2014). The ratio of the Northern Oregon/Washington Coast stock (0.40) to that of the Northern California/Southern Oregon stock (0.60) was then used to prorate the total modeled exposures in order to estimate acoustic exposures for each of these stocks in the offshore portion of the Study Area.

6.5.1.5 Northern Fur Seal (Eastern Pacific and California Stocks)

For northern fur seals in the Study Area, there is insufficient information available to allow for a density that is broken out by the Eastern Pacific stock and California stock. The Navy derived a ratio based on the abundance estimates for these two northern fur seal stocks as reported in the NMFS' Stock Assessment Report (Carretta et al. 2014). The ratio of the Eastern Pacific stock (0.985) to that of the California stock (0.015) was then used to prorate the total modeled exposures in order to estimate acoustic exposures for each of these stocks of northern fur seal in the Study Area.

6.5.1.6 Pygmy Sperm Whale and Dwarf Sperm Whale

As detailed in U.S. Department of the Navy (2014b), pygmy sperm whales and dwarf sperm whales are *Kogia* species that are difficult to detect and distinguish from one another during surveys. As a result, NMFS is only able to provide density data for *Kogia* as a guild. For this reason, a single *Kogia* density was used to represent the two species (pygmy sperm whale and dwarf sperm whale) for acoustic impact modeling purposes.

6.5.1.7 Cuvier's Beaked Whale and *Mesoplodon* Beaked Whale

There is insufficient data to derive an individual Cuvier's beaked whale density in the offshore portion of the Study Area, however, Cuvier's beaked whales were considered in the modeling of activities in that area since they were grouped in with the *Mesoplodon* beaked whale density and distribution. Based on ship surveys conducted in waters off Washington and Oregon from 1991 to 2008 (reported in Barlow 2010), the abundances for these stocks are as follows: Cuvier's beaked whales, n= 137; Mesoplodon beaked whales, n= 565. Therefore, to derive Cuvier's beaked whale numbers from the modeling results for *Mesoplodon* beaked whales, the Navy has derived a ratio based on the abundance estimates for the two resulting in 20 percent of the *Mesoplodon* beaked whale modeled effects being counted as effects

to Cuvier's beaked whale. In the Western Behm Canal (Alaska) portion of the Study Area, there was sufficient data for derivation of a Cuvier's beaked whale density and acoustic modeling for activities in that location was conducted without the need for other considerations.

6.5.1.8 Gray Whale (Western North Pacific Stock)

As described in detail in Section 3.4.2.12 (Gray Whales [*Eschrichtius robustus*]), the migration routes of the Western North Pacific stock of gray whales are poorly known. Research indicates that in the western Pacific, the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of their presently identified migratory route and the coastal waters of Canada, the U.S., to at least Baja California, in Mexico are part of their identified migratory route in the eastern Pacific (Weller et al. 2002, 2012, 2013).

Gray whales are generally slow-moving animals (Jefferson et al. 2008). Migrating gray whales sometimes exhibit a unique "snorkeling" behavior, whereby they surface cautiously, exposing only the area around the blowhole, exhale quietly without a visible blow, and sink silently beneath the surface (Jones and Swartz 2009). Mate and Urban-Ramirez (2003) report an average gray whale speed of approximately 2.8 knots (5.2 kilometers/hour) based on a tagged migrating animal. At this swim speed and assuming a coastal migration route through the NWTT Study Area similar to that presented in Sumich and Snow (2011), it should take approximately 8 days for a gray whale to cross through the offshore portion of the Study Area (approximately 510 nm). It is assumed they will do this twice a year during their annual southbound and northbound migration legs.

Given the emergent nature of the science associated with the Western North Pacific stock of gray whales, there is no data that provides an estimate of the number of animals in this stock that may be present when migrating through the Study Area. Based on the estimated population of approximately 155 individuals (International Union for Conservation of Nature 2012) and the data in Weller at al. (2013), the Navy conservatively estimates 23 Western North Pacific gray whales may migrate along the U.S. Pacific coast. Therefore, based on the Navy's estimate for the number of Western North Pacific stock of gray whales possibly in the Study Area and the latest abundance for the Eastern North Pacific stock (n=19,126), the resulting ratio of the Western North Pacific stock (0.12 percent) to that of the Eastern North Pacific stock (99.88 percent) was used to prorate the modeled exposures for the Eastern North Pacific gray whale (for which a density was derived) in order to estimate acoustic effects to the Western North Pacific stock of gray whale.

6.5.1.9 Guadalupe Fur Seal

There is insufficient information available for the accurate derivation of a density or abundance representing the likely presence of Guadalupe fur seals in the offshore portion of the Study Area given the emergent nature of the data associated with the return of this species to the Washington/Oregon coast. Although rare Guadalupe fur seals are known to be present. In 2012, there were 58 Guadalupe fur seals found stranded on Washington/Oregon coast (Lambourn 2013). Under the assumption that not more than 50 percent of animals (mostly young of the year) have stranded, the number of strandings in 2012 suggests there are approximately 116 Guadalupe fur seals present offshore in the Study Area. Given the offshore portion of the Study Area is approximately 416,845 km^2 in area, this suggested number of animals present based on standings would translate to a density of 0.00028 Guadalupe fur seal per km^2 in the offshore area. In comparison, in the warm season there should be 663 California

stock[9] of northern fur seal present in the same offshore area having a calculated density of 0.00159 per km^2 or approximately 5.5 times that estimated for Guadalupe fur seal. Given there is density data and acoustic effects modeling for northern fur seal, in a conservative approach (assumed to overestimate actual impacts) that provides for a quantification of effects to Guadalupe fur seals, the Navy has taken the acoustic effects modeling results for California stock northern fur seals as a surrogate for Guadalupe fur seals. This is suggested as a reasonable approach since the most recent stranding data suggests it should provide a conservative estimate of effects to Guadalupe fur seals. In addition, the seasonal presence for the two species/stocks is likely the same and both have a similar approximate distances to cover from the Study Area migrating south to their rookery; for the California stock of northern fur seal (1,100 nm); for Guadalupe fur seal (1,400 nm). Given the latest abundance for California stock of northern fur seals as provided by Carretta et al. (2013) is n=12,844 and as provided in Esperon-Rodriguez and Gallo-Reynoso (2012) for Guadalupe fur seals is "14,000-15,000" (from a 2008 survey) it is assumed that potential differences in relative abundances for the two species in the Study Area are evened-out by the additional 360 mi. distance from the Guadalupe Island rookery. For these reasons, the Navy will assume acoustic effects modeling results for the California stock of northern fur seal are a reasonable approximation and conservative estimation of effects to Guadalupe fur seals once adjustments for the more limited distribution of Guadalupe fur seals in the Study Area are also considered.

6.5.1.10 Harbor seals (Washington Inland Waters stocks; Hood Canal, Washington Northern Inland Waters, and Southern Puget Sound stocks)

For harbor seals in the inland waters portion of the Study Area, there was a change to the Washington Inland Waters stock in 2014 subsequent to the presentation of the NWTT Draft EIS/OEIS to the public. Based on DNA evidence, the single Inland Waters stock was broken up into three new stocks, designated the Hood Canal, the Washington Northern Inland Waters, and the Southern Puget Sound stocks (Carretta et al. 2014). Evidence from tagging data (London et al. 2012) suggests the Hood Canal stock generally does not forage beyond Hood Canal. The Navy has assumed that acoustic effects modeling for locations in Hood Canal and Dabob Bay can therefore be accurately assigned to the Hood Canal stock. For the Washington Northern Inland Waters stock and the Southern Puget Sound stock and because it is possible that these stocks overlap while foraging, modeled acoustic effects to harbor seals in the inland waters portion of the Study Area (excluding Hood Canal and Dabob Bay) were therefore assigned to the appropriate stock using a derived ratio based on the abundance estimates for the two stocks as reported in the 2013 Pacific Stock Assessment Report (Carretta et al. (2014); Washington Northern Inland Waters stock: n = 11,036; Southern Puget Sound stock: n = 1,568). The ratio of the Washington Northern Inland Waters stock (0.88) to that of the Southern Puget Sound stock (0.12) was then used to prorate the total modeled exposures in order to estimate acoustic exposures for each of these stocks in the inland waters portion of the Study Area.

6.5.2 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 (see Finneran and Jenkins 2012). These are not the same as the values used to calculate weighting curves, but exceed the

[9] The warm season density for northern fur seals in this area used in modeling is 0.106 per km^2 or approximately 44,186 animals in the Study Area. The ratio of the Eastern Pacific stock (0.985) to that of the California stock (0.015) indicates there should be a California stock northern fur seal density of 0.00159 per km^2 and 663 animals from that stock in this area based on that warm season density.

demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 6-5 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 & Mustelidae (in water)	50	60,000
Phocidae Pinnipeds (in water)	50	80,000

Notes: Hz = Hertz

6.5.3 Navy Acoustic Effects Model

For this analysis of Navy training and testing activities in the Study Area, the Navy uses software tools, up to date marine mammal density data, and other oceanographic data for the quantification of predicted acoustic impacts to marine mammals. These tools and databases collectively form the NAEMO. Details of this model's processes and the description and derivation of the inputs are presented in the Navy's Determination of Acoustic Effects Technical Report (Marine Species Modeling Team 2013). The NAEMO improves upon previous modeling efforts in several ways. First, unlike the method used previously (e.g., U.S. Department of the Navy 2010a) that modeled sources individually, the NAEMO 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 NAEMO, virtual animals or "animats" are distributed non-uniformly 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 NAEMO, rather than a two-dimensional environment where the worse case SPL 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 (Marine Species Modeling Team 2013). The following paragraphs provide an overview of the NAEMO 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 NAEMO derives an abundance (total number 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 (acoustic energy footprint). For example, for non-impulse sources, all animats that are predicted to occur within a range that could receive SPLs greater than or equal to 120 dB re 1 µPa are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles; see Marine Species Modeling Team (2013) for a detailed discussion on animal dive profiles). Animats change depths every 4 minutes but do

not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus, 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 NAEMO 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 NAEMO, animats are placed horizontally dependent upon non-uniform density information, and then move up and down over time within the water column by interrogating 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 NAEMO. 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 NAEMO overpopulates the animats over a non-uniform 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 carried out during development of the NAEMO. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures were similar between the NAEMO and the fully moving distribution, however, computational time was much longer for the fully moving distribution.

The NAEMO 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 NAEMO 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 to 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 NAEMO provides the initial predicted impacts to marine species (based on application of multiple conservative assumptions which are assumed to overestimate impacts), which are then further analyzed to produce final estimates used in the Navy's MMPA application for LOA and ESA risk analyses (see

Section 3.4.3.6.1.2, Avoidance Behavior and Mitigation Measures, for further information on additional analyses).

6.5.4 Model Assumptions and Limitations

There are limitations to the data used in the NAEMO, and the results must be interpreted with consideration for these known limitations. Output from the NAEMO relies heavily on the quality of both the input parameters and impact thresholds and criteria. 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 mitigation zone 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. In short, when there was a lack of definitive data to support an aspect of the modeling (such as lack of well described diving behavior for all marine species), conservative assumptions believed to overestimate the number of exposures were chosen:

- Animats are modeled as being underwater and facing the source and therefore always predicted to receive the maximum sound level at their position within the water column (e.g., the model does not account for conditions such as body shading, porpoising out of the water, or an animal such as a pinniped raising its head 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 toward the rear or side of an animal (Kastelein et al. 2005; Mooney et al. 2008; Popov and Supin 2009)
- 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 permanent hearing loss (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 implemented during many training and testing activities were not considered in the model (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). 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, initial predicted model results must be further analyzed, considering such factors as the range to specific effects, likely avoidance by marine mammals, and the likelihood of successfully implementing mitigation measures. This analysis uses a

number of factors in addition to the acoustic model results to more accurately estimate the acoustic effects to marine mammals as described in the following sections: Section 3.4.3.6.1.2, Avoidance Behavior and Mitigation Measures; 3.4.3.5.4, Marine Mammal Avoidance of Sound Exposures; and Section 3.4.3.5.5, Implementing Mitigation to Reduce Sound Exposures.

6.5.5 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid underwater sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the NAEMO does not consider horizontal movement of animats, including avoidance of human activity or sounds, it overestimates 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 6.1.2 (Analysis Background and Framework).

6.5.5.1 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 porpoise and beaked whales have been observed to be especially sensitive to human activity (Tyack et al. 2011; Pirotta et al. 2012), which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonar and other active acoustic sources (see Section 6.1.2, Analysis Background and Framework). Harbor porpoises routinely avoid and swim away from large motorized vessels (Barlow 1988; Palka and Hammond 2001; Polacheck and Thorpe 1990). 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; Tyack et al. 2011).

Therefore, for certain naval activities proceeded by high levels of vessel activity (multiple vessels) or hovering aircraft, harbor porpoise 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 porpoise 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 recoverable injury, respectively, due to animals moving away from the activity and into a lower effect range.

6.5.5.2 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 sonar or other active acoustic source and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 6.3.2.2 (Range to Impulsive Effects for Sonar and Other Active Acoustics Sources), and avoidance of repeated explosive exposures is discussed further in Section 6.3.2.4 (Range to Impulsive Effects for Explosives).

6.5.5.3 Harbor Seal Haulout Behavior

Harbor seal are the most numerous pinniped in the Study Area. While the estimate for the number of harbor seal in the area is likely a conservative overestimate, it was used in all acoustic impact modeling

and it did not take into account haulout behavior by harbor seal. Consistent with previous MMPA authorizations for actions in the inland waters portion of the NWTT EIS/OEIS Study Area (with the exception of Hood Canal), there is sufficient data to determine that approximately 65 percent of harbor seals are hauled out at a given moment and only 35 percent of seals are in the water (Huber et al. 2001; Jeffries et al. 2003; National Oceanic and Atmospheric Administration 2011). In Hood Canal, approximately 20% of the harbor seals are hauled out at any given time and 80% of the seals are in the water (derived from London et al. 2012). Therefore, to account for haulout behavior by harbor seals in the inland waters (except Hood Canal) and offshore portions of the Study Area, model-predicted effects to harbor seals will be multiplied by a factor of 0.35. In Hood Canal model-predicted effects to harbor seals will be multiplied by a factor of 0.80. This adjustment factor is used to limit overestimation of potential take from underwater acoustic sources otherwise applied to harbor seals that should be hauled out on land. Given there is insufficient data to determine a similar haulout correction factor for other pinniped in the area (California sea lion, northern fur seal, northern elephant seal, Guadalupe fur seal, and Steller sea lion) and to remain consistent with previous MMPA authorizations for the area (National Oceanic and Atmospheric Administration 2011), there is no reduction in the model-predicted effects to other pinniped or for harbor seal in the offshore portion of the Study Area.

6.5.6 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 NAEMO estimates acoustic effects without any shutdown or delay of the activity in the presence of marine mammals; therefore, the model overestimates impacts to marine mammals within mitigation zones. The post-model adjustment factors in and quantifies the potential for highly effective mitigation to reduce the likelihood or risk of PTS due to exposure to sonar and other active acoustic sources and injuries and mortalities due to explosives. A detailed explanation of this analysis is provided in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Northwest Training and Testing* (U.S. Department of the Navy 2014c).

Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity, and (2) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics. 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 quantified reduction of model predicted effects when the mitigation zone can be fully or mostly observed prior to and during a sound-producing activity. Mitigation for each training or testing event is considered in its entirety, taking into account the different ways an event's activities may take place as part of that event (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) were estimated for each training or testing event. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the 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 range to effects zone can be visually observed for the majority of the scenarios), 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 as an adjustment factor in the acoustic effects analysis.

The ability of Navy Lookouts to detect marine mammals in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data were available to numerically approximate the sightability of marine mammals and determined that the standard "detection probability" referred to as g(0) was most appropriate. The abundance of marine mammals is typically estimated using line-transect analyses (Buckland et al. 2001), in which g(0) is the probability of detecting an animal or group of animals on the transect line (the straight-line course of the survey ship or aircraft). This detection probability is derived from systematic line-transect marine mammal surveys based on species-specific estimates for vessel and aerial platforms. Estimates of g(0) are available from peer-reviewed marine mammal line-transect survey reports, generally provided through research conducted by the National Marine Fisheries Service Science Centers. The g(0) values used in this analysis are provided in Table 6-6.

There are two separate components of g(0); perception bias and availability bias (Marsh and Sinclair 1989). Perception bias accounts for marine mammals that are on the transect line and detectable, but are simply missed by the observer (Barlow 2013). Various factors influence the perception bias component of g(0), including species-specific characteristics (e.g., behavior and appearance, group size, and blow characteristics), viewing conditions during the survey (e.g., sea state, wind speed, wind direction, wave height, and glare), observer characteristics (e.g., experience, fatigue, and concentration), and platform characteristics (e.g., pitch, roll, speed, and height above water). To derive estimates of perception bias, typically an independent observer is present who looks for marine mammals missed by the primary observers. Mark-recapture methods are then used to estimate the probability that animals are missed by the primary observers. Availability bias accounts for animals that are missed because they are not at the surface at the time the survey platform passes by, which may for example occur with deep diving whales (e.g., sperm whale and beaked whale). The availability bias portion of g(0) is independent of prior marine mammal detection experience since it only reflects the probability of an animal being at the surface within the survey track and therefore available for detection.

Some g(0) values are estimates of perception bias only, some are estimates of availability bias only, and some reflect both, depending on the species and data currently available. The Navy used g(0) values with both perception and availability bias components if those data were available. If both components were not available for a particular species, the Navy determined that g(0) values reflecting perception bias or availability bias, but not both, still represented the best statistically derived factor for assessing the likelihood of marine mammal detection by Navy Lookouts.

As noted above, line-transect surveys and subsequent analyses are typically used to estimate cetacean abundance. To systematically sample portions of an ocean area (such as the coastal waters off the continental U.S.), marine mammal surveys are designed to uniformly cover the survey area and are conducted at a constant speed (generally 10 knots for ships and 100 knots for aircraft). Survey transect lines typically follow a pattern of straight lines or grids. Generally there are two primary observers

searching for marine mammals. Each primary observer looks for marine mammals in the forward 90-degree quadrant on their side of the survey platform. Based on data collected during the survey, scientists determine the factors that affected the detection of an animal or group of animals directly along the transect line.

Visual marine mammal surveys (used to derive g(0)) are conducted during daylight.[10] Marine mammal surveys are typically scheduled for a season when weather at sea is more likely to be good; however, observers on marine mammal surveys will generally collect data in sea-state conditions up to Beaufort 6 and do encounter rain and fog at sea, which may also reduce marine mammal detections (Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflect the fact that marine mammal surveys are often conducted in less than ideal conditions (Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., some beaked whales, *Kogia* spp., and Dall's porpoise) decreases dramatically with increasing sea states, so g(0) estimates for these species are usually restricted to observations in sea-state conditions of Beaufort 0 to 2 (Barlow 2003, 2013).

[10] At night, passive acoustic data may still be collected during a marine mammal survey.

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

Species	Family	Vessel Sightability	Aircraft Sightability
Baird's Beaked Whale	Ziphidae	0.96	0.18
Blue whale, Fin Whale, Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin	Delphinidae	0.76	0.67
California Sea Lion	Otariidae	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.)	Delphinidae	0.35	0.074
Gray Whale	Balaenopteridae	0.921	0.482
Guadalupe Fur Seal	Otariidae	0.299	0.299
Harbor Porpoise	Phocoenidae	0.769	0.292
Harbor Seal	Phocidae	0.281	0.281
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.921	0.95
Mesoplodon Beaked Whale	Ziphidae	0.45	0.11
Minke Whale	Balaenopteridae	0.856	0.386
North Pacific Right Whale	Balaenidae	0.645	0.41
Northern Elephant Seal	Phocidae	0.105	0.105
Northern Fur Seal	Otariidae	0.299	0.299
Northern Right Whale Dolphin	Delphinidae	0.856	0.67
Pacific White-sided Dolphin	Delphinidae	0.856	0.67
Risso's Dolphin	Delphinidae	0.76	0.67
Short-beaked Common Dolphin	Delphinidae	0.865	0.67
Short-finned Pilot Whale, Striped Dolphin	Delphinidae	0.76	0.67
Sperm Whale	Physeteridae	0.87	0.32
Steller Sea Lion	Otariidae	0.299	0.299

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 a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0). The published California Sea Lion aircraft g(0) is used for Steller Sea Lion, Guadalupe Fur Seal, and Northern Fur Seal since all are in the otariidae family and there is no g(0) data for these other species. Pinniped g(0) are not available for vessels so the aircraft value has been used as a conservative under estimate of sightability. North Atlantic right whale data (Palka 2005) has been used for North Pacific right whale.

Sources: Barlow 2006; Barlow et al. 2006; Barlow and Forney 2007; Carretta et al. 2000; Forney and Barlow 1998; Laake et al. 1997; Palka 2005

Navy training and testing events differ from systematic line-transect marine mammal surveys in several respects. These differences suggest the use of g(0), as a sightability factor to quantitatively adjust model-predicted effects based on mitigation, is likely to result in an underestimate of the protection afforded by the implementation of mitigation as follows:

- Mitigation zones for Navy training and testing events are significantly smaller (typically less than 1,000 yd. radius) than the area typically searched during line-transect surveys, which includes the maximum viewable distance out to the horizon.
- In some cases, Navy events can involve more than one vessel or aircraft (or both) operating in proximity to each other or otherwise covering the same general area. Additional vessels and aircraft can result in additional watch personnel observing the mitigation zone (e.g., ship shock trials). This would result in more observation platforms and observers looking at the mitigation zone than the two primary observers used in marine mammal surveys upon which g(0) is based. For some Navy activities taking place in the inland waters of the Study Area, additional Navy shore-based observers may also be present.
- A systematic marine mammal line-transect survey is designed to sample broad areas of the ocean, and generally does not retrace the same area during a given survey. Therefore, in terms of g(0), the two primary observers have only a limited opportunity to detect marine mammals that may be present during a single pass along the trackline (i.e., deep diving species may not be present at the surface as the survey transits the area). In contrast, many Navy training and testing activities involve area-focused events (e.g., ASW TRACKEX), where participants are likely to remain in the same general area during an event. In other cases, Navy training or testing activities are stationary (i.e., pierside sonar testing or use of dipping sonar), which allow Lookouts to focus on the same area throughout the activity. Both of these circumstances result in a longer observation period of a focused area with more opportunities for detecting marine mammals than are offered by a systematic marine mammal line-transect survey that only passes through an area once.

Although Navy Lookouts on ships have hand-held binoculars and on some ships, pedestal-mounted binoculars very similar to those used in marine mammal surveys, there are differences between the scope and purpose of marine mammal detections during research surveys along a trackline and Navy Lookouts observing the water near a Navy training or testing activity to facilitate implementation of mitigation. The distinctions require careful consideration when comparing the Navy Lookouts and Navy shore-based observers to marine mammal surveys.[11]

[11] Barlow and Gisiner (2006) provide a description of typical marine mammal survey methods from ship and aircraft and then provide "a crude estimate" of the difference in detection of beaked whales between trained marine mammal observers and seismic survey mitigation, which is not informative with regard to Navy mitigation procedures for the following reasons. The authors note that seismic survey differs from marine mammal surveys in that, "(1) seismic surveys are also conducted at night; (2) seismic surveys are not limited to calm sea conditions; (3) mitigation observers are primarily searching with unaided eyes and 7x binoculars; and (4) typically only one or possibly two observers are searching." When Navy implements mitigation for which adjustments to modeling output were made, the four conditions Barlow and Gisiner (2006) note are not representative of Navy procedures nor necessarily a difference in marine mammal line-transect survey procedures. The Navy accounts for reduced visibility (i.e., activities that occur at night, etc.) by assigning a lower value to the mitigation effectiveness factor. On Navy ships, hand-held binoculars are always available, and pedestal mounted binoculars, very similar to those used in marine mammal surveys, are generally available to Navy Lookouts on board vessels over 60 ft. Also, like marine mammal observers, Navy Lookouts are trained to use a methodical combination of unaided eye and optics as they search the surface around a vessel. The implication that marine mammal surveys only occur in "calm sea conditions" is not accurate since the vast majority of marine mammal surveys occur in conditions up to sea states of Beaufort 5. The specific g(0) values analyzed by Barlow and Gisiner (2006) were derived from survey data for Cuvier's and *Mesoplodon* beaked whales detected in sea states of Beaufort 0–2 during daylight hours. However, marine mammal surveys are not restricted to sea states of Beaufort 0–2 and many species' g(0) values are based on conditions up to and including Beaufort 5; therefore, the conclusions reached by Barlow and Gisiner (2006) regarding the effect of sea state conditions on sightability do not apply to other species. Finally, when

- A marine mammal observer is responsible for detecting marine mammals in their quadrant of the trackline out to the limit of the available optics. Although Navy Lookouts and shore-based observers are responsible for observing the water for safety of ships and aircraft, during specific training and testing activities, they need only detect marine mammals in the relatively small area that surrounds the mitigation zone (in most cases less than 1,000 yd. from the ship) for mitigation to be implemented.
- Navy Lookouts, personnel aboard aircraft, on watch onboard vessels at the surface, and at shore-based locations will have less experience detecting marine mammals than marine mammal observers used for line-transect survey. However, Navy personnel responsible for observing the water for safety of ships and aircraft do have significant experience looking for objects (including marine mammals) on the water's surface and Lookouts are trained using the NMFS-approved Marine Species Awareness Training.
- Navy shore-based observers associated with some testing activities in inland waters are manning a fixed location providing visual surveillance of the event location. These shore-based observers are trained in marine mammal recognition by qualified NMFS approved organizations in addition to the NMFS-approved Marine Species Awareness Training.

Although there are distinct differences between marine mammal surveys and Navy training and testing, the use of g(0) as an approximate sightability factor for quantitatively adjusting model-predicted impacts due to mitigation (mitigation effectiveness x g(0)) is an appropriate use of the best available science based on the way it has been applied. Consistent with the Navy's impact assessment processes, the Navy applied g(0) in a conservative manner (erring on the side of overestimating the number of impacts) to quantitatively adjust model-predicted effects to marine mammals within the applicable mitigation zones during Navy training and testing activities. Conservative application of g(0) includes:

- In addition to a sightability factor (based on g(0)), the Navy also applied a mitigation effectiveness factor to acknowledge the uncertainty associated with applying the g(0) values derived from marine mammal surveys to specific Navy training and testing activities where the ability to observe the whole mitigation zone is less than optimal (generally due to the size of the mitigation zone).
- For activities that can be conducted at night, the Navy assigned a lower value to the mitigation effectiveness factor. For example, if an activity can take place at night half the time, then the mitigation effectiveness factor was only given a value of 0.5.
- The Navy did not quantitatively adjust model-predicted effects for activities that were given a mitigation effectiveness factor of zero. A mitigation effectiveness factor of zero was given to activities where 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. However, some protection from applied mitigation measures would be afforded during these activities, even though they are not accounted for in the quantitative reduction of model-predicted impacts.
- The Navy did not quantitatively adjust model-predicted effects based on detections made by other personnel that may be involved with an event (such as range support personnel aboard a

Lookouts are present, there are always more than the "one or two personnel" described by Barlow and Gisiner (2006) observing the area ahead of a Navy vessel (additional bridge watch personnel are also observing the water around the vessel).

torpedo retrieval boat or support aircraft), even though information about marine mammal sightings are shared among units participating in the training or testing activity. In other words, the Navy only quantitatively adjusted the model-predicted effects based on the required number of Lookouts.

- The Navy only quantitatively adjusted model-predicted effects within the range to mortality (explosives only) and injury (all sound-producing activities), and not for the range to TTS or other behavioral effects (see Chapter 11 for a comparison of the range to effects for PTS, TTS, and the recommended mitigation zone). Despite employing the required mitigation measures during an activity that will also reduce some TTS exposures, the Navy did not quantitatively adjust the model-predicted TTS effects as a result of implemented mitigation.
- The total model-predicted number of animals affected is not reduced by the post-model mitigation analysis, since all reductions in mortality and injury effects are then added to and counted as TTS effects.
- Mitigation involving a power-down or cessation of sonar, or delay in use of explosives, as a result of a marine mammal detection, protects the observed animal and all unobserved (below the surface) animals in the vicinity. The quantitative adjustments of model-predicted impacts, however, assume that only animals on the water surface, approximated by considering the species-specific g(0) and activity-specific mitigation effectiveness factor, would be protected by the applied mitigation (i.e., a power down or cessation of sonar or delaying the event). The quantitative post-model mitigation analysis, therefore, does not capture the protection afforded to all marine mammals that may be near or within the mitigation zone.

The Navy recognizes that g(0) values are estimated specifically for line-transect analyses; however, g(0) is still the best statistically derived factor for assessing the likely marine mammal detection abilities of Navy Lookouts. Based on the points summarized above, as a factor used in accounting for the implementation of mitigation, g(0) is therefore considered to be the best available scientific basis for the Navy's representation of the sightability of a marine mammal as used in this analysis.

The post-model acoustic effect analysis quantification process is summarized in Table 6-7 and presented in detail in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Northwest Training and Testing* (U.S. Department of the Navy 2014c).

In brief, the mitigation effectiveness score for an event is multiplied by the estimated sightability of each species to quantify the number of animals that were originally modeled as a mortality (explosives only) or injury (all sound-producing activities) exposure but would, in reality, be observed by Lookouts or shore-based observers prior to or during a sound-producing activity. Observation of marine mammals prior to or during a sound-producing event would be followed by stop or delay of the sound-producing activity, which would reduce actual marine mammal sound exposures. 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 Table 5-2 and Table 5-5.

Table 6-7: Post-Model Effects Quantification 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., harbor porpoises and 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 TTS (animal is assumed to move into the range of potential TTS). 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., harbor porpoises and 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. Can Lookouts observe the activity-specific mitigation zone (Chapter 11) up to and during the sound-producing activity?	***E-2. Can Lookouts observe the activity-specific mitigation zone (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-3. 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 NAEMO 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 and low frequency cetaceans are expected to actually occur (after accounting for mitigation in step S-2). 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. 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).	The NAEMO 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.

The incorporation of mitigation factors for the reduction of predicted effects used a conservative approach (erring on the side of overestimating the number of effects) since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals. It is important to note that there are additional protections offered by mitigation procedures which will further reduce effects to marine mammals, but these are not considered in the quantitative adjustment of the model predicted effects.

6.5.7 Impacts on Marine Mammals

6.5.7.1 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 (Quantitative Modeling for Impulsive and Non-Impulsive Sources). Direct injury from sonar and other non-impulse sources (other than potential PTS) would not occur under conditions present in the natural environment, and therefore, is not considered further in this analysis.

Exposure of marine mammals to non-impulse sources such as active sonar would not result in primary blast injuries or barotraumas. Sonar induced acoustic resonance and bubble formation phenomena are unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 6.3.1 (Direct Injury). Direct injury from sonar and other non-impulse sources (other than potential PTS) would not occur under conditions present in the natural environment, and therefore, is not considered further in this analysis.

Research and observations of auditory masking in marine mammals is discussed in Section 6.3.3 (Auditory Masking). Anti-submarine warfare sonar can produce intense underwater sounds in the Study Area. These sounds are likely within the audible range of most marine mammals, 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 but most are shorter than one second. The duty cycle is low with most tactical ASW sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed since the platforms are moving and most event durations are limited to a few hours. Tactical sonar's transmit frequencies are typically narrow band (typically less than one-third octave; within a few hundred Hertz). These factors reduce the likelihood or severity of these sources causing significant auditory masking in marine mammals.

Some active acoustic sources (e.g., some countermeasures) have a high duty cycle. These sources employ high frequencies (10 kHz and above) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher frequency active acoustic sources are typically above the estimated upper hearing range of mysticetes used in this analysis, therefore mysticetes are unlikely to be able to detect the higher frequency active acoustic sources, and these sources 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 higher frequency sources overlap the hearing and vocalization abilities of some odontocetes, however the frequency band of these sources is also limited which limits the likelihood of auditory masking. With any of these activities, again,

the limited duration of the overall activities limit the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other non-impulse sources are PTS, TTS, and behavioral reactions (see Section 6.2.1). The NAEMO is used to produce initial estimates of the number of animals that may receive these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. These are discussed below in the following sections.

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 on Navy inland ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed in this analysis where applicable.

6.5.7.1.1 Range to Non-Impulsive Effects for Sonar and Other Active Acoustic Sources

The following section provides range (distance) over which specific physiological or behavioral effects are expected to occur based on the acoustic criteria (see Finneran and Jenkins 2012) and the acoustic propagation calculations from the NAEMO. The range to specific effects are used to assess model results and determine adequate mitigation ranges to avoid higher level effects, especially physiological effects. Additionally, these data can be used to analyze the likelihood of an animal being able to avoid the effects of an oncoming sound source by simply moving a short distance away (e.g., a few hundred meters).

Although the Navy uses a number of sonar and active acoustic sources, the three sonar bins provided in Table 6-8 (MF1, MF4, and MF5) represent three of the most powerful sources in use in the Study Area. This section discusses sonar and other active acoustic source bins included in the 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.

Table 6-8: Approximate Ranges to Permanent Threshold Shift Criteria for Each Functional Hearing Group for a Single Ping from Three of the Most Powerful Sonar Systems within Representative Acoustic Ocean Environments

Functional Hearing Group	Ranges to the Onset of PTS for One Ping (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	70	10	≤ 2
Mid-Frequency Cetaceans	10	≤ 2	≤ 2
High-Frequency Cetaceans	100	20	10
Phocid Seals	80	10	≤ 2
Otariid Seals & Sea Lion, & Mustelid (Sea Otter)	10	≤ 2	≤ 2

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

PTS: The ranges to the PTS threshold (i.e., range to the onset of PTS: the approximate maximum distances to which PTS would be expected) are shown in Table 6-8 relative to the marine mammal's functional hearing group. For a SQS-53C sonar transmitting for one second at 3 kHz and a source level of 235 dB re 1 µPa^2-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 (109 yd.). Since any hull-mounted sonar (e.g., Bin MF1, such as the SQS-53) engaged in ASW training would be moving at 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 260 m (284 yd.) during the time between those pings (note: 10 knots is the speed used in the NAEMO). 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 and mid-frequency cetaceans, phocid and otariid pinniped, and sea otter) single-ping PTS zones are within 100 m (109 yd.) 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 6-8, 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 experience PTS. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are well within 50 m, even for multiple pings (up to 10 pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

TTS: Table 6-9 illustrates the range to TTS (i.e., the maximum distances to which TTS would be expected) for one, five, and ten pings from three representative sonar systems if they are stationary while pinging. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, sound energy from successive pings can add together, further increasing the range to onset-TTS, and if animals remain in vicinity of the sound exposure over several successive pings there is the potential for a TTS to occur.

Behavioral Response: Table 6-10 shows the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete behavioral response functions, at various SPLs (in 6 dB received level increments), from three representative sonar sources. See Section 6.2.2 and Finneran and Jenkins (2012) for details on the derivation and use of the behavioral response function as well as the step function thresholds for harbor porpoises and beaked whales of 120 dB re 1 µPa and 140 dB re 1 µPa, respectively.

Table 6-9: Approximate Ranges to the Onset of Temporary Threshold Shift for Three Representative Sonar for Three Representative Sonar Over a Representative Range of Ocean Environments

Functional Hearing Group	Approximate Ranges to Onset of TTS (meters)[1]								
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)[2]			Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		
	1 Ping	5 Pings	10 Pings	1 Ping	5 Pings	10 Pings	1 Ping	5 Pings	10 Pings
Low-Frequency Cetaceans	560–2,280	1,230–6,250	1,620–8,860	220–240	490–1,910	750–2,700	110–120	240–310	340–1,560
Mid-Frequency Cetaceans	150–180	340–440	510–1,750	< 50	< 50	< 50	< 50	< 50	< 50
High-Frequency Cetaceans	2,170–7,570	4,050–15,350	5,430–19,500	90	180–190	260–950	< 50	< 50	< 50
Pinnipeds	72–1,720	200–3,570	350–4,850	< 50	100	150	< 50	< 50	< 50

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to receive TTS extends from onset-PTS to the distance indicated.
[2] This worst case example for 5 and 10 pings is only applicable for a hull-mounted sonar that is stationary such as might occur during pierside sonar maintenance. If a vessel is moving, the time between pings and the distance covered at a nominal 10–15 knots would generally not result in overlap of sufficient sound energy for the range to PTS or TTS to expand significantly due to the accumulation of energy from subsequent pings.
Notes: ASW = anti-submarine warfare; TTS = temporary threshold shift

Table 6-10: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Low-Frequency Cetaceans under the Mysticete Behavioral Response Function for Three Representative Sonar Systems (Average Values for the Study Area)

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)	
	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	178,750–156,450	0.00%	100,000–92,200	0.00%	22,800–15,650	0.00%
126 ≤SPL <132	156,450–147,500	0.00%	92,200–55,050	0.11%	15,650–11,850	0.05%
132 ≤SPL <138	147,500–103,700	0.21%	55,050–46,550	1.08%	11,850–6,950	2.84%
138 ≤SPL <144	103,700–97,950	0.33%	46,550–15,150	35.69%	6,950–3,600	16.04%
144 ≤SPL <150	97,950–55,050	13.73%	15,150–5,900	26.40%	3,600–1,700	33.63%
150 ≤SPL <156	55,050–49,900	5.28%	5,900–2,700	17.43%	1,700–250	44.12%
156 ≤SPL <162	49,900–10,700	72.62%	2,700–1,500	9.99%	250–100	2.56%
162 ≤SPL <168	10,700–4,200	6.13%	1,500–200	9.07%	100–<50	0.76%
168 ≤SPL <174	4,200–1,850	1.32%	200–100	0.18%	<50	0.00%
174 ≤SPL <180	1,850–850	0.30%	100–<50	0.05%	<50	0.00%
180 ≤SPL <186	850–400	0.07%	<50	0.00%	<50	0.00%
186 ≤SPL <192	400–200	0.01%	<50	0.00%	<50	0.00%
192 ≤ SPL <198	200–100	0.00%	<50	0.00%	<50	0.00%
Mid Frequency Cetaceans						
120 ≤ SPL <126	179,400–156,450	0.00%	100,000–92,200	0.00%	23,413–16,125	0.00%
126 ≤ SPL <132	156,450–147,500	0.00%	92,200–55,050	0.11%	16,125–11,500	0.06%
132 ≤ SPL <138	147,500–103,750	0.21%	55,050–46,550	1.08%	11,500–6,738	2.56%
138 ≤ SPL <144	103,750–97,950	0.33%	46,550–15,150	35.69%	6,738–3,825	13.35%
144 ≤ SPL <150	97,950–55,900	13.36%	15,150–5,900	26.40%	3,825–1,713	37.37%
150 ≤ SPL <156	55,900–49,900	6.12%	5,900–2,700	17.43%	1,713–250	42.85%
156 ≤ SPL <162	49,900–11,450	71.18%	2,700–1,500	9.99%	250–150	1.87%
162 ≤ SPL <168	11,450–4,350	7.01%	1,500–200	9.07%	150–<50	1.93%
168 ≤ SPL <174	4,350–1,850	1.42%	200–100	0.18%	<50	0.00%
174 ≤ SPL <180	1,850–850	0.29%	100–<50	0.05%	<50	0.00%
180 ≤ SPL <186	850–400	0.07%	<50	0.00%	<50	0.00%
186 ≤ SPL <192	400–200	0.01%	<50	0.00%	<50	0.00%
192 ≤ SPL <198	200–100	0.00%	<50	0.00%	<50	0.00%

Notes: (1) ASW = anti-submarine warfare, m = meters, SPL = sound pressure level; (2) Odontocete behavioral response function is also used for high-frequency cetaceans, phocid seals, otariid seals and sea lions, and sea otters.

Range to 120 dB re 1 µPa varies by system, output setting, and environmental conditions, but can exceed 179 km (97 nm) for the most powerful hull mounted mid-frequency sonar; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 144 dB re 1 µPa, with the exception of harbor porpoises. All harbor porpoises that are predicted to receive 120 dB re 1 µPa or greater would be assumed to exhibit a behavioral response. Likewise, beaked whales would be predicted to have behavioral reactions at distances to approximately 73 km (40 nm) in reaction to received level of 140 dB re 1 µPa or greater. For context, measurements of the ambient sound level in Admiralty Inlet have indicated a maximum broadband SPL of 140 dB re 1 µPa and that "large commercial vessels transiting the area are expected to elevate broadband ambient noise levels over the entire width of the channel to levels in excess of 120 dB" (Bassett et al. 2012). While the low received sound level (approximately 120 dB SPL) from sonar at a maximum distance is modeled and quantified in this analysis as having some behavioral effects, masking by other ambient sounds have the potential to make perception of and reaction to the sound from the sonar at that distance less likely.

6.5.7.2 Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources

As discussed above, within the NAEMO, animats (virtual marine mammals) do not move horizontally or react in any way to avoid sound at any level. Various researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source) relative to their own location and react with responsive movement, often at distances of a kilometer or more (Au and Perryman 1982; Watkins 1986; Richardson et al. 1995; Würsig et al. 1998; Jansen et al. 2010; Tyack et al. 2011). See Section 6.3.5 (Behavioral Responses) for a review of research and observations of marine mammals' reactions to sound sources including sonar, ships, and aircraft. 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 NAEMO does not account for the implementation of mitigation, discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other non-impulse sources are further analyzed considering avoidance and implementation of mitigation measures described in Section 6.5.6. For example, if sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, harbor porpoise and beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed above in Section 6.4.5.1 (Avoidance of Human Activity). Table 6-9 shows the ranges to PTS for three of the most common and powerful sound sources proposed for use when training and testing in the Study Area. The source class Bin MF1 includes the most powerful ASW system for a surface combatant, the SQS-53. The range to PTS for all systems is generally much less than 50 m (55 yd.), with the exception of high-frequency cetaceans exposed to Bin MF1 with a PTS range of approximately 100 m (110 yd.). Because the NAEMO does not include avoidance behavior, the preliminary 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 away from the activity and into the range of TTS prior to the start of the sound-producing event for the activities listed in Table 6-11 and Table 6-12. For activities where multiple vessel traffic or hovering aircraft do not precede the sound transmissions, model-predicted PTSs were not reduced based on this factor.

The NAEMO does not consider implemented mitigation, discussed in detail in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). As explained in Section 6.5.6 (Implementing Mitigation to Reduce Sound Exposures), 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 Lookouts up to and during use of the sound source, considering the sightability of a species based on g(0) (see Table 6-6), the range to PTS for each hearing group and source (see Table 6-8), and mitigation effectiveness (Table 6-12).

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

Training
Civilian Port Defense
Mine Countermeasures Exercise – Ship Sonar
Tracking Exercise/Torpedo Exercise – Helicopter
Testing
Acoustic Test Facility
Airborne Mine Hunting Test
Anti-Submarine Warfare Mission Package Testing
Anti-Submarine Warfare Tracking Test – Helicopter
Cold Water Training
Component System Testing
Countermeasure Testing
General Test/Experimental Test Vehicle
Littoral Combat Ship Mission Package Testing – Anti-Submarine Warfare
Mine Countermeasure Mission Package Testing
Mine Countermeasure/Neutralization Testing
Mine Detection/Classification Testing
System – Subsystem & Component Acoustic Testing Pierside
System – Subsystem & Component Development Testing & Training
Torpedo Exercise (all TORPEX)
Torpedo (Explosive) Testing
Underwater Vessel Acoustic Measurement (all)
Underwater Unmanned Vehicle (all UUV)

The range to PTS is generally less than 50 m (55 yd.), and the largest single ping range to PTS for the most powerful sonar system is approximately 100 m (109 yd.), so Lookouts need only to detect animals before they are within a very close range of a sound source to prevent PTS. The preliminary model-estimated PTS numbers are reduced by the portion of animals that are likely to be seen (Mitigation Adjustment Factor x Sightability). Model predicted PTS effects are adjusted based on these factors and added to the model predicted TTS exposures. This is a conservative approach that will still result in an overestimation of PTS effects since the range to PTS is generally much less than 55 yd. (50 m), Lookouts need only detect animals before they are within this very close range to implement mitigation to prevent PTS, and the g(0) detection probabilities used as a sightability factor are based on having to detect animals at much greater distance (many kilometers).

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 (see Table 6-8) do not exceed 10 m (11 yd.) in any environment modeled for the most powerful non-impulsive acoustic sources, hull-mounted sonar (e.g., Bin MF1; SQS-53C). Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (see Table 6-8) do not exceed approximately 77 and 110 yd. (70 and 100 m), respectively. Considering vessel speed during ASW 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 22 yd. (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. In addition, the animal(s) or pod would have to remain unobserved; otherwise, implemented mitigation would result in the sonar transmissions being shut down and thus ending any further exposure. Finally, the majority of marine mammals (odontocetes) have been demonstrated to have directional hearing, with best hearing sensitivity when 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 orientation (its tail pointed toward the source), potentially reducing impacts. All model-estimated PTS exposures of 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: Mitigation Adjustment Factors for Activities Using Sonar and Other Active Acoustic Sources Integrated into Modeling Analyses

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Training		
Civilian Port Defense	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Sonar Maintenance	1	Vessel
Tracking Exercise – Helo	1	Vessel
Tracking Exercise – Surface	1	Aircraft
Testing		
Acoustic Test Facility	1	Vessel
Cold Water Training	1	Vessel
Component System Testing	1	Vessel
Countermeasure Testing	1	Vessel
Electromagnetic Measurement	1	Vessel
General Test/Experimental Test Vehicle	1	Vessel
Littoral Combat Ship Mission Package Testing – Anti-Submarine	1	Vessel
LFBB	1	Vessel
Measurement System Repair/Replacement	1	Vessel
Pierside Integrated Swimmer Defense	1	Vessel
Pierside Sonar Testing	1	Vessel
POPS	1	Vessel
Proof-of-Concept Testing	1	Vessel

Table 6-12: Mitigation Adjustment Factors for Activities Using Sonar and Other Active Acoustic Sources Integrated into Modeling Analyses (continued)

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Testing (continued)		
SSBN-PRST	1	Vessel
Surface Vessel Acoustic Measurement – SAS	1	Vessel
Swimmer Detection	1	Vessel
System – Subsystem & Component Acoustic Testing Pierside	1	Vessel
System – Subsystem & Component Development Testing & Training	1	Vessel
System – Subsystem & Component Performance Testing At-Sea	1	Vessel
Submarine Sonar Testing	0.5	Vessel
Submarine Sonar Testing/Maintenance	0.5	Vessel
Target Strength Testing	1	Vessel
Torpedo Exercise (all TORPEX)	1	Vessel
Torpedo (Explosive) Testing	1	Vessel
Underwater Vessel Acoustic Measurement (all)	1	Vessel
Underwater Unmanned Vehicle (all UUV)	1	Vessel

[1] The adjustment factor for all other activities (not listed) is zero; there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation.

[2] An activity is not listed in this table if less than half of the mitigation zone cannot 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, wherein the mitigation is not used as an adjustment factor in the acoustic effects analysis.

As noted previously, the NAEMO does not account for several factors (see Section 6.3.2) that must be considered in the overall acoustic analysis. The results in the following tables are the predicted exposures from the NAEMO adjusted by the animal avoidance and mitigation factors discussed in the section above. Mitigation measures are discussed in detail in Chapter 11, and provide additional protections that are not considered in the numerical results presented in Chapter 5.

Marine mammals in other functional hearing groups (i.e., low-frequency cetaceans and high-frequency cetaceans, and pinnipeds) if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first few pings, thereby reducing SELs and the potential for PTS. Based on nominal marine mammal swim speeds and normal operating parameters for Navy vessels it was determined that an animal can easily avoid PTS zones within the timeframe it takes an active sound source to generate one to two pings. As a conservative measure, and to account for activities where there may be a pause in sound transmission, PTS was accounted for over three to four pings of an activity. Additionally and as presented above, during the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and it was not possible to implement mitigation measures (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy for that to result in a PTS exposure. Only these initial PTS exposures at the beginning of the activity or after a pause in sound transmission, are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to animal avoidance.

6.5.7.3 Impulsive (In-Water Explosives)

Explosions associated with Navy proposed training and testing activities could occur throughout the Study Area. These activities include AMW, strike warfare, ASUW, ASW, and MIW (EOD). Activities that involve explosions are described in Chapter 1 (see Table 1-5, Table 1-6, and Table 1-7). The NAEMO, in conjunction with the explosive thresholds and criteria (see Section 6.4, Thresholds and Criteria for Predicting Non-Impulsive and Impulsive Acoustic Impacts on Marine Mammals) are used to predict impacts on marine mammals from underwater explosions.

Section 6.3.1 (Direct Injury) presents a review of observations and experiments involving marine mammals and reactions to impulse sounds and underwater detonations. Energy from explosions is capable of causing mortality, direct injury, hearing loss, 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, the majority of these events are dispersed in time and throughout the offshore portion of the Study Area. These factors reduce the likelihood of these sources causing substantial or long term auditory masking in marine mammals.

6.5.7.3.1 Range to Impulsive Effects for Explosives

Table 6-13 shows the minimum and maximum ranges to the potential effect based on the thresholds described in Section 6.4. Table 6-13 also shows the ranges to onset mortality for mid-frequency and high frequency cetaceans for a representative range of charge sizes. 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 for all categories: behavioral, TTS, PTS, onset slight gastrointestinal injury, onset slight lung injury, and onset mortality.

Table 6-13: Average Approximate Range to Effects from a Single Explosion for Marine Mammals (Nominal Values for Deep Water Offshore Areas; Not Specific to the Study Area)

Hearing Group Criteria/Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins				
	Bin E3 (>0.5–2.5 lb. NEW)	Bin E5 (> 5–10 lb. NEW)	Bin E9 (> 100–250 lb. NEW)	Bin E10 (> 250–500 lb. NEW)	Bin E12 (> 650–1,000 lb. NEW)
Low-frequency Cetaceans (calf weight 200 kg)					
Onset Mortality	10	20	65	80	95
Onset Slight Lung Injury	20	40	110	135	165
Onset Slight GI Tract Injury	40	80	145	180	250
PTS	85	170	255	305	485
TTS	215	445	515	690	1,760
Behavioral Response	320	525	710	905	2,655
Mid-frequency Cetaceans (calf weight 5 kg)					
Onset Mortality	25	45	135	165	200
Onset Slight Lung Injury	50	85	235	285	345
Onset Slight GI Tract Injury	40	80	145	180	250
PTS	35	70	170	205	265
TTS	100	215	355	435	720
Behavioral Response	135	285	455	555	970
High-frequency Cetaceans (calf weight 4 kg)					
Onset Mortality	30	50	145	175	215
Onset Slight Lung Injury	55	90	250	305	370
Onset Slight GI Tract Injury	40	80	145	180	250
PTS	140	375	470	570	855
TTS	500	705	810	945	2,415
Behavioral Response	570	930	2,010	4,965	5,705
Otariidae and Mustelidae					
Onset Mortality	35	65	175	215	260
Onset Slight Lung Injury	70	115	307	370	450
Onset Slight GI Tract Injury	40	8	145	180	250
PTS	30	50	50	85	150
TTS	40	85	220	260	400
Behavioral Response	60	145	300	350	530
Phocidae					
Onset Mortality	30	50	150	185	225
Onset Slight Lung Injury	60	100	265	320	385
Onset Slight GI Tract Injury	40	80	145	180	250
PTS	95	180	340	445	680
TTS	235	500	665	815	1,350

Notes: NEW = net explosive weight, lb. = pound(s), GI = gastrointestinal, PTS = permanent threshold shift, TTS = temporary threshold shift, kg = kilogram(s)

6.5.7.4 Avoidance Behavior and Mitigation Measures as Applied to Explosions

As discussed above, within the NAEMO, 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) 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; Würsig et al. 1998). Section 6.3.5 (Behavioral Reactions) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives and other stimuli. The NAEMO 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 (see Section 6.5.6).

If explosive activities are preceded by multiple vessels or hovering aircraft, 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 low-frequency, mid-frequency, and high frequency cetaceans for a representative range of charge sizes for explosives. The range to onset mortality for all species and NEWs is less than 260 m, which is conservatively based on range to onset mortality for a calf. Because the Navy NAEMO does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for beaked whales—that they would tolerate staying in an area of high human activity. Therefore, beaked whales that were model-estimated to experience mortality are assumed to move into the range of potential slight lung injury prior to the start of the explosive activity for the activities listed in Table 6-14.

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

Training
Mine Neutralization – Explosive Ordnance Disposal
Missile Exercise (Surface-to-Surface) Ship
Sinking Exercise
Testing
Torpedo (explosive) Testing

The NAEMO does not consider mitigation, discussed in detail in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). As explained in Section 6.5.6 (Implementing Mitigation to Reduce Sound Exposures), 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 Lookouts up to and during the use of explosives, considering the mitigation effectiveness (Table 6-15) and sightability of a species based on g(0) (see Table 6-6).

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) the 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	Mortality Zone	
Training			
Bombing Exercise (Air to Surface)	0.5	0.5	Aircraft
Gunnery Exercise (Surface-to-Surface) – Ship	0.5	0.5	Vessel
Mine Neutralization – Explosive Ordnance Disposal	1	1	Vessel
Sinking Exercise	0.5	1	Aircraft
Testing			
Torpedo (Explosive) Testing	0.5	1	Aircraft

[1] The adjustment factor for all other activities (not listed) is zero and there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation for those activities. If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be 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.

During an activity with a series of explosions (not concurrent multiple explosions; Table 6-16; note there are no testing activities in the Study Area for which this applies), 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 6-13. 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.

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

Training
Bombing Exercise (Air-to-Surface) (High-frequency/Low-frequency)
Gunnery Exercise (Surface-to-Surface) – Ship
Mine Neutralization – Explosive Ordnance Disposal
Sinking Exercise

Note: There are no testing activities in the Study Area for which this applies.

Research has demonstrated that odontocetes have directional hearing, with best hearing sensitivity facing a sound source (Kastelein et al. 2005b; Mooney et al. 2008; Popov and Supin 2009). Therefore, an odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the NAEMO 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 exposures from multiple explosives (resulting from accumulated energy) are considered to be TTS due to avoidance.

6.6 Summary of All Estimated Impulsive and Non-Impulsive Source Effects

Table 5-2 and Table 5-5 represent the Navy's final estimated impulsive and non-impulsive source effects to marine mammals by MMPA criteria for the Study Area.

Table 5-2 shows the estimated impulsive and non-impulsive source effects with mitigation analysis for training activities within the Study Area and includes training activities using non-impulsive sources (e.g., sonar), impulsive sources (e.g., underwater explosives).

Table 5-5 shows estimated impulsive and non-impulsive source effects with mitigation analysis for all testing activities within the Study Area.

6.7 Estimated Take of Large Whales by Navy Vessel Strike

Worldwide, many cetacean species have been documented to have been hit by transiting surface vessels (Berman-Kowalewski 2010; Carrillo and Ritter 2010; Douglas et al. 2008; Félix and Van Waerebeek 2005; Gabriele et al. 2007; Glass et al. 2010; Jensen and Silber 2003; Laist et al. 2001; Richardson et al. 1995). Interactions between surface vessels and marine mammals have demonstrated that surface vessels can be a source of acute and chronic disturbance for marine mammals (Au and Green 2000, Bejder et al. 2006; Erbe et al. 2012; Holt et al. 2008; Nowacek et al. 2004a, 2004c; Noren et al. 2009; Richter et al. 2003, 2006; Rolland et al. 2012; Watkins 1986). Specifically, in some circumstances, marine mammals respond to vessels with the same behavioral repertoire and tactics they employ when they encounter predators (Richardson et al. 1995). However, it is not clear what environmental cue or cues marine animals might respond to: the sounds of water being displaced by the ships, the sounds of the ships' engines, or a combination of environmental cues surface vessels produce while they transit. While the analysis of potential impact form the physical presence of the vessel is presented here, the analysis of potential impacts in response to sounds are addressed in Section 3.4 of the NWTT EIS/OEIS.

These studies establish that marine mammals are likely to engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two. Though the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels. In one study, North Atlantic right whales were documented to show little overall reaction to the playback of sounds of approaching vessels, but they did respond to an alert signal by swimming strongly to the surface (Nowacek et al. 2004a). While this may increase their risk of collision, neither the North Atlantic nor the North Pacific right whale is expected to be present in the Study Area. Aside from the potential for an increased risk of collision addressed below, physical disturbance from vessel use is not expected to result in more than a short-term behavioral response.

Vessel speed, size, and mass are all important factors in determining potential impacts of a vessel strike to marine mammals. For large vessels, speed and angle of approach can influence the severity of a strike. Based on modeling, Silber et al. (2010) found that whales at the surface experienced impacts that increased in magnitude with the ship's increasing speed. Results of the study also indicated that potential impacts were not dependent on the whale's orientation to the path of the ship, but that vessel speed may be an important factor. At ship speeds of 15 knots or higher (7.7 m/second), there was a marked increase in intensity of centerline impacts to whales. Results also indicated that when the whale was below the surface (about one to two times the vessel draft), there was a pronounced propeller

suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes (Silber et al. 2010).

Vessel strikes from commercial, recreational, and Navy vessels are known to affect large whales in other areas and have resulted in serious injury and occasional fatalities to cetaceans (Abramson et al. 2009; Berman-Kowalewski et al. 2011; Calambokidis 2012, Douglas et al. 2008). Reviews of the literature on ship strikes mainly involve collisions between commercial vessels and whales (e.g., Laist et al. 2001; Jensen and Silber 2004). Based on commercial shipping in 2012, the Port of Seattle ranks eighth largest in the United States and in 2012 there were an additional 202 cruise vessels also docking there (Port of Seattle 2013). Navy vessel traffic is extremely minimal in comparison.

The ability of any 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. Differences between most Navy ships and commercial ships also 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. 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.
- A standard operating procedure that is also a mitigation measure in previous MMPA permits is for Navy vessels to maneuver to keep at least 500 yd. (457.2 m) 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.
- 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 assist in avoiding interactions with marine mammals.

For submarines, when on the surface there are Lookouts serving the same function as they do on surface ships and are thus able to detect and avoid marine mammals. When submerged, submarines are generally slow moving (to avoid detection), and therefore marine mammals at depth with a submarine are likely able to avoid collision with the submarine.

6.7.1.1 Mysticetes

Virtually all of the rorqual whale species have been documented to have been hit by vessels. This includes blue whales (Berman-Kowalewski et al. 2010; Van Waerebeek et al. 2007; Calambokidis 2012), fin whales (as recently as November 2011 in San Diego) (Van Waerebeek et al. 2007; Douglas et al. 2008), sei whales (Felix and Van Waerebeek 2005; Van Waerebeek et al. 2007), Bryde's whales (Felix

and Van Waerebeek 2005; Van Waerebeek et al. 2007), minke whales (Van Waerebeek et al. 2007), and humpback whales (Lammers et al. 2003; Van Waerebeek et al. 2007; Douglas et al. 2008). For example, in April 2013 (at Burien, Washington) and June 2013 (at Ocean City, Washington), two stranded fin whales that had been struck by vessels brought the total to 9 known fin whales having stranded in Washington after being struck by commercial vessels in approximately the last decade (Cascadia Research 2013).

6.7.1.2 Odontocetes

Sperm whales may be exceptionally vulnerable to vessel strikes as they spend extended periods of time "rafting" at the surface in order to restore oxygen levels within their tissues after deep dives (Jaquet and Whitehead 1996; Watkins et al. 1999). There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (Aguilar de Soto et al. 2006). In general, odontocetes move quickly and seem to be less vulnerable to vessel strikes than other cetaceans; however, most small whale and dolphin species have at least occasionally suffered from vessel strikes including: killer whale (Visser and Fertl 2000; Van Waerebeek et al. 2007), short-finned and long-finned pilot whales (Aguilar et al. 2000; Van Waerebeek et al. 2007), bottlenose dolphin (Bloom and Jager 1994; Wells and Scott 1997; Van Waerebeek et al. 2007), white-beaked dolphin, short-beaked common dolphin, striped dolphin, Atlantic spotted dolphin, and pygmy sperm whales (*Kogia breviceps*) (Van Waerebeek et al. 2007); and spinner dolphin (Camargo and Bellini 2007; Van Waerebeek et al. 2007). Beaked whales documented in vessel strikes include: Arnoux's beaked whales (Van Waerebeek et al. 2007), Cuvier's beaked whales (Aguilar et al. 2000; Van Waerebeek et al. 2007), and several species of *Mesoplodon* (Van Waerebeek et al. 2007). However, evidence suggests that beaked whales may be able to hear the low-frequency sounds of large vessels and thus avoid collision (Ketten 1998).

6.7.1.3 Pinnipeds and Sea Otters

Pinnipeds in general appear to suffer fewer impacts from vessel strikes than do cetaceans and strikes are not a major concern for pinnipeds in general (Antonelis et al. 2006; Marine Mammal Commission 2002; National Marine Fisheries Service 2007a). This may be due, at least in part, to the large amount of time they spend on land (especially when resting and breeding), and their high maneuverability in the water. Interactions between pinnipeds and Navy activities are more likely in the inland waters and Western Behm Canal (Alaska) portions of the Study Area; however, there is no record of any pinniped being struck by a Navy vessel in any location under any circumstances.

Sea otters generally inhabit nearshore shallow waters along the Pacific coastline, where there will be no training activities and only limited testing activities using small vessels. Because of there is likely to be no interaction between sea otters and Navy activities, the potential for a vessel strike can be discounted.

6.7.1.4 Data Analysis for Navy Vessel Strike of Marine Mammals

From unpublished data provided by NMFS Northwest, for the 20-year period from 1991 to 2010, there were 28 reported marine mammal vessel strikes in the Pacific Northwest from commercial vessels and unknown vessels suspected to have been commercial ships (Brent Norburg 2013). These include strikes to 9 gray whales, 7 fin whales, 3 humpback whales, 2 sperm whales, 1 blue whale, 1 sei whale, 1 Baird's beaked whale, 1 Bryde's whale, 1 California sea lion, and 1 harbor seal. Douglas et al. (2008) provided similar data regarding 19 whale strikes in Washington State between 1980 and 2006 which involved 7 fin whales, 6 grey whales, 2 blue whales, and one each of humpback whale, sei whale, sperm whale, and Baird's beaked whale.

There are no records of any Navy vessel strikes during training and testing to marine mammals in the Study Area since such records have been kept (June 1994–present). The Navy does not, therefore, anticipate ship strikes to marine mammals within the Study Area as a result of training or testing activities under the proposed action. Furthermore:

- The Navy reports 100 percent 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, fishing boats, work vessels, etc.).
- For the 20-year period from 1991 to 2010, there were 28 whale strikes by vessels in the Northwest (Brent Norburg 2013).
- During this same 20-year period, there were no (zero) Navy vessel strikes in the Northwest.
- Thus the average number of whale strikes per year by Navy vessels has been zero in the Study Area.
- The Navy's planned future training and testing in the Study Area would remain consistent with the range of variability observed over the last two decades.

Consequently, the Navy does not anticipate vessel strikes would occur within the Study Area as a result of training and testing during the 5-year period of the authorization.

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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:

- Most acoustic harassments (greater than 99.9 percent) are within the non-injurious TTS or behavioral effects zones (Level B harassment) (see Table 5-2 and Table 5-5).
- Marine mammal densities inputted into the model are also overly conservative, particularly when considering species where data is limited in portions of the 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 highly sensitive resident beaked whales at some locations) and increases in the number of some species.
- Years of monitoring of Navy-wide activities (since 2006) have documented hundreds of thousands of marine mammals on the range complexes and there are only two instances of overt behavioral change that have been observed.
- Years of monitoring of Navy-wide activities have documented no instances of injury to marine mammals as a result of non-impulsive acoustic sources.
- In at least three decades of the same type activities, only one instance of injury to marine mammals (25 March 2011; three long-beaked common dolphin off Southern California) has occurred as a known result of training or testing using an impulsive source (underwater explosion).
- The Navy has determined that the Level A and Level B harassment exposures to the Hood Canal stock of harbor seals are not biologically significant to the population because 1) none of the estimated exposures result in mortality; 2) the monitoring and mitigations employed would likely reduce the Level A exposures; 3) there are no indications that these harassments have affected this population's survival by altering behavior patterns such as breeding, nursing, feeding, or sheltering; 4) the population has been stable and likely at carrying capacity (Jeffries et al. 2003); 5) the population continues to use known large haulouts in Hood Canal and Dabob Bay which are adjacent to Navy testing and training activities; 6) the population continues to use known haulouts for pupping; and 7) the population continues to use the waters in and around Dabob Bay and Hood Canal.

This LOA application assumes that short-term non-injurious SELs predicted to cause onset-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 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. 2012; Thompson et al. 2010; Tyack 2009; 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, and feeding or socializing cetaceans often interrupt these events by diving or swimming away. 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 is little effect on survival (Lusseau and Bejder 2007). On the other hand, if a sound source displaces a marine mammal from an important feeding or breeding area for a prolonged period and it does 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. Disruptions to 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 and underwater detonation events within the Study Area 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 concentrated in one area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. For example, within Puget Sound, there are several locations where pinnipeds use Navy structures (e.g., submarines, security barriers) for haulouts in spite of the degree of activity surrounding these sites. 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 individual marine mammals or the population. In the NWTT Study Area, there are no new areas being considered for training or testing and the same historically used areas are being proposed for the future continuation of those activities.

The Context of Behavioral Disruption, TTS, and PTS – Long-Term Consequences to Populations

The exposure estimates calculated by predictive models currently available reliably predict propagation of sound and received levels, and estimate 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 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.

Acoustic impact modeling proposed in this application indicates use of impulsive and non-impulsive sources during training and testing events are not expected to result in serious injuries or mortality to any marine mammals. Although the Navy does not believe vessel strikes to large whales will occur, as a precaution this request includes takes as a result of vessel strikes to large whales.

Conclusion – The Navy concludes that training and testing activities proposed in the NWTT Study Area would result in Level B and Level A takes, and could result in mortality takes from vessel strikes, as summarized in Table 5-2 and Table 5-5. Based on best available science the Navy concludes that exposures to marine mammal species and stocks due to NWTT 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 TTS or behavioral effects zones (Level B harassment).
- Although the numbers presented in Tables 5-1, 5-2, 5-3, and 5-4 represent estimated harassment under the MMPA, as described above, they are conservative estimates of harassment, primarily by behavioral disturbance, and made without taking into consideration all possible reductions as a result of standard operating procedures and mitigation measures (only a subset of mitigations are factored into the post-modeling analysis).
- The protective measures described in Chapter 11 are designed to reduce vessel strike potential and avoid sound exposures that may cause serious injury, and to achieve the least practicable adverse effect on marine mammal species or stocks.

Consideration of negligible impact is required for NMFS 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 NWTT activities would have a negligible impact on marine mammals.

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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.

Because the Navy does not expect its activities to result in impacts to marine mammal populations, there would be no impacts on the availability of species or stocks for subsistence use.

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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 masking resulting from training and testing activities, which could occur in the Offshore Area, the Inland Waters, and in the Western Behm Canal, Alaska. However, the acoustic energy does 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, and missile exercises occur in the Offshore Area but 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 neutralization occur in shallow areas of the inland waters and will not impact known marine mammal foraging or haulout habitats. Temporary impacts and disturbance to marine mammal prey such as salmon are not expected to be significant in terms of impacts on forage species with a wide distribution throughout the Study Area 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 NWTT EIS/OEIS.

Based on the detailed review within the NWTT 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.

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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 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 Hempen 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). 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 involving underwater explosions 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.

Biologically Important Areas – Already incorporated into the Navy's and NMFS' analysis of affects to marine mammals, has been consideration of emergent science regarding locations where cetaceans are known to engage in activities at certain times of the year that are important to individual animals as well as populations of marine mammals (see discussion in Van Parijs 2015). As explained in that paper, each such location has been designated a Biologically Important Area (BIA). It is important to note that the BIAs were not meant to define exclusionary zones, nor were they meant to be locations that serve as sanctuaries from human activity, or areas analogous to marine protected areas (see Ferguson et al. (2015a) regarding the envisioned purpose for the BIA designations). The delineation of BIAs does not have direct or immediate regulatory consequences. The intention was that the BIAs would serve as resource management tools and their boundaries be dynamic and considered along with any new information as well as, "existing density estimates, range-wide distribution data, information on population trends and life history parameters, known threats to the population, and other relevant information" (Van Parijs 2015).

The Navy and NMFS have supported and will continue to support the Cetacean and Sound Mapping project, including providing representation on the Cetacean Density and Distribution Mapping Working Group (CetMap) developing the BIAs. The final products including U.S. West Coast BIAs from this mapping effort were completed and published in March 2015 (Aquatic Mammals 2015; Calambokidis et al. 2015; Ferguson et al. 2015a, 2015b; Van Parijs 2015). A review of the final BIAs for humpback whales and gray whales against areas where most acoustic activities are conducted in the NWTT study area (especially those that involve ASW hull mounted sonar, sonobuoys, and use of explosive munitions) identified that there is no spatial overlap. For the remaining activities, any spatial or temporal overlap

between Navy activities within the NWTT Study Area and BIAs would be small, infrequent, and therefore biologically insignificant since Navy's proposed training and testing events are unlikely to significantly affect the marine mammal activities for which the BIAs were designated. Navy has determined that in light of the lack of biological significance of Navy's activities on marine mammals in these areas, no additional mitigation measures for Navy activities in the BIAs are necessary.

Critical Habitat – The southern resident killer whale is the only ESA-listed marine mammal species with designated critical habitat located in the NWTT Study Area. The majority of the Navy's proposed training and testing activities would, however, not occur in the southern resident killer whale's designated critical habitat (NMFS 2006). For all substressors that would occur within the critical habitat, those training and testing activities are not expected to impact the identified primary constituent elements of that habitat and therefore would have no effect on that critical habitat. In 2014, NMFS received a petition to revise the existing Southern Resident killer whale critical habitat. NMFS found the revision may be warranted given tag data demonstrating the species spends considerable time outside the inland waters of the Pacific Northwest while inhabitating nearshore areas along the Washington/Oregon/California coastline (NOAA 2014a). A review of the currently designated critical habitat by NMFS, to determine whether the areas designated for this species needs to be revised, is still underway as of April 2015. In support of improved science for critical habitat determination, the Navy is currently funding from 2014-2016 continued offshore Southern Resident killer whale monitoring in partnership with NMFS' Northwest Fisheries Science Center. The migration and feeding activities upon which the proposed expanded critical habitat are based, generally occur closer to shore than the Navy's NWTT Study Area and the location for most of the proposed training and testing activitites occurring offshore. No further analysis of the proposed expanded critical habitat area or the proposed additional primary constituent element involving "in-water sound levels" (NOAA 2014a), can not be made at this time given the undefined nature of this proposed element of the habitat.

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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. 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, ESA biological opinions, MMPA LOA, 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: those positioned on ships; and those positioned ashore, in aircraft, or on small boats. Lookouts positioned on ships will diligently observe 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 the mitigation zones, and monitoring for vessel and personnel safety concerns.

Due to manning and space restrictions on aircraft, small boats, and some Navy ships, Lookouts for these platforms may be supplemented by the aircraft crew or pilot, boat crew, range site personnel, or shore-side personnel. Lookouts positioned in minimally manned platforms may be responsible for tasks in addition to observing the air or surface of the water (e.g., navigation of a helicopter or small boat). However, all Lookouts will (considering personnel safety, practicality of implementation, and impact on the effectiveness of the activity) comply with the observation objectives described above for Lookouts positioned on 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 NWTT Draft EIS/OEIS (U.S. Department of the Navy 2014).

The Navy proposes to use one or more Lookouts during the training and testing activities described below, which are organized by stressor category.

11.1.1 ACOUSTIC STRESSORS – NON-IMPULSIVE SOUND

11.1.1.1 Low Frequency and Hull Mounted Mid-Frequency Active Sonar

For this application, low-frequency active sonar would be used only during testing activities conducted in the Offshore Area and in the Inland Waters of the Study Area, and not during any proposed training activities. Therefore, mitigation measures for low-frequency active sonar sources currently exist only for these testing activities.

Training

The Navy's current Lookout mitigation measures during training activities involving hull-mounted mid-frequency active sonar include requirements such as the number of personnel on watch and the manner in which personnel are to visually search the area in the vicinity of the ongoing activity.

The Navy is proposing to maintain the number of Lookouts currently implemented for ships using hull-mounted mid-frequency active sonar. Ships using hull-mounted mid-frequency active sonar sources associated with ASW and mine warfare activities at sea (with the exception of ships less than 65 ft. [20 m] in length, which are minimally manned) will have two Lookouts at the forward position. For the purposes of this document, low-frequency active sonar does not include surface towed array surveillance system low-frequency active sonar, which is not a part of this Proposed Action.

While using hull-mounted mid-frequency active sonar sources underway, vessels less than 65 ft. [20 m] in length and ships that are minimally manned will have one Lookout at the forward position 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.

Testing

There are no current mitigation measures for hull-mounted mid-frequency sonar testing activities in the Study Area because this activity was not part of previous planning efforts. The Navy's current Lookout mitigation measures, which apply to activities conducted by Naval Undersea Warfare Center Keyport Division during low-frequency sonar testing activities, include:

- Lookouts with marine mammal observer training are used during all hours of range activities.
- Visual surveillance is conducted just prior to all in-water exercises. Surveillance includes, as a minimum, monitoring from all participating surface craft and, where available, adjacent shore sites.
- Passive acoustic monitoring for cetaceans is implemented during NUWC Division Keyport testing activities involving active sonar transmissions when passive acoustic monitoring capabilities are being operated during the testing activity.

The Navy's Proposed Action includes hull-mounted mid-frequency active sonar testing activities as well as low-frequency active sonar testing. The Navy proposes to revise the testing mitigation measures to align with the Lookout measures given for training activities as adapted for testing conditions, and apply these measures to both low-frequency and hull-mounted mid-frequency testing. Any appropriately trained member of the test support staff may serve as a Lookout at any time during an event so long as the observation and reporting is carried out as identified in existing measures. Testing conducted at sea on a maximally manned vessel over 65 ft. [20 m] will employ two Lookouts. Testing conducted pierside or shore-based testing will employ one Lookout. Testing conducted from small boats, range craft, minimally manned vessels, or aircraft will employ one Lookout.

When testing is conducted in the Inland Waters or Western Behm Canal, visual surveillance will begin prior to in-water acoustic activity and be conducted from all participating surface craft and, where available, adjacent shore sites; all marine mammal sightings will be reported to the Range Officer in charge of the event.

11.1.1.2 High-Frequency and Non-Hull-Mounted Mid-Frequency Active Sonar

Training

The Navy currently conducts high-frequency and non-hull-mounted mid-frequency active sonar training in the Study Area. Non-hull-mounted mid-frequency active sonar training activities include the use of aircraft deployed sonobuoys and helicopter dipping sonar. During those activities, the Navy employs the following mitigation measure regarding Lookout procedures:

- Navy aircraft participating in exercises at sea shall conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.
- Helicopters shall observe/survey the vicinity of an ASW training event for 10 minutes before the first deployment of active (dipping) sonar in the water.

The Navy is proposing to continue using the number of Lookouts currently implemented for aircraft conducting non-hull-mounted mid-frequency active sonar activities.

Mitigation measures do not currently exist for other high-frequency active sonar activities associated with ASW and MIW training, or for new platforms; therefore, the Navy is proposing to add a new measure for these activities and on these platforms when conducted in the Study Area. The recommended measure is provided below.

The Navy will have one Lookout on ships or aircraft conducting high-frequency or non-hull-mounted mid-frequency active sonar activities associated with ASW and MIW activities at sea.

Testing

The Navy currently conducts high-frequency and non-hull-mounted mid-frequency active sonar testing activities in the Study Area. These activities include the use of aircraft deployed sonobuoys, countermeasure testing, unmanned vehicle testing, and non-explosive torpedo testing. Mitigation measures for high-frequency active sonar sources currently exist only for some NAVSEA testing activities conducted in the Offshore Area and Inland Waters of the Study Area. These mitigation measures are the same as described above for testing in Section 11.1.1.1 (Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar). The Navy is proposing to apply the same Lookout requirements to all NAVSEA testing activities in the Proposed Action.

The Navy's proposed mitigation measures for NAVAIR testing activities are consistent with Navy training mitigation measures described above.

11.1.2 ACOUSTIC STRESSORS – EXPLOSIVES AND IMPULSIVE SOUND

11.1.2.1 Improved Extended Echo Ranging Sonobuoys

Training

The Navy does not propose to include Improved Extended Echo Ranging training activities in this application.

Testing

The Navy is proposing to continue the Lookout procedural measures currently implemented for this activity, and to clarify that one Lookout is required:

- Crews shall conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search shall be conducted at an altitude below 1,500 ft. (460 m) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft operations, crews are allowed to conduct area clearances utilizing more than one aircraft.
- Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post detonation. This 30-minute observation period may include pattern deployment time.
- When operationally feasible, Navy crews shall conduct continuous visual and aural monitoring of marine mammal activity. This shall include monitoring of aircraft sensors from the time of the first sensor placement until the aircraft have left the area and are out of range of these sensors.
- Aural Detection – If the presence of marine mammals is detected aurally, then that shall cue the Navy aircrew to increase the vigilance of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the crew may continue multi-static active search.
- Mammal monitoring shall continue until out of own-aircraft sensor range.

11.1.2.2 Explosive Signal Underwater Sound Buoys Using 0.6–2.5 Pound Net Explosive Weight

Lookout measures do not currently exist for explosive Signal Underwater Sound (SUS) buoy exercises using >0.5–2.5 lb. NEW.

Training

The Navy is proposing to add this measure. Aircraft conducting explosive sonobuoy exercises using >0.5–2.5 lb. NEW will have one Lookout.

Testing

The Navy’s proposed mitigation measures for testing activities are consistent with Navy training mitigation measures described above.

11.1.2.3 Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

Training

Mine countermeasure and neutralization activities in the Study Area involve the use of diver-placed charges that typically occur close to shore. When 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.

Currently, the Navy employs the following Lookout procedures during mine countermeasure and neutralization activities using positive control firing devices:

- Two survey boats will be used to conduct marine mammal surveys within a 700 yd. (640 m) radius of >0.5 to 2.5 lb. (1.1 kg) NEW training activities.
- Transect lines will be no more than 110 yd. (100 m) apart and beginning at the outside radius.
- Pre-exercise surveys shall be conducted within 30 minutes prior to commencement of the scheduled explosive event.
- The two survey boats will approach from the opposite direction and move toward the center (or explosive charge placement area) and work their way to the outside of the radius.
- Survey boats will maintain speed equal to or less than 10 knots.
- Each boat will have a minimum of two surveyors using aid of binoculars.
  In case of fog or reduced visibility, the surveyors must be able to see a minimum of 55 yd. (50 m) or the training event cannot be conducted.

The Navy is proposing to continue using the Lookout procedures currently implemented for mine neutralization activities involving positive control diver placed charges from >0.5 to 2.5 lb. NEW. The Navy is proposing a new mitigation zone of 400 yd. (366 m) for >0.5-2.5 lb NEW detonations based on the smaller charge sizes used in NWTT training activities.

The Navy is also proposing that activities using up to a >0.5-2.5 lb. NEW (Bin E3) detonation will have a total of two Lookouts (one Lookout positioned in each of two support vessels). All divers placing the charges on mines will support the Lookouts while performing their regular duties.

The divers and Lookouts will report all marine mammal sightings to their dive support vessel.

Testing

The Navy does not propose to include mine neutralization testing activities in this application.

11.1.2.4 Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target

Training

Currently, the Navy employs the following Lookout procedures during gunnery exercises:

- From the intended firing position, trained Lookouts shall survey the mitigation zone for marine mammals prior to commencement and during the exercise as long as practicable.
- If applicable, target towing vessels shall maintain a Lookout. If a marine mammal is sighted in the vicinity of the exercise, the tow vessel shall immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

The Navy is proposing to continue using the Lookout procedures currently implemented for this activity. The Navy will have one Lookout on the vessel or aircraft conducting small-, medium-, or large-caliber gunnery exercises against a surface target. Towing vessels, if applicable, shall also maintain one Lookout.

Testing

The Navy does not include gunnery testing activities in this application.

11.1.2.5 Missile Exercises Using a Surface Target

Training

Currently, the Navy employs the following Lookout procedures during missile exercises:

- Aircraft shall visually survey the target area for marine mammals. Visual inspection of the target area shall be made by flying at 1,500 ft. (460 m) or lower, if safe to do so, and at slowest safe speed.
- Firing or range clearance aircraft must be able to actually see ordnance impact areas.

The Navy is proposing to continue using the Lookout procedures currently implemented for this activity. When aircraft are conducting missile exercises against a surface target, the Navy will have one Lookout positioned in an aircraft.

Testing

The Navy does not include missile testing activities in this application.

11.1.2.6 Bombing Exercises (Explosive)

Training

Currently, the Navy employs the following Lookout procedures during bombing exercises:

- If surface vessels are involved, Lookouts shall survey for floating kelp and marine mammals.
- Aircraft shall visually survey the target and buffer zone for marine mammals prior to and during the exercise. The survey of the impact area shall be made by flying at 1,500 ft. (460 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.

The Navy is proposing to (1) continue implementing the current measures for bombing exercises, and (2) clarify the number of Lookouts currently implemented for this activity. The Navy will have one Lookout positioned in an aircraft conducting bombing exercises, and trained Lookouts in any surface vessels involved.

Testing

The Navy does not include bomb testing activities in this application.

11.1.2.7 Torpedo (Explosive) Testing

The Navy currently has no Lookout procedures for this activity in the Study Area.

Training

The Navy does not include training with explosive torpedoes in this application.

Testing

For explosive torpedoes tested from a surface ship, the Navy is proposing to use the Lookout procedures currently implemented for hull-mounted mid-frequency active sonar activities. For explosive torpedo tests with low-altitude aircraft present, the Navy will have one Lookout positioned in an aircraft.

11.1.2.8 Weapons Firing Noise During Gunnery Exercises

Training

The Navy is proposing to continue using the number of Lookouts currently implemented for gunnery exercises. The Navy will have one Lookout on the ship conducting explosive and non-explosive large-caliber gunnery exercises. This may be the same Lookout described in Section 11.1.2.5 (Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target) when that activity is conducted from a ship against a surface target.

Testing

The Navy does not include gun testing activities in this application.

11.1.2.9 Sinking Exercises

The Navy has historically conducted sinking exercises in the Study Area, and has completed environmental planning documents analyzing up to two sinking exercises per year. However, sinking exercises are not proposed in this application.

11.1.3 Physical Disturbance and Strike

11.1.3.1 Vessels

Training

Currently, the Navy employs the following Lookout procedures to avoid physical disturbance and strike of marine mammals during at-sea training and testing:

- While underway, surface vessels shall have at least two Lookouts with binoculars; surfaced submarines shall have at least one Lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, Lookouts will watch for and report to the Officer of the Deck the presence of marine mammals.

The Navy is proposing to revise the mitigation measures for this activity as follows: while underway, vessels will have a minimum of one Lookout.

Testing

The Navy's current mitigation measures for testing activities are consistent with Navy training mitigation measures described above.

11.1.3.2 Towed In-Water Devices

The Navy currently has no Lookout procedures for this activity in the Study Area.

Training

The Navy is proposing to have one Lookout during activities using towed in-water devices when towed from a manned platform.

Testing

The Navy's proposed mitigation measures for testing activities from manned platforms are consistent with Navy training mitigation measures described above. During testing in which in-water devices are towed by unmanned platforms, a manned escort vessel will be included and one Lookout will be employed.

11.1.4 Non-Explosive Practice Munitions

11.1.4.1 Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target

Currently, the Navy employs the same mitigation measures for non-explosive gunnery exercises as described above in Section 11.1.2.5 (Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target).

Training

The Navy is are proposing to continue using the number of Lookouts currently implemented for these activities. The Navy will have one Lookout during activities involving non-explosive practice munitions (e.g., small-, medium-, and large-caliber gunnery exercises) against a surface target.

Testing

The Navy's Proposed Action does not include gunnery testing activities in the Study Area.

11.1.4.2 Bombing Exercises

Currently, the Navy employs the same mitigation measures for non-explosive bombing exercises as described above in Section 11.1.2.7 (Bombing Exercises).

Training

The Navy is proposing to continue using the same Lookout procedures currently implemented for these activities. The Navy will have one Lookout positioned in an aircraft during non-explosive bombing exercises, and trained Lookouts in any surface vessels involved.

Testing

The Navy's Proposed Action does not include bomb testing activities.

11.1.5 Effectiveness Assessment of 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 NWTT Draft EIS/OEIS (U.S. Department of the Navy 2014).

11.2 Mitigation Zone Procedural Measures

Safety zones are designed for human safety, whereas this section will introduce mitigation zones. A mitigation zone is designed solely for the purpose of reducing potential impacts on 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. (460 m) altitude or lower at the slowest safe speed.

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 Phase I (e.g., NWTRC EIS/OEIS) mitigation zones for activities that involve the use of impulsive and non-impulsive sources were originally designed to reduce the potential for onset of TTS. For the NWTT EIS/OEIS and this application, 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 *Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Northwest Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement* technical report (Marine Species Modeling Team 2013).

As a result of the updates to the acoustic propagation modeling, in some cases the ranges to onset of TTS effects are much larger than those output by previous Phase I models. Due to the ineffectiveness and unacceptable operational impacts associated with mitigating these large areas, the Navy is unable to mitigate for onset of TTS for every activity. In this NWTT analysis, the Navy developed each recommended mitigation zone to avoid or reduce the potential for onset of the lowest level of injury, PTS, out to the predicted maximum range. In some cases where the ranges to effects are smaller than previous models estimated, the mitigation zones were adjusted accordingly to provide consistency across the measures. Mitigating to the predicted maximum range to PTS consequently also mitigates to the predicted maximum range to onset mortality (1 percent 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. The predicted ranges are based on local environmental conditions and are unique to the NWTT Study Area.

The activity-specific mitigation zones are based on the longest range for all the functional hearing groups. The mitigation zone for a majority of activities is 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 (i.e., low-frequency cetaceans, mid-frequency cetaceans, and pinnipeds), and likely cover a larger portion of the potential range to onset of TTS.

This evaluation included explosive ranges to TTS and the onset of auditory injury, non-auditory injury, slight lung injury, and mortality. For every source proposed for use by the Navy, the recommended mitigation zones included in Table 11-1 exceed each of these ranges.

The range to effects for activities using sonar and other active acoustic sources used in the Inland Waters differ from the ranges used in Table 11-1 based on Offshore Area activities. For pierside maintenance and testing of hull-mounted mid-frequency sources in the Inland Waters, modeling provides an overestimate of the range to effects because it cannot adequately account for the complex interactions of the sound energy into very shallow water and associated shorelines, the loss into dampening structures (e.g., adjacent pilings, jetties, or seawalls), or occasions when a ship or submarine is moored bow in so that the sonar is transmitted toward the nearby shoreline. Therefore, the ranges in Table 11-1 are even more protective for activities in the Inland Waters.

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 recommended mitigation zones and their associated assessments are provided throughout the remainder of this section. The recommended measures are either currently implemented, are modifications of current measures, or are new measures.

For some activities specified throughout the remainder of this section, Lookouts may be required to observe for concentrations of detached floating vegetation (i.e., kelp paddies), which are indicators of potential marine mammal presence within the mitigation zone. Those specified activities will not commence if floating vegetation (i.e., kelp paddies) is observed within the mitigation zone prior to the initial start of the activity. If floating vegetation is observed prior to the initial start of the activity, the activity will be relocated to an area where no floating vegetation is observed.

Training and testing will not cease as a result of indicators entering the mitigation zone after activities have commenced. This measure is intended only for floating vegetation detached from the seafloor.

Table 11-1: Predicted Range to Effects and Recommended Mitigation Zones

Activity Category	Representative Source (Bin)[1]	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Sonar and Other Active Acoustic Sources					
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)	Training: 1,000 yd. (920 m) and 500 yd. (460 m) power downs and 200 yd. (180 m) shutdown for cetaceans, 100 yd. (90 m) mitigation zone for pinnipeds Testing: 1,000 yd. (920 m) and 500 yd. (460 m) power downs for sources that can be powered down and 200 yd. (180 m) shutdown for cetaceans, 100 yd. (90 m) for pinnipeds
High-Frequency and Non-Hull-Mounted Mid-Frequency Active Sonar[2]	AQS-22 ASW dipping sonar (MF4)	226 yd. (207 m)	< 55 yd. (< 50 m)	< 55 yd. (< 50 m)	Training: 200 yd. (180 m) Testing: 200 yd. (180 m) for cetaceans, 100 yd. (90 m) for pinnipeds
Explosive and Impulsive Sound					
Improved Extended Echo Ranging Sonobuoys	Explosive sonobuoy (E4)	237 yd. (217 m)	133 yd. (122 m)	235 yd. (215 m)	Training: n/a Testing: 600 yd. (550 m)
Signal Underwater Sound (SUS) buoys using >0.5–2.5 lb. NEW	Explosive sonobuoy (E3)	178 yd. (163 m)	92 yd. (84 m)	214 yd. (196 m)	Training: 350 yd. (320 m) Testing: 350 yd. (320 m)
Mine Countermeasure and Neutralization Activities (positive control)	2.5 lb NEW (E3)	495 yd. (453 m)	145 yd. (133 m)	373 yd. (341 m)	Training: 400 yd. (366 m) Testing: n/a
Gunnery Exercises – Small- and Medium-Caliber (Surface Target)	25 mm projectile (E1)	72 yd. (66 m)	48 yd. (44 m)	73 yd. (67 m)	Training: 200 yd. (180 m) Testing: n/a
Gunnery Exercises – Large-Caliber (Surface Target)	5 in. projectiles (E5 at the surface)[3]	210 yd. (192 m)	110 yd. (101 m)	177 yd. (162 m)	Training: 600 yd. (550 m) Testing: n/a
Missile Exercises up to 500 lb. NEW (Surface Target)	Harpoon missile (E10)	1,164 yd. (1,065 m)	502 yd. (459 m)	955 yd. (873 m)	Training: 2,000 yd. (1.8 km) Testing: n/a
Bombing Exercises	MK-84 2,000 lb. bomb (E12)	1,374 yd. (1,256 m)	591 yd. (540 m)	1,368 yd. (1,251 m)	Training: 2,500 yd. (2.3 km) Testing: n/a
Lightweight Torpedo (Explosive) Testing	MK-46 torpedo (E8)	497 yd. (454 m)	245 yd. (224 m)	465 yd. (425 m)	Training: n/a Testing: 2,100 yd. (1.9 km)
Heavyweight Torpedo (Explosive) Testing	MK-48 torpedo (E11)	1,012 yd. (926 m)	472 yd. (432 m)	885 yd. (809 m)	Training: n/a Testing: 2,100 yd. (1.9 km)

[1] 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; [2] High-frequency and non-hull-mounted mid-frequency active sonar category includes unmanned underwater vehicle and torpedo testing activities; [3] The representative source Bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).

Notes: ASW = anti-submarine warfare, in. = inch, km = kilometer, m = meter, mm = millimeter, n/a = Not Applicable, NEW = net explosive weight, PTS = permanent threshold shift, TTS = temporary threshold shift, yd. = yard

11.2.1 Acoustic Stressors – Non-Impulsive Sound

11.2.1.1 Low Frequency and Hull Mounted Mid-Frequency Active Sonar

Under the Proposed Action, low-frequency active sonar would be used only during testing activities conducted in the Offshore Area, the Inland Waters, and the Western Behm Canal, and not during any proposed training activities. Therefore, mitigation measures for low-frequency active sonar sources currently exist only for these testing activities conducted in the Offshore Area and Inland Waters of the Study Area.

Training

The Navy is proposing to (1) continue implementing the current measures for mid-frequency active sonar, (2) clarify the conditions needed to recommence an activity after a sighting, and (3) implement mitigation measures for pinnipeds and for pierside sonar testing in the vicinity of hauled out pinnipeds. For training activities, the recommended measures are provided below.

Activities that involve the use of hull-mounted mid-frequency active sonar (including pierside) will use Lookouts for visual observation from a ship immediately before and during the activity. Mitigation zones for these activities involve powering down the sonar by 6 dB when a marine mammal is sighted within 1,000 yd. (920 m) of the sonar dome, and by an additional 4 dB when sighted within 500 yd. (460 m) from the source, for a total reduction of 10 dB. Active transmissions will cease if a marine mammal is sighted within 200 yd. (180 m). Active transmission will recommence if any one of the following conditions is 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 minutes, (4) the ship has transited more than 2,000 yd. (1.8 km) beyond the location of the last sighting, or (5) the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave (and there are no other marine mammal sightings within the mitigation zone). Active transmission may resume when dolphins are bow riding because they are out of the main transmission axis of the active sonar while in the shallow-wave area of the ship bow.

For pinnipeds, the Navy proposes a 100 yd. mitigation zone. The pinniped mitigation zone does not apply for pierside maintenance in the vicinity of pinnipeds hauled out on man-made structures and vessels. Within Puget Sound there are several locations where pinnipeds use Navy structures (e.g., submarines, security barriers) for haulouts in spite of the degree of activity surrounding these sites. Given that animals continue to choose these areas for their resting behavior, it would appear there are no long-term effects or consequences to those animals as a result of ongoing and routine Navy activities.

Testing

There are no current hull-mounted mid-frequency active sonar testing activities in the Study Area, and no mitigation procedures. However, the Navy's Proposed Action includes newly assessed hull-mounted mid-frequency active sonar testing activities. For testing activities, the recommended measures are provided below.

Activities that involve the use of low-frequency active sonar (including pierside) will use Lookouts for visual observation immediately before and during the event. If a marine mammal is sighted within 200 yd. (180 m) of the sound source, active transmissions will cease. Active transmission will recommence if any one of the following conditions is 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 minutes, or (4) the sound source has transited more than 2,000 yd. (1.8 km) beyond the location of the last sighting.

Activities that involve the use of hull-mounted mid-frequency active sonar (including pierside and shore-based testing) will follow the mitigation measures described above for Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar Training.

For pinnipeds, the Navy proposes a 100 yd. mitigation zone. The pinniped mitigation zone does not apply for pierside testing in the vicinity of pinnipeds hauled out on man-made structures and vessels.

11.2.1.2 High-Frequency and Non-Hull-Mounted Mid-Frequency Active Sonar

Training

Non-hull-mounted mid-frequency active sonar training activities include the use of aircraft deployed sonobuoys and helicopter dipping sonar. The Navy is proposing to: (1) continue implementing the current mitigation measures for activities currently being executed, such as dipping sonar activities; (2) extend the implementation of its current mitigation to all other activities in this category; and (3) clarify the conditions needed to recommence an activity after a sighting. The recommended measures are provided below.

Mitigation will include visual observation from a 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. (180 m) from the active sonar source. For activities involving helicopter deployed dipping sonar, visual observation will commence 10 minutes before the first deployment of active dipping sonar. Helicopter dipping and sonobuoy deployment will not begin if concentrations of floating vegetation (kelp paddies), 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 sighted within the mitigation zone. Active transmission will recommence if any one of the following conditions is 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 minutes for an aircraft-deployed source, (4) the mitigation zone has been clear from any additional sightings for a period of 30 minutes for a vessel-deployed source, (5) the vessel or aircraft has repositioned itself more than 400 yd. (370 m) away from the location of the last sighting, or (6) the vessel concludes that dolphins are deliberately closing in to ride the vessel's bow wave (and there are no other marine mammal sightings within the mitigation zone).

Testing

Mitigation measures for high-frequency active sonar sources currently exist only for testing activities conducted in the Inland Waters of Puget Sound. These activities include the use of unmanned vehicles, non-explosive torpedoes, and similar systems. The current mitigation measures used for these testing activities are the same as described above in Section 11.2.1.1 (Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar).

For all high-frequency and non-hull-mounted mid-frequency active sonar testing activities in the Proposed Action, the Navy proposes to employ the mitigation measures described above for training. For pinnipeds, the Navy proposes a 100 yd. (90 m) mitigation zone during testing.

The pinniped mitigation zone does not apply for pierside or shore-based testing in the vicinity of pinnipeds hauled out on man-made structures and vessels.

11.2.2 Acoustic Stressors – Explosives and Impulsive Sound

11.2.2.1 Improved Extended Echo Ranging Sonobuoys

Training

The Navy does not propose to include Improved Extended Echo Ranging training activities in this application.

Testing

The Navy is proposing to (1) modify the mitigation measures currently implemented for this activity by reducing the marine mammal mitigation zone from 1,000 yd. (920 m) to 600 yd. (550 m), (2) clarify the conditions needed to recommence an activity after a sighting, and (3) adopt the marine mammal mitigation zone size for floating vegetation for ease of implementation. The recommended measures are provided below.

Mitigation will include pre-testing aerial observation and passive acoustic monitoring, which will begin 30 minutes before the first source/receiver pair detonation and continue throughout the duration of the test. The pre-testing 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 (kelp paddies) are observed in the mitigation zone around the intended deployment location. Explosive detonations will cease if a marine mammal is sighted within the mitigation zone. Detonations will recommence if any one of the following conditions is 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 minutes.

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 provide only limited range and 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 vessels in order to increase vigilance of their visual surveillance.

11.2.2.2 Explosive Signal Underwater Sound Buoys Using >0.5–2.5 Pound Net Explosive Weight

Mitigation measures do not currently exist for activities using SUS buoys.

Training

The Navy is proposing to add the following recommended measures. Mitigation will include pre-exercise aerial monitoring during deployment within a mitigation zone of 350 yd. (320 m) around an explosive SUS buoy. Explosive SUS buoys will not be deployed if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone (around the intended deployment location). SUS deployment will cease if a marine mammal is sighted within the mitigation zone. Deployment will recommence if any one of the following conditions is 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 10 minutes.

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.

Testing

The Navy's proposed mitigation measures for testing activities are consistent with Navy training mitigation measures described above.

11.2.2.3 Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

Training

Mine countermeasure and neutralization activities in the Study Area involve the use of diver-placed charges that typically occur close to shore. When 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.

Currently, the Navy employs the following mitigation zone procedures during mine countermeasure and neutralization activities using positive control firing devices:

- Mitigation Zone – The exclusion zone for marine mammals shall extend in a 700 yd. (640 m) arc radius around the detonation site for all charges sizes from >0.5 to 2.5 lb. NEW.
- Pre-Exercise Surveys – For Demolition and Mine Countermeasures Operations, pre-exercise surveys shall be conducted within 30 minutes prior to the commencement of the scheduled explosive event. The survey may be conducted from the surface, by divers, or from the air, and personnel shall be alert to the presence of any marine mammal. Should such an animal be present within the survey area, the explosive event shall not be started until the animal voluntarily leaves the area. The Navy will ensure the area is clear of marine mammals for a full 30 minutes prior to initiating the explosive event. Personnel will record any marine mammal observations during the exercise as well as measures taken if species are detected within the exclusion zone.
- Post-Exercise Surveys – Surveys within the same radius shall also be conducted within 30 minutes after the completion of the explosive event.

For activities involving positive control diver-placed charges, the Navy is proposing to (1) modify the currently implemented mitigation measures for this activity involving >0.5 to 2.5 lb. NEW by changing the mitigation zone from 700 yds. (640 m) to 400 yd. (366 m), (2) clarify the conditions needed to recommence an activity after a sighting, and (3) add a requirement to observe for floating vegetation.

The recommended measures for activities involving positive control diver-placed activities are provided below.

The Navy is proposing to use the 400 yd. (366 m) mitigation zones for marine mammals described above during activities involving positive control diver-placed charges. Visual observation will be conducted by two small boats, each with a minimum of one surveyor.

Explosive detonations will cease if a marine mammal is sighted in the water portion of the mitigation zone (i.e., not on shore). Detonations will recommence if any one of the following conditions is 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 minutes.

Testing

The Navy's Proposed Action does not include mine countermeasure and neutralization testing activities.

11.2.2.4 Gunnery Exercises – Small- and Medium-Caliber Using a Surface Target

The Navy is proposing to (1) continue implementing the current mitigation measures for this activity, (2) clarify the conditions needed to recommence an activity after a sighting, and (3) add a requirement to visually observe for kelp paddies.

Mitigation will include visual observation from a vessel or aircraft immediately before and during the exercise within a mitigation zone of 200 yd. (180 m) around the intended impact location. Vessels will observe the mitigation zone from the firing position. When aircraft are firing, the aircrew will maintain visual watch of the mitigation zone during the activity. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Firing will cease if a marine mammal is sighted within the mitigation zone. Firing will recommence if any one of the following conditions is 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 minutes for a firing aircraft, (4) the mitigation zone has been clear from any additional sightings for a period of 30 minutes for a firing ship, or (5) the intended target location has been repositioned more than 400 yd. (370 m) away from the location of the last sighting.

Testing

The Navy's Proposed Action does not include gunnery testing activities.

11.2.2.5 Gunnery Exercises – Large-Caliber Explosive Rounds Using a Surface Target

Training

There are currently no existing mitigation measures unique to large-caliber explosive gunnery exercises in the Study Area. The Navy is proposing to adopt mitigation measures in place at other Navy training ranges outside of the Study Area.

For all explosive and non-explosive large-caliber gunnery exercises conducted from a ship, 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. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Firing will cease if a marine mammal is sighted within the mitigation zone. Firing will recommence if any one of the following conditions is 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 minutes, or (4) the vessel has repositioned itself more than 140 yd. (128 m) away from the location of the last sighting.

Testing

The Navy's Proposed Action does not include gunnery testing activities.

11.2.2.6 Missile Exercises up to 250 Pound Net Explosive Weight Using a Surface Target

Currently, the Navy employs a mitigation zone of 1,800 yd. (1.6 km) for all missile exercises. Because the Navy is not proposing to use missiles with less than a 251 lb. NEW warhead in the Study Area, separate mitigation procedures for this exercise have not been developed. Should the need arise to conduct training using missiles in this category, the Navy proposes that mitigation procedures be followed as described below for the larger category of missiles (Section 11.2.2.8, Missile Exercises 251–500 Pound Net Explosive Weight [Surface Target]).

11.2.2.7 Missile Exercises 251–500 Pound Net Explosive Weight (Surface Target)

Training

Current mitigation measures apply to all missile exercises, regardless of the warhead size. The Navy proposes to add a mitigation zone that applies only to missiles with a NEW of 251–500 lb. The recommended measures are provided below.

When aircraft are involved in the missile firing, mitigation will include visual observation by the aircrew prior to commencement of the activity within a mitigation zone of 2,000 yd. (1.8 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Firing will cease if a marine mammal is sighted within the mitigation zone. Firing will recommence if any one of the following conditions is 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 10 minutes or 30 minutes (depending on aircraft type).

Testing

The Navy's Proposed Action does not include missile testing activities.

11.2.2.8 Bombing Exercises

Training

Currently, the Navy employs the following mitigation zone procedures during bombing exercises:

- Ordnance shall not be targeted to impact within 1,000 yd. (920 m) of known or observed floating kelp or marine mammals.
- A 1,000 yd. (920 m) radius mitigation zone shall be established around the intended target.
- The exercise will be conducted only if marine mammals are not visible within the mitigation zone.

The Navy is proposing to (1) maintain the existing mitigation zone to be used for non-explosive bombing activities, (2) revise the mitigation zone procedures to account for predicted ranges to impacts to marine species when high explosive bombs are used, (3) clarify the conditions needed to recommence an activity after a sighting, and (4) add a requirement to visually observe for kelp paddies.

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 for explosive bombs and 1,000 yd. (920 m) for non-explosive bombs. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Bombing will cease if a marine mammal is sighted within the mitigation zone. Bombing will recommence if any one of the following conditions is 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 10 minutes.

Testing

The Navy's Proposed Action does not include bomb testing activities.

11.2.2.9 Torpedo (Explosive) Testing

The Navy currently has no mitigation zone procedures for torpedo (explosive) testing in the Study Area.

Training

The Navy does not include training with explosive torpedoes in the Proposed Action.

Testing

The Navy is proposing to (1) establish mitigation measures for this activity that include a mitigation zone of 2,100 yd. (1.9 km), (2) establish the conditions needed to recommence an activity after a sighting, and (3) establish a requirement to visually observe for kelp paddies. The recommended measures are provided below.

Mitigation will include visual observation by aircraft (with the exception of platforms operating at high altitudes) immediately before, during, and after the event within a mitigation zone of 2,100 yd. (1.9 km) around the intended impact location. The event will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Firing will cease if a marine mammal is sighted within the mitigation zone. Firing will recommence if any one of the following conditions is 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 10 minutes or 30 minutes (depending on aircraft type).

In addition to visual observation, passive acoustic monitoring will 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.

11.2.2.9.1 Weapons Firing Noise During Gunnery Exercises – Large-Caliber

The Navy currently has no mitigation zone procedures for this activity in the Study Area.

Training

The Navy is proposing to adopt measures currently used during Navy gunnery exercises in other ranges outside of the Study Area. For all explosive and non-explosive large-caliber gunnery exercises conducted from a ship, 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. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Firing will cease if a marine mammal is sighted within the mitigation zone. Firing will recommence if any one of the following conditions is 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 minutes, or (4) the vessel has repositioned itself more than 140 yd. (128 m) away from the location of the last sighting.

Testing

The Navy’s Proposed Action does not include gun testing activities.

11.2.3 Physical Disturbance and Strike – Vessels and In-Water Devices

11.2.3.1 Vessels

Training

The Navy's current measures to mitigate potential impacts to marine mammals from vessel and in-water device strikes during training activities are provided below:

- Naval vessels shall maneuver to keep at least 500 yd. (460 m) away from any observed whale in the vessel's path and avoid approaching whales head-on. These requirements do not apply if a vessel's safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are engaged in dredging, submerged activities, launching and recovering aircraft or landing craft, minesweeping activities, replenishment while underway and towing activities that severely restrict a vessel's ability to deviate course.
- Vessels will take reasonable steps to alert other vessels in the vicinity of the whale. Given rapid swimming speeds and maneuverability of many dolphin species, naval vessels would maintain normal course and speed on sighting dolphins unless some condition indicated a need for the vessel to maneuver.

The Navy is proposing to continue to use the 500 yd. (460 m) mitigation zone currently established for whales, and to implement a 200 yd. (180 m) mitigation zone for all other marine mammals. Vessels will avoid approaching marine mammals head on and will maneuver to maintain a mitigation zone of 500 yd. (460 m) around observed whales and 200 yd. (180 m) around all other marine mammals (except bow-riding dolphins), providing it is safe to do so.

Testing

The Navy's current measures to mitigate potential impacts to marine mammals from vessel and in-water device strikes during testing activities are provided below:

- Range activities shall be conducted in such a way as to ensure marine mammals are not harassed or harmed by human-caused events.
- Visual surveillance shall be accomplished just prior to all in-water exercises. This surveillance shall ensure that no marine mammals are visible within the boundaries of the area within which the test unit is expected to be operating. Surveillance shall include, as a minimum, monitoring from all participating surface craft and, where available, adjacent shore sites.
- The Navy shall postpone activities until cetaceans (whales, dolphins, and porpoises) leave the activity area. When cetaceans have been sighted in an area, all range participants increase vigilance and take reasonable and practicable actions to avoid collisions and activities that may result in close interaction of naval assets and marine mammals. Actions may include changing speed or direction and are dictated by environmental and other conditions (e.g., safety, weather).
- Range craft shall not approach within 100 yd. (90 m) of marine mammals and shall be followed to the extent practicable considering human and vessel safety priorities. All Navy vessels and aircraft, including helicopters, are expected to comply with this directive. This includes marine mammals "hauled-out" on islands, rocks, and other areas such as buoys.

The Navy is proposing to incorporate the training mitigation measures described above during testing activities involving surface ships, and for all other testing activities to continue using the mitigation measures currently implemented, revised to exclude pinnipeds during test body retrieval and to include the exception for bow-riding dolphins as described above under Training. During test body retrieval, the activity cannot be relocated away from marine mammals active in the area, or significantly delayed without risking loss of the test body, so the activity must proceed even if pinnipeds are present in the immediate vicinity. However, the retrieval vessel is a range craft and risks to marine mammals are very low.

11.2.3.2 Towed In-Water Devices

The Navy currently has no mitigation zone procedures for this activity in the Study Area.

Training

The Navy is proposing to adopt measures currently used in other ranges outside of the Study Area during activities involving towed in-water devices. The Navy will ensure that towed in-water devices being towed from manned platforms avoid coming within a mitigation zone of 250 yd. (230 m) around any observed marine mammal, providing it is safe to do so.

Testing

The Navy's proposed mitigation measures for testing activities from manned platforms are consistent with Navy training mitigation measures described above. During testing in which in-water devices are towed by unmanned platforms, a manned escort vessel will be included and one Lookout will be employed.

11.2.4 Non-Explosive Practice Munitions

11.2.4.1 Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target

Training

Currently, the Navy employs the same mitigation measures for non-explosive gunnery exercises as described above in Section 11.2.2.5 (Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target).

The Navy is proposing to (1) continue using the mitigation measures currently implemented for this activity, and (2) clarify the conditions needed to recommence an activity after a sighting. The recommended measures are provided below.

Mitigation will include visual observation from a vessel or aircraft immediately before and during the exercise within a mitigation zone of 200 yd. (180 m) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Firing will cease if a marine mammal is sighted within the mitigation zone. Firing will recommence if any one of the following conditions is 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 minutes for a firing aircraft, (4) the mitigation zone has been clear from any additional sightings for a period of 30 minutes for a firing ship, or (5) the intended target location has been repositioned more than 400 yd. (370 m) away from the location of the last sighting.

Testing

The Navy's Proposed Action does not include gunnery testing activities.

11.2.4.2 Bombing Exercises

Training

The Navy is proposing to continue using the mitigation measures currently implemented for this activity. The recommended measure includes clarification of a post-sighting activity recommencement criterion.

Mitigation will include visual observation from the aircraft immediately before the exercise and during target approach within a mitigation zone of 1,000 yd. (920 m) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (kelp paddies) are observed in the mitigation zone. Bombing will cease if a marine mammal is sighted within the mitigation zone. Bombing will recommence if any one of the following conditions is 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 10 minutes

Testing

The Navy's Proposed Action does not include bomb testing activities.

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12 SUBSISTENCE EFFECTS AND PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area 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 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 NWTT LOA application, none of the proposed training or testing activities in the Study Area occur where subsistence hunting exists. Based on the Navy discussions and conclusions in Chapters 7 and 8, there are no anticipated effects on any species or stocks residing in or migrating through the Study Area that might impact their availability for subsistence use.

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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 monitoring program is composed of a collection of range and site-specific monitoring plans. Each plan was developed individually as part of the MMPA/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.

From 2009 to 2013 the Navy, in coordination with NMFS, developed a more overarching program plan in which range complex specific monitoring would occur. This plan, called the Integrated Comprehensive Monitoring Program (ICMP), was developed in coordination with NMFS concurrent with development of the range complex specific monitoring plans. 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 OPAREAs for which the Navy is seeking or has sought incidental take authorizations. The ICMP is intended to coordinate 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 future refinement.

In October 2010, the Navy held a Monitoring meeting in Arlington, VA, to critically evaluate current Navy monitoring plans. The Navy began 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 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, California 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 NWTRC since 2010 and in the NUWC Keyport Range Complex since 2011.

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 goals:

1) An increase in our understanding of the likely occurrence of marine mammals or ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, or density of species);
2) An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals 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 or ESA-listed marine species with the action (in whole or part) associated with specific adverse effects; or (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal 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 Northwest Training and Testing Study Area Monitoring 2010–2014

This section is a summary of Navy-funded compliance monitoring in the NWTRC since 2010 and in the NUWC Keyport Range Complex since 2011. Additional Navy-funded monitoring outside of and in addition to the Navy's commitments to NMFS is provided in Section 13.4.2 (Other Regional Navy Funded Monitoring Efforts). The monitoring years are shown in Table 13-1.

Table 13-1: Navy Monitoring Years in the Study Area

Range Complex	Year 1	Year 2	Year 3
Northwest Training Range Complex	12 November 2010– 01 May 2011	02 May 2011– 01 May 2012	02 May 2012– 01 May 2013
Keyport Range Complex	12 April 2011– 08 November 2011	09 November 2011– 08 November 2012	09 November 2012– 08 November 2013

13.4.1 Northwest Training Range Complex

13.4.1.1 Passive Acoustic Monitoring

As part of previous monitoring within the Pacific Northwest, the Navy funded deployment of two passive acoustic devices along the central coast of Washington State from 2011 to2013. Results from this effort is summarized in the Navy's annual NWTRC monitoring reports for 2011, 2012, and 2013 (U.S. Department of the Navy 2011, Širović et al. 2012a and 2012b in U.S. Department of the Navy 2012a, Kerosky et al. 2013 in U.S. Department of the Navy 2013). Total passive acoustic data recorded over the 3 years totals over 17,417 hours and includes signals from four baleen whale species (blue whales, fin whales, gray whales, and humpback whales) and seven odontocetes (Kerosky et al. 2013 in U.S. Department of the Navy 2013). Previous research-funded results from these same locations from 2004 to 2010 is available in Oleson et al. (2009) and Oleson and Hildebrand (2012).

13.4.1.2 Satellite Tagging

The Navy purchased 10 satellite tracking tags in Year 1, suitable for deployment by on a suite of marine species within the offshore waters of the NWTRC. The tags used were the Andrews-style LIMPET (Low Impact Minimally Percutaneous External Transmitter), in either the location-only Spot5 configuration or the location/dive data Mk10-A configuration (Wildlife Computers, Redmond, Washington) (Schorr et al. 2012). Tags were programmed to species-specific, transmission schedule-based surfacing behavior and transmission data from previous deployments. Tags transmit animal movement data via the Argos satellite system. The commercial Argos system consists of data acquisition and relay equipment attached to NOAA low-orbiting weather satellites and ground-based receivers and data processing systems.

The Navy purchased these satellite tracking tags as part of the NWTRC monitoring from 2010 to2013. The tags were deployed opportunistically during field efforts associated with a 3-year collaborative field project addressing marine mammal distribution and habitat use off Oregon and Washington (Schorr et al. 2012). The species of interest were endangered cetaceans such as blue whales, fin whales, humpback whales, and sperm whales, but also included high-priority cetaceans such as beaked whales, in the event

they were encountered in favorable tagging conditions. Other species of interest for tagging included seasonal resident gray whales and transient or offshore killer whales.

Annual results from this effort are summarized in the Navy's NWTRC Monitoring Reports for 2011, 2012, and 2013 (U.S. Department of the Navy 2011a, 2012a, and 2013d) and collectively in Schorr et al. (2012). During this reporting period (2010–2013), a collective total of 21 tags were deployed on four different species off the Washington coast (3 gray whales, 5 humpback whales, 11 fin whales, and 2 offshore killer whales). A total of approximately 348 days of animal movement data was obtained (Schorr et al. 2012; U.S. Department of the Navy 2013d).

In 2012, the Navy funded a multi-year satellite tracking study of Pacific Coast Feeding Group gray whales (U.S. Department of the Navy 2013d). Tags were attached to 11 gray whales near Crescent City, California, in fall 2012 (Mate 2013). Good track histories were received from nine of the 11 tags which confirmed an exclusive near shore (< 15 km) distribution and movement along the California, Oregon, and Washington coast. Additional tag deployments on gray whales have occurred since the Mate (2013) report. These will be described in the NWTRC Year 4 Annual Monitoring Report in 2014.

Satellite tagging efforts are also funded for 2014–2018 along the U.S. west coast and include fin and blue whales. Longer term tags (up to 1 year) will allow for an assessment of animal occurrence, movement patterns, and residence time at areas within and outside of Navy at-sea ranges, including the NWTRC.

13.4.1.3 Explosive Ordnance/Underwater Detonation Monitoring

The Navy has conducted two annual underwater detonation training events in the NWTRC at the Floral Point site in Hood Canal. In 2012, the event was monitored by marine mammal and seabird observers, and acoustic measurements were also recorded. The observers were positioned aboard small Navy craft that followed a closely spaced transect pattern in nearshore waters. In 2013, a similar monitoring effort occurred, but two beach observers were added to the monitoring team in order to provide a training opportunity. The beach observers are not required under the permits. The entire area to be monitored can be seen via the small craft vessels and as a result of the tightly spaced transect observation pattern. Pre-event and post-event surveys were also conducted. Harbor seals were the only marine mammal species seen either before or after the training event, and no marine mammals were in the exclusion zone during the detonations.

13.4.2 Keyport Range Complex

Biannual monitoring surveys were undertaken in2011, 2012, and 2013 in the DBRC portion of the Keyport Range Complex. These surveys included both visual and passive acoustic monitoring during a mid-frequency active sonar test and a high-frequency active sonar test. In addition to Navy Lookouts, Navy marine mammal observers were positioned aboard range vessels and at a high elevation observation point on land to monitor the events. A pre-event and post-event survey was also conducted. Species seen included harbor seals, California sea lions, and harbor porpoise. In total over all years, there were 262 sightings representing 420 individuals seen during the visual surveys, which may include repeat sightings of the same individuals. No marine mammals were detected using the bottom-moored passive acoustic monitoring array in any year. Discussion and results from these efforts are summarized in the Navy's Keyport Range Complex Annual Monitoring Reports for 2011, 2012, and 2013 (U.S. Department of the Navy 2012c, 2012d, and 2013e).

13.4.3 Other Regional Navy-Funded Monitoring Efforts

Additional marine mammal studies are being funded or conducted by the Navy outside of and in addition to the Navy's commitments to NMFS for the NWTRC and the NUWC Keyport Range Complex. A variety of field survey methodologies are being utilized in order to better determine marine mammal presence, seasonality, abundance, distribution, habitat use, and density in these areas. The following studies either have been conducted or are underway during the 2010–2014 period:

- **Naval Base Pinniped Haulout Surveys (2010–2014):** Biologists located at NAVBASE Kitsap, Bangor, Bremerton, the Manchester Fuel Depot, and Naval Station Everett have been conducting year-round counts of sea lions hauled out on site-specific structures such as the floating security fences, submarines, or other opportunistic haulouts such as the large floating dock near Manchester. These counts are typically conducted weekly and involve identifying the sea lions to species and documenting branded animals. This information has shown seasonal use of the haulouts at each site, as well as trends in the number of animals by species using the haulouts at each site. In the case of Bangor, there are no haulout areas used by adult harbor seals, despite the adults being seen daily in the water, year-round. The only exception to this would be during pupping season when one wave screen (floating dock) is used temporarily by adult females to give birth. In late fall 2013, there were sightings of individual harbor seal pups using opportunistic manmade structures as temporary haulouts. These sightings include one harbor seal pup using a partially submerged ladder rung as a haulout and place to nurse; another pup resting on a floating oil boom; a third pup resting on a large piece of chain hanging in the water; a fourth pup managing to get aboard a submarine and haulout next to the California sea lions; and a fifth, older juvenile resting on the outer pontoon of the floating security fence. Harbor seals have not been seen hauled out at Bremerton or at the floating dock near Manchester. Harbor seals do haulout on the log rafts near Naval Station Everett.

- **Marine Mammal Surveys in Hood Canal and Dabob Bay (2011–2012):** The Navy conducted an opportunistic marine mammal vessel-based line transect density survey in Hood Canal and Dabob Bay during September and October 2011 and again in October 2012. In Hood Canal, the surveys followed a double saw-tooth pattern to achieve uniform coverage of the entire NAVBASE Kitsap, Bangor waterfront. Transects generally covered the area from Hazel Point on the south end of the Toandos Peninsula to Thorndyke Bay. Surveys in the adjacent Dabob Bay followed a slightly different pattern and generally followed more closely to the shoreline while completing a circular route through the Bay. These surveys had a dual purpose of collecting marine mammal and marbled murrelet (bird species) data, and near-shore surveys tended to yield more marbled murrelet sightings. During surveys, the survey vessels traveled at a speed of approximately five knots when transiting along the transect lines. Two observers recorded sightings of marine mammals both in the water and hauled out. Marine mammal sightings data included species identification, Global Positioning System animal locations relative to vessel position, and detailed behavioral notes. Data from the line transect surveys can be used to improve estimates of marine mammal density in Hood Canal and Dabob Bay.

- **Aerial Surveys of Pinniped Haulout Sites in Pacific Northwest Inland Waters (2013–2014):** Navy-funded aerial surveys of pinniped haulout sites in the inland waters of Washington state were initiated in March 2013 (Jeffries 2013b) and will continue until March 2014 (1-year study design). The objectives of this effort were to provide estimates of seasonal abundance, identify seasonal distribution patterns, and collect data to determine seal and sea lion densities. Aerial

surveys being conducted under this effort represent the first pinniped assessments to be done in the region over all four seasons, and will therefore provide much-needed information about seasonal variation of harbor seal, northern elephant seal, California sea lion, and Steller sea lion distribution and abundance in the inland waters of Washington. In addition, this effort will update the Atlas of Seal and Seal Lion Haulout Sites in Washington (inland waters region) (Jeffries et al. 2000). Finally, in a collaborative effort, the NMFS Northwest Region provided additional funding to support summer-only aerial surveys of the U.S. waters of the Strait of Juan de Fuca (Cape Flattery to Port Angeles), as well as the San Juan Islands. This collaborative approach between the Navy and NMFS will allow NMFS to update the SAR for the Pacific harbor seal (Washington Inland Waters stock). The current SAR is derived from population estimates from 1999, and abundance information from current surveys will provide NMFS with required data to revise this outdated stock assessment.

- **Aerial Surveys of Marine Mammals in Pacific Northwest Inland Waters (2013–2014):** Navy-funded aerial line-transect density surveys in the inland waters of Washington State were initiated in August 2013 (Smultea and Bacon 2013). Surveys are planned to continue quarterly (every season) through 2014. These surveys were designed in cooperation with NMFS in order to estimate density and abundance of species with sufficient sightings, document distribution and habitat use, and describe behaviors seen. Smultea and Bacon (2013) reported a total of 779 sightings composed of an estimated 1,716 individual marine mammals representing four species: harbor seal, harbor porpoise, California sea lion, and Risso's dolphins. Eighty-seven percent of sightings were of harbor seals, while harbor porpoise were the second-most frequent sighting (9 percent), followed by California sea lions; a pair of Risso's dolphins were seen twice.

- **Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities (2013–2015):** In an Interagency Agreement between the Navy and the NMFS Alaska Fisheries Science Center, the Navy has funded a sea lion satellite tagging study beginning in 2013 through 2015. Tagging is anticipated to occur in early 2014 with monitoring and data analysis extending into 2015. There are significant scientific data gaps in identifying the location of local foraging areas and percentage of time hauled out for pinniped species near Puget Sound Navy facilities. Data collected from this project will directly tie into Navy's future Phase III marine mammal density modeling for training and testing activities at-sea, and within Puget Sound. In particular, integration of improved haulout percentages will lower over-predictive modeled takes which currently, due to lack of regional data, assume all pinniped species are always in-water for purposes of model assessment of takes. Numbers of animals observed hauled out can be corrected into a population estimate by applying an estimate of the proportion of satellite-tagged-animals that are hauled out at the time of the census. Satellite-linked dive recorders can be used to assess location of foraging activity and describe the diving behavior, as well as record when the animal is hauled out.

13.4.4 Future Compliance Monitoring for Northwest Training and Testing

Based on NMFS-Navy meetings in June and October 2011, future Navy compliance monitoring, including pending NWTT monitoring, will address ICMP top-level goals through a series of regional and ocean basin study questions with a prioritization and funding focus on species of interest as identified 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 NWTT area, the Navy's initial recommendation for species of interest includes blue whale, fin whale, humpback whale, Southern Resident killer whale (offshore portion of their annual movements), and beaked whales. Navy monitoring for NWTT under this LOA authorization and concurrently in other areas of the Pacific Ocean will therefore be structured to address region-specific species-specific study questions that will be outlined in the final NWTT Monitoring Project Table in consultation with NMFS.

As an early start to NWTT monitoring, in July 2014 the Navy provided funding ($209,000) to NMFS' Northwest Fisheries Science Center to jointly participate in a new NWTT specific study:

MODELING THE DISTRIBUTION OF SOUTHERN RESIDENT KILLER WHALES IN THE PACIFIC NORTHWEST

The goal of this new study is to provide a more scientific understanding of endangered southern resident killer whale winter distribution off the Pacific Northwest coast. While the end project will work to develop a Bayesian space-state model for predicting the offshore winter occurrence, the project will actually consist of analysis of existing NMFS data (passive acoustic detections, satellite tag tracks) as well as new data collection from fall 2014 through spring 2015. The eight main tasks the study supports include:

- Identification and classification of marine mammal detections from acoustic recorders
- Acquisition and field deployment of satellite-linked transmitters (n=4) to track and determine southern resident killer whales movements
- Deployment of autonomous underwater acoustic recorders in and adjacent to the coastal and shelf/slope waters of Washington State. Navy funding will allow 10 additional recorders to be purchased and deployed along with four NMFS recorders for a total of 14 deployed recorders.
- Estimation of the probability of Southern Resident killer whale detection on acoustic recorders
- Development of the state-space occurrence models
- Development of predicative maps of the seasonal annual occurrence of southern resident killer whales
- Development a cost efficient strategy for the deployment of acoustic recorders in and adjacent to Pacific Northwest Navy ranges
- Reporting

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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 U.S. Navy is one of the world's leading organizations in assessing the effects of human activities the marine environment including marine mammals. From 2004 through 2013, the Navy has funded over $240M specifically for marine mammal research. 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 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], and 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 (LMR) Research and Development Program (http://www.lmr.navy.mil/). The goal of the LMR Research and Development 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:

- Providing science-based information to support Navy environmental effects assessments for research, development, acquisition, testing, and evaluation as well as Fleet at-sea training, exercises, maintenance, and support activities.
- Improving knowledge of the status and trends of marine species of concern and the ecosystems of which they are a part.
- Developing the scientific basis for the criteria and thresholds to measure the effects of Navy-generated sound.
- Improving understanding of underwater sound and sound field characterization unique to assessing the biological consequences resulting from underwater sound (as opposed to tactical applications of underwater sound or propagation loss modeling for military communications or tactical applications).
- Developing technologies and methods to monitor and, where possible, mitigate biologically significant consequences to living marine resources resulting from naval activities, emphasizing those consequences that are most likely to be biologically significant.

14.2 NAVY RESEARCH AND DEVELOPMENT

Both the LMR and ONR Research and Development programs periodically fund projects within the NWTT Study Area. Some data and results, when available from these Research and Development projects, are typically summarized in the Navy's annual range complex Monitoring Reports that are currently submitted to the NMFS each year. In addition, the Navy's Range Complex monitoring during training and testing activities is coordinated with the Research and Development monitoring in a given region to leverage research objectives, assets, and studies where possible under the ICMP.

The integration between the Navy's new LMR research and development program and related range complex monitoring will continue and improve during this LOA application period with applicable results presented in NWTT 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 DoD'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.

15 REFERENCES

Abramson, L., Polefka, S., Hastings, S. & Bor, K. (2009). Reducing the Threat of Ship Strikes on Large Cetaceans in the Santa Barbara Channel Region and Channel Islands National Marine Sanctuary: Recommendations and Case Studies. Prepared for and Adopted by the Channel Islands National Marine Sanctuary Advisory Council (Ed.). (pp. 73).

Acevedo, A. (1991). Interactions between boats and bottlenose dolphins, *Tursiops truncatus*, in the entrance to Ensenada De La Paz, Mexico. *Aquatic Mammals* 17(3): 120-124.

Aguilar, N., Carrilllo, M., Delgado, I., Diaz, F., & Brito, A. (2000). Fast ferries impact on cetacean in Canary Islands: Collisions and displacement. *European Research on Cetaceans* 14: 164.

Aguilar de Soto, N., Johnson, M., Madsen, P. T., Tyack, P. L., Bocconcelli, A. & Borsani, J. F. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? Marine Mammal Science, 22(3), 690-789.

Allen, B. M. & Angliss, R. P. (2010). Alaska Marine Mammal Stock Assessments 2009. (NOAA Technical Memorandum NMFS-AFSC-206, pp. 276). Seattle, WA: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Allen, B. M. & Angliss, R. P. (2012). Alaska Marine Mammal Stock Assessments, 2011. (pp. 278) National Marine Mammal Laboratory Alaska Fisheries Science Center.

Allen, B. M. and R. P. Angliss. (2014). Alaska marine mammal stock assessments, 2013, U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-277.

Allen, M. J. (2006). Continental shelf and upper slope. In L. G. Allen, D. J. Pondella, II and M. H. Horn (Eds.), The Ecology of Marine Fishes: California and Adjacent Waters (pp. 167-202). Berkeley, CA: University of California Press.

Allen, A.N., Schanze, J.J., Solow, A.R., and P.L. Tyack. (2014). Analysis of a Blainville’s beaked whale’s movement response to playback of killer whale vocalizations. Marine Mammal Science 30(1):154-168. doi: 10.1111/mms.12028

Antonelis, G. A., J. D. Baker, et al. (2006). Hawaiian monk seal (*Monachus schauinslandi*): Status and conservation issues. *Atoll Research Bulletin* 543: 75-101.

Aquatic Mammals (2015). Supplemental Tables to Aquatic Mammals Volume 41(1) regarding Biologically Important Areas for Cetaceans, Sections 4 and 6, downloaded 25 March 2015 from http://www.aquaticmammalsjournal.org/images/files/AM_41.1_Supplemental_Tables.pdf; 71 pages.

Arcangeli, A. & R. Crosti (2009). The short-term impact of dolphin-watching on the behaviour of bottlenose dolpjhins (*Tursiops truncatus*) in western Australia. *Journal of Marine Animals and Their Ecology* 2(1): 3-9.

Au, W. W. L. & Green, M. (2000). Acoustic interaction of humpback whales and whale-watching boats. [doi: 10.1016/S0141-1136(99)00086-0]. *Marine Environmental Research*, 49(5), 469-481.

Au, W. W. L. & Pawloski, D. A. (1989). A comparison of signal detection between an echolocating dolphin and an optimal receiver. Journal of Comparative Physiology A, 164(4), 451-458.

Au, D. & Perryman, W. L. (1982). Movement and speed of dolphin schools responding to an approaching ship. Fishery Bulletin, 80(2), 371-372.

Au, D. W. K. & Perryman, W. L. (1985). Dolphin habitats in the eastern tropical Pacific. *Fishery Bulletin, 83*, 623-643.

Ayres, K. l. R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, S. K. Wasser. (2012). Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (Orcinus orca) Population. PLoS ONE:7(6), pp 12.

Bain, D. (2002). A Model Linking Energetic Effects of Whale Watching to Killer Whale (Orcinus Orca) Population Dynamics. Report for the Orca Relief Citizens Alliance. Unpublished manuscript on file, pp. 23.

Baird, R.W. (2001). Status of harbour seals, *Phoca vitulina*, in Canada. *Canadian Field-Naturalist,* 11 5(4),663-675.

Baird, R.W. & Dill, L.M. (1995). Occurrence and behaviour of transient killer whales: Seasonal and pod-specific variability, foraging behaviour, and prey handling. *Canadian Journal of Zoology*, 73,1300-1311.

Baird, R.W. & Dill, L.M. (1996). Ecological and social determinants of group size in transient killer whales. *Behavioral Ecology*, 7(4),408-416.

Baird, R. & Gorgone, A. (2005). False Killer Whale Dorsal Fin Disfigurements as a Possible Indicator of Long-Line Fishery Interactions in Hawaiian Waters. *Pacific Science,* 59(4), 593-601.

Baird, R.W. & Hanson, M.B. (1997). Status of the northern fur seal, *Callorhinus ursinus*, in Canada. *Canadian Field-Naturalist,* 111 (2),263-269.

Baird, R.W. & Stacey, P.J. (1991). Status of Risso's dolphin, *Grampus griseus*, in Canada. *Canadian Field-Naturalist*, 105(2), 233-242.

Baird, R.W., P.J. Stacey, & Whitehead, H. (1993). Status of the striped dolphin, *Stenella coeruleoalba*, in Canada. *Canadian Field-Naturalist,* 107(4),455-465.

Baird, R.W., D. Nelson, J. Lien, &Nagorsen, D.W. (1996). The status of the pygmy sperm whale, *Kogia breviceps*, in Canada. *Canadian Field-Naturalist,* 110(3),525-532.

Baker, C. S., L. M. Herman, B. G. Bays and G. Bauer (1983). The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Honolulu, Hawaii, Kewalo Basin Marine Mammal Laboratory, University of Hawaii: 1-86.

Balcomb, K. C. (1989). Baird's beaked whale *Berardius bairdii* Stejneger, 1883: Arnoux's beaked whale *Berardius arnuxii* Duvernoy, 1851. In. *Handbook of Marine Mammals,* (Vol 4, pp. 261-288). S. H. Ridgway and R. Harrison (Eds.), Academic Press.

Barbieri, M.M, S. Reverty, M.B. Hanson, S. Venn-Watson, J.K. Ford, and J.K. Gaysos. (2013). Spatial and temporal analysis of killer whale (*Orcinus orca*) strandings in the North Pacific Ocean and the benefits of a coordinated stranding response protocol. Marine Mammal Science, 29(4):E448–E462, doi: 10.1111/mms.12044.

Barlow, J. (1988). Harbor porpoise, *Phocoena Phoconea*, abundacne estimation for California, Oregon, and Washington: I. Ship surveys. Fishery Bulletion: Volumn 86, No. 8.

Barlow, J. (1994). "Abundance of large whales in California coastal waters: A comparison of ship surveys in 1979/80 and in 1991." Report of the International Whaling Commision 44: 399-406.

Barlow, J. (1995). The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin, 93, 1-14.

Barlow, J. (1997). *Preliminary Estimates of Cetacean Abundance off California, Oregon and Washington Based on a 1996 Ship Survey and Comparisons of Passing and Closing Modes*. (NMFS-SWFSC Administrative Report LJ-97-11). La Jolla, CA: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Barlow, J. (2003). *Cetacean Abundance in Hawaiian Waters During Summer/Fall 2002*. (Administrative Report LJ-03-13, pp. 22). La Jolla, CA: Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA.

Barlow, J. (2006). Cetacean Abundance in Hawaiian Waters Estimated from a Summer/Fall Survey in 2002. *Marine Mammal Science, 22*(2), 446-464. 10.1111/j.1748-7692.2006.00032.x.

Barlow, J. (2010). Cetacean abundance in the California Current estimated from a 2008 ship-based line-transect survey. National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-456. 19 pp.

Barlow, J. (2013). Inferring Trackline Detection Probabilities from Differences in Apparent Densities of Beaked Whales and Dwarf & Pygmy Sperm Whales in Different Survey Conditions. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-508, U.S. Department of Commerce, National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA., 14 p.

Barlow, J., Ferguson, M., Becker, E., Redfern, J., Forney, K., Vilchis, I. & Ballance, L. (2009). Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean National Oceanic and Atmospheric Administration (Ed.), NOAA Technical Memorandum NMFS-SWFSC-444. (pp. 229). La Jolla, California: Southwest Fisheries Science Center.

Barlow, J., Ferguson, M. C., Perrin, W. F., Ballance, L., Gerrodette, T., Joyce, G. & Waring, G. (2006). Abundance and densities of beaked and bottlenose whales (family *Ziphiidae*). Journal of Cetacean Research and Management, 7(3), 263-270.

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

Barlow, J. & Gisiner, R. (2006). Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 239-249.

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

Barlow, J. & Forney, K. A. (2007). Abundance and population density of cetaceans in the California Current ecosystem. *Fishery Bulletin, 105*, 509-526.

Barlow, J., Calambokidis, J., Falcone, E., Baker, C., Burdin, A., Clapham, P., . . . Yamaguchi, M. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Marine Mammal Science, 0-0*. 10.1111/j.1748-7692.2010.00444.x.

Baumgartner, M. F. (1997). The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Marine Mammal Science, 13*(4), 614-638.

Bejder, L., Samuels, A., Whitehead, H. & Gales, N. (2006). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. Animal Behaviour, 72, 1149–1158. doi: 10.1016/j.anbehav.2006.04.003

Berman-Kowalewski, M., Gulland, F. M. D., Wilkin, S., Calambokidis, J., Mate, B., Cordaro, J., & Dover, S. (2010). Association Between Blue Whale (*Balaenoptera musculus*) Mortality and Ship Strikes Along the California Coast. *Aquatic Mammals*, 36(1), 59-66. doi: 10.1578/am.36.1.2010.59.

Bernaldo de Quiros, Y., Gonzalez-Diaz, O., Arbelo, M., Sierra, E., Sacchini, S. & Fernandex, A. (2012). Decompression vs. decomposition: distribution, amount, and gas composition of bubbles in stranded marine mammals. [Original Research Article]. Frontiers in Physiology, 3 Article 177, 19. 10.3389/fPhys.2012.0177.

Bernard, H. J. & Reilly, S. B. (1999). Pilot whales *Globicephala* Lesson, 1828. In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals,* (Vol. 6, pp. 245-280). San Diego, CA: Academic Press.

Berta, A., Sumich, J. L. & Kovacs, K. M. (2006). *Marine Mammals: Evolutionary Biology* (2nd ed.). Burlington, MA: Elsevier.

Best, P. B. & Lockyer, C. H. (2002). Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. *South African Journal of Marine Science, 24*, 111-133.

Boyd, I., Claridge, D., Clark, C., Southall, B. & Tyack, P., (eds). (2008). BRS 2008 Preliminary Report. US Navy NAVSEA PEO IWS 5, ONR, US Navy Environmental Readiness Division, NOAA, SERDP.

Branch, T. A., Stafford, K. M., Palacios, D. M., Allison, C., Bannister, J. L., Burton, C. L. K., . . . Warneke, R. M. (2007). Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. *Mammal Review, 37*(2), 116-175. 10.1111/j.1365-2907.2007.00106.

Brown, R. F., B. E. Wright, S. D. Riemer, and J. Laake. 2005. Trends in abundance and current status of harbor seals in Oregon: 1977-2003. Mar. Mammal Sci. 21(4):657-670.

Brownell, R. L., W. A. Walker, & Forney, K. A. (1999). Pacific white-sided dolphin *Lagenorhynchus obliquidens* Gill, 1865. In: *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison, Academic Press. 6: The second book of dolphins and the porpoises: 57-84.

Brownell, R.L., Jr., P.J. Clapham, T. Miyashita, & T. Kasuya. (2001). Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management* (Special Issue 2) 269-286.

Calambokidis, J. (2012). Summary of ship-strike related research on blue whales in 2011. Manuscript on file: 9.

Calambokidis, J. & Baird, R.W. (1994). Status of marine mammals in the Strait of Georgia, Puget Sound, and Juan de Fuca Strait and potential human impacts. p 282-303 In: *Review of the marine environment and biota of Strait of Georgia, Puget Sound, and Juan de Fuca Strait.* Proceedings of the BC/Washington Symposium on the Marine Environment, January 13 and 14, 1994. (R.C.H. Wilson, R.J. Beamish, F. Aitkens, and J. Bell, Ed.). *Canadian Technical Report of Fisheries and Aquatic Sciences No. 1948.*

Calambokidis, J. & Barlow, J. (2004). Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. Marine Mammal Science, 20(1), 63-85.

Calambokidis, J. & J. Huggins. (2008). Final Report – NA04NMF4390016: Cetacean stranding response in Washington with special attention to gray whales and harbor porpoise. Cascadia Research Collective, Olympia, WA.

Calambokidis, J., G.H. Steiger, & J.C. Cubbage. (1987). Marine mammals in the southwestern Strait of Juan de Fuca: Natural history and potential impacts of harbor development in Neah Bay. Contract number DACW67-85-M-0046. Prepared for Seattle District Army Corps of Engineers, Seattle, Washington by Cascadia Research Collective, Olympia, Washington. 103pp.

Calambokidis, J. & Steiger, G.H. (1990). Sightings and movements of humpback whales in Puget Sound, Washington. Northwestern Naturalist, 71, 45-49.

Calambokidis, J., J.R. Evenson, J.C. Cubbage, P.J. Gearin, & S.D. Osmek. (1992). Harbor porpoise distribution and abundance off Oregon and Washington from aerial surveys in 1991. Final report by Cascadia Research Collective, Olympia, WA, to National Marine Mammal Laboratory. Seattle, Washington: NMFS-AFSC. 44 pp.

Calambokidis, J., Steiger, G. H., Straley, J. M., Quinn II, T. J., Herman, L. M., Cerchio, S., . . . Rasmussen, K. (1997). *Abundance and population structure of humpback whales in the North Pacific basin* [Unpublished contact report the SWFSC]. (pp. 72).

Calambokidis, J., J.D. Darling, V. Deecke, P. Gearin, M. Gosho, W. Megill, C.M. Tombach, D. Goley, C. Toropova, & B. Gisborne. (2002). Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius robustus*) from California to southeastern Alaska in 1998*. Journal of Cetacean Research and Management,* 4(3), 267-276.

Calambokidis, J., Chandler, T., Falcone, E. & Douglas, A. (2004). Research on large whales off California, Oregon, and Washington in 2003 [Annual Report]. (Contract number 50ABNF100065). La Jolla, California: U. S. Department of Commerce. Prepared by Cascadia Research Collective. Prepared for National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Calambokidis, J., Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, P. J., Ford, J. K. B., . . . Maloney, N. (2008). *SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific* [Final report]. (pp. 57). Seattle, Washington. Prepared for U. S. Dept of Commerce Western Administrative Center.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Huggins (2009a). Photographic identification of humpback and blue whales off the U.S. West Coast: results and updated abundance estimates from 2008 field season. Final Report for Contract AB133F08SE2786 National Marine Fisheries Service, Southwest Fisheries Science Center.

Calambokidis, J., Barlow, J., Ford, J. K. B., Chandler, T. E. & Douglas, A. B. (2009b). Insights into the population structure of blue whales in the Eastern North Pacific from recent sightings and photographic identification. Marine Mammal Science, 25(4), 816-832. 10.1111/j.1748-7692.2009.00298.x

Calambokidis, J., J.L. Laake and A. Klimek. (2010). Abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998–2008. Paper IWC/62/BRG32 submitted to the International Whaling Commission Scientific Committee. 50 pp.

Calambokidis, J. (2012). Personal communication between John Calambokidis (Cascadia Research Collective) and Sharon Rainsberry (Navy) on February 16, 2012 regarding information and number of humpback whales present in Hood Canal from January/February 2012 sightings and other documented sightings of humpback whales in Hood Canal.

Calambokidis, J., Laake, J.L. & Klimek, A. (2012). Updated analysis of abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998-2010. Paper SC/M12/AWMP2-Rev submitted to the IWC Scientific Committee. 65 pp.

Calambokidis, J. (2013). Personal communication between John Calambokidis (Cascadia Research Collective) and Andrea Balla-Holden (Navy) via email between February 21 and February 22, 2013 regarding historical stranding and sighting records of gray whales in Hood Canal.

Calambokidis, J., Steiger, G.H., Curtice, C., Harrison, J., Ferguson, M.C., Becker, E., DeAngelis, M., &Van Parijs, S.M. (2015). Biologically Important Areas for Cetaceans within U.S. Waters – West Coast Region. Aquatic Mammals 41(1), 39-53, DOI 10.1578/AM.41.1.2015.39; 15 pp.

Caldwell, D. K. & Caldwell, M. C. (1989). Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals* (Vol. 4, pp. 234-260). San Diego, CA: Academic Press.

Canadas, A., Sagarminaga, R. & Garcia-Tiscar, S. (2002). Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep Sea Research I*, 49, 2053-2073.

Carretta, J. V., K. A. Forney and J. L. Laake. (1998). "Abundance of Southern California coastal bottlenose dolphins estimated from tandem aerial surveys." Marine Mammal Science 14(4): 655-675.

Carretta, J. V., T. Price, Read, R., & Petersen, D. (2004). Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. *Marine Fisheries Review*, 66(2), 21-30.

Carretta, J. V., Forney, K. A., Oleson, E., Martien, K., Muto, M. M., Lowry, M. S., Barlow, J., Baker, J., Hanson, B., Lynch, D., Carswell, L., Brownell, R.L. Jr., Robbins, J., Mattila, D.K., Ralls, K, & Hill, M. C. (2012). *U.S. Pacific Marine Mammal Stock Assessments: 2011* (NOAA Technical Memorandum NMFS-SWFSC-488. pp. 356). La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J.V., E. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, B. Hanson, K. Martien, M.M. Muto, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, D. Lynch, L. Carswell, R.L. Brownell Jr, and D.K. Mattila. (2014). U.S. Pacific Marine Mammal Stock Assessments: 2013. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-532.

Carretta, J. V., Forney, K. A., Lowry, M. S., Barlow, J., Baker, J., Johnston, D., . . . Carswell, L. (2009). U. S. Pacific marine mammal stock assessments: 2008. (NOAA Technical Memorandum NMFS-SWFSC-434, pp. 340) NOAA. Available from http://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-434.pdf

Carretta, J. V., Lowry, M. S., Stinchcomb, C. E., Lynne, M. S. & Cosgrove, R. E. (2000). Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: Results from aerial and ground surveys in 1998 and 1999 [Administrative Report]. (LJ-00-02, pp. 43). La Jolla, CA: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J.V., E. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, B. Hanson, K. Martien, M.M. Muto, M.S. Lowry, J. Barlow, D. Lynch, L. Carswell, R.L. Brownell Jr, D.K. Mattila, and M. C. Hill. (2014). U.S. Pacific Marine Mammal Stock Assessments: 2013. U.S. Department of Commerce, NOAA Technical Memorandum, in press.

Carrillo, M. and F. Ritter. (2010). Increasing numbers of ship strikes in the Canary Islands: proposals for immediate action to reduce risk of vessel-whale collisions. Journal of Cetacean Research and Management 11(2): 131-138.

Cascadia Research. (2010a). Unusual Strandings of Bryde's whales in Puget Sound (January 2010). Online at http://www.cascadiaresearch.org/Strandings.htm

Cascadia Research. (2010b). Injured Bryde's whales in Puget Sound (6 December 2010), Cascadia Research. Online at http://www.cascadiaresearch.org/Strandings.htm

Cascadia Research. (2011). Unusual Sightings of Risso's Dolphins in S. Puget Sound (30 December 2011), Cascadia Research. Online at http://www.cascadiaresearch.org/Strandings.htm

Cascadia Research. (2012a). Stranding of one of the long-beaked common dolphins in Puget Sound (29 March 2012). Online at http://www.cascadiaresearch.org/CommonDolphinStrand2012.htm

Cascadia Research. (2012b). Examination of stranded gray whale found floating in Saratoga Passage on 22 April 2012. Online at [http://www.cascadiaresearch.org/examination_of_stranded_gray_whale-23April2012.htm

Cascadia Research. (2013). Cascadia stranding response and unusual sightings. Online at http://www.cascadiaresearch.org/Strandings.htm

Christiansen, F., Lusseau, D., Stensland, E. & Berggren, P. (2010). Effects of tourist boats on the behaviour of Indo-Pacific bottlenose dolphins off the south coast of Zanzibar. *Endangered Species Research,* 11: 91-99.

Christiansen, F., Rasmussen, M, and Lusseau, D. (2013) Whale watching disrupts feeding activities of minke whales on a feeding ground. Marine Ecology Progress Series 478:239-251. doi: 10.3354/meps10163

Clapham, P.J., C. Good, S.E. Quinn, R.R. Reeves, J.E. Scarff, and R.L. Brownell, Jr. (2004). Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *Journal of Cetacean Research and Management,* 6(1), 1-6.

Claridge, D. & Durban, J. (2009, December 7-10, 2009). Abundance and movement patterns of Blainville's beaked whales at the Atlantic undersea test and evaluation center (AUTEC). Presented at the 2009 ONR Marine Mammal Program Review, Alexandria, VA.

Clark, C., W. Ellison, B. Southall, L. Hatch, S. Van Parijs, A. Frankel, and D. Ponirakis. (2009). Acoustic masking inmarine ecosystems: intuitions, analysis, and implication. *Marine Ecology Progess Series. 395*:201-22 pp. 201-222.

Clark, C. W. & Fristrup, K. M. (2001). Baleen whale responses to low-frequency human-made underwater sounds. [Abstract Only]. Journal of the Acoustical Society of America, 110(5), 2751.

Clark, S. L. & Ward, J. W. (1943). The Effects of Rapid Compression Waves on Animals Submerged In Water. *Surgery, Gynecology & Obstetrics*, 77, 403-412.

Clark, L. S., Cowan, D. F. & Pfeiffer, D. C. (2006). Morphological changes in the Atlantic bottlenose dolphin (*Tursiops truncatus*) adrenal gland associated with chronic stress. Journal of Comparative Pathology, 135, 208-216.

Costa, D. P., Crocker, D. E., Gedamke, J., Webb, P. M., Houser, D. S., Blackwell, S. B., . . . Le Boeuf, B. J. (2003). The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on

the diving behavior of juvenile northern elephant seals, *Mirounga angustirostris*. Journal of the Acoustical Society of America, 113, 1155-1165.

Cowan, D. & Curry, B. (2008). Histopathology of the Alarm Reaction in Small Odontocetes. [Electronic Version]. Journal of Comparative Pathology, 139, 24-33. 10.1016/j.jcpa.2007.11.009

Cowan, I.M. and C.J. Guiguet. (1952). Three cetacean records from British Columbia. *Murrelet,* 33(1): 10-11.

Cox, T., Ragen, T., Read, A., Vox, E., Baird, R., Balcomb, K., . . . Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management, 7*(3), 177-187.

Craig, J. C. & Hearn, C. W. (1998a). Physical Impacts of Explosions On Marine Mammals and Turtles Department of the Navy (Ed.), Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine (pp. 43). North Charleston, SC: U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command.

Craig, J. C., Jr. & Hearn, C. W. (1998b). Appendix D. Physical impacts of explosions on marine mammals and turtles Final Environmental Impact Statement on Shock Testing of the Seawolf Submarine (pp. D1-D41). North Charleston, South Carolina: Department of the Navy.

Craig Jr., J. C. (2001). Appendix D, Physical Impacts of Explosions on Marine Mammals and Turtles Final Environmental Impact Statement, Shock Trial of the WINSTON CHURCHILL (DDG 81) (Final, pp. 43). U.S. Department of the Navy, Naval Sea Systems Command (NAVSEA).

Croll, D. A., Clark, C. W., Calambokidis, J., Ellison, W. T. & Tershy, B. R. (2001). Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales. Animal Conservation, 4(PT1), 13-27.

Crum, L., Bailey, M., Guan, J., Hilmo, P., Kargl, S. & Matula, T. (2005, July). Monitoring bubble growth in supersaturated blood and tissue *ex vivo* and the relevance to marine mammal bioeffects. *Acoustics Research Letters Online, 6*(3), 214-220. 10.1121/1.1930987.

Crum, L. & Mao, Y. (1996, May). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *Acoustical Society of America, 99*(5), 2898-2907.

D'Amico, A., Gisiner, R., Ketten, D., Hammock, J., Johnson, C., Tyack, P., Mead, J. (2009). "Beaked Whale Strandings and Naval Exercises." Aquatic Mammals 35(4): 452-472.

Dahlheim, M. E. & Heyning, J. E. (1999). Killer whale *Orcinus orca* (Linnaeus, 1758). In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals,* (Vol. 6, pp. 281-322). San Diego, CA: Academic Press.

Dahlheim, M. E., Schulman-Janiger, A., Black, N., Ternullo, R., Ellifrit, D. & Balcomb, K. C. (2008). Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): Occurrence, movements, and insights into feeding ecology. *Marine Mammal Science, 24*(3), 719-729. doi: 10.1111/j.1748-7692.2008.00206.x.

Dahlheim, M. E., P. A. White, & J. M. Waite. (2009). Cetaceans of Southeast Alaska: Distribution and seasonal occurrence. *J. Biogeogr*. 36:410-426.

Dalebout, M. L., Mead, J. G., Baker, C. S., Baker, A. N. & van Helden, A. L. (2002). A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: *Ziphiidae*) discovered through phylogenetic analyses of mitochondrial DNA sequences. *Marine Mammal Science, 18*(3), 577-608.

Danil, K. & St. Ledger, J. A. (2011, November/December). Seabird and dolphin mortality associated with underwater detonation exercises. *Marine Technology Society Journal*, 45(6), 89-95.

Davis, R.W., T.M. Williams and F.T. Awbrey. (1988). Sea Otter Oil Spill Avoidance Study, Minerals Management Service: 76.

Davis, R.B., R.D. Andrews, and O. Lee. 2008. Winter Movements, Foraging Behavior and Habitat - Associations of Northern Fur Seal (*Callorhinus ursinus*) Pups. North Pacific Research Board NPRB Project F0513 Final Report- June 2008.

Deecke, V. B., Slater, P. J. B. & Ford, J. K. B. (2002). Selective habituation shapes acoustic predator recognition in harbour seals. Nature, 420(14 November), 171-173.

Dennison S., Moore M. J., Fahlman A., Moore K., Sharp S., Harry C. T., Hoppe J., Niemeyer M., Lentell B., Wells R. S. (2011). Bubbles in live-stranded dolphins. Proc. R. Soc. Lond. B Biol. Sci. 79, 1396–1404. doi: 10.1098/rspb.2011.1754.

DeRuiter, S.L., I.L. Boyd, D.E. Claridge, C.W. Clark, C. Gagnon, B.L. Southall, and P.L. Tyack (2013a). Delphinid whistle production and call matching during playback of simulated military sonar. Marine Mammal Science 29(2): E46-E59.

De Ruiter, S.L., B.L. Southall, J. Calambokidis, W.M.X. Zimmer, D. Sadykova, E.A. Falcone, A.S. Friedlaender, J.E. Joseph, D. Moretti, G.S. Schorr, L. Thomas, and P.L Tyack (2013b). First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. *Biology Letters*, 9(4): 1-5.

Dizon, A. E., Perrin, W. F. & Akin, P. A. (1994). *Stocks of dolphins (Stenella spp. and Delphinus delphis) in the eastern tropical Pacific: A phylogeographic classification* (NOAA Technical Report, NMFS 119, pp. 20).

Di Iorio, L. & Clark, C. W. (2010). Exposure to seismic survey alters blue whale acoustic communication. Biology Letters, 6, 3. 10.1098/rsbl.2009.0651

Dorsey, EM. (1983). Exclusive adjoining ranges in individually indetified minke whales (*Balaenoptera acutorostrata*) in Washington State. *Canadian Journal of Zoology. 61*: 174-181.

Dorsey, E.M., S.J. Stern, A.R. Hoelzel, & Jacobsen, J. (1990). Minke whales (*Balaenoptera acutorostrata*) from the west coast of North America: Individual recognition and small-scale site fidelity. *Reports of the International Whaling Commission* (Special Issue 12) 357-368.

Douglas, A. B., Calambokidis, J., Raverty, S., Jeffries, S. J., Lambourn, D. M. & Norman, S. A. (2008). Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association of the United Kingdom, 88(6), 1121-1132.

Engelhard, G. H., Brasseur, S. M. J. M., Hall, A. J., Burton, H. R. & Reijnders, P. J. H. (2002). Adrenocortical responsiveness in southern elephant seal mothers and pups during lactation and the effect of scientific handling. Journal of Comparative Physiology - B, 172, 315–328.

Engelhard, J., C. V. Löhr, J. Rice, and D. Duffield. (2012). Retrospective Analyses of Marine Mammal Strandings on the Oregon Coast. Poster Presentations Oregon State University http://ir.library.oregonstate.edu/xmlui/handle/1957/29416

Erbe, C. (2000). Detection of whale calls in noise: Performance comparison between a beluga whale, human listeners, and a neural network. Journal of the Acoustical Society of America, 108(1), 297-303.

Erbe, C. (2002). Underwater Noise of Whale-Watching Boats and Potential Effects on Killer Whales (Orcinus Orca), Based on an Acoustic Impact Model. Marine Mammal Science, 18(2), 394-418.

Erbe, C. (2002, April). Underwater Noise of Whale-Watching Boats and Potential Effects on Killer Whales (Orcinus Orca), Based on an Acoustic Impact Model. Marine Mammal Science, 18(2), 394-418.

Eskesen, I. G., Teilmann, J., Geertsen, B. M., Desportes, G., Riget, F., Dietz, R., . . . Siebert, U. (2009). Stress level in wild harbour porpoises (*Phocoena phocoena*) during satellite tagging measured by respiration, heart rate and cortisol. Journal of the Marine Biological Association of the United Kingdom, 89(5), 885–892.

Evans, P. G. H. & Miller, L. A. (2003). Proceedings of the workshop on active sonar and cetaceans European cetacean society newsletter, No. 42 - Special Issue. Las Palmas, Gran Canaria.

Falcone, E. A., Schorr, G. S., Douglas, A. B., Calambokidis, J., Henderson, E., McKenna, M. F., . . . Moretti, D. (2009). Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: A key area for beaked whales and the military? *Marine Biology, 156*, 2631-2640.

Felix, F. & Van Waerebeek, K. (2005, January/June). Whale Mortality from Ship Strikes in Ecuador and West Africa. Latin American Journal of Aquatic Mammals, 4(1), 55-60. 10.5597/lajam00070 Retrieved from http://dx.doi.org/10.5597/lajam00070

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

Ferguson, M.C., Curtice, C., Harrison, J., & Van Parijs, S.M. (2015a). Biologically Important Areas for Cetaceans within U.S. Waters – Overview and Rationale. Aquatic Mammals 41(1), 2-16, DOI 10.1578/AM.41.1.2015.2; 41 pp.

Ferguson, M.C., Curtice, C., & Harrison, J. (2015b). Biologically Important Areas for Cetaceans Within U.S. Waters – Gulf of Alaska Region. Aquatic Mammals 41(1), 65-78, DOI 10.1578/AM.41.1.2015.65; 14 pp.

Fernandez, A., Edwards, J. F., Rodriguez, F., Espinosa De Los Monteros, A., Herraez, P., Castro, P., Jaber, J. R., Martin, V. and Arbelo, M. (2005). Gas and fat embolic syndrome involving a mass stranding of beaked whales (Family *Ziphiidae*) exposed to anthropogenic sonar signals. Vet. Pathol. 42, 446-457.

Finneran, J. J., Carder, D. A. & Ridgway, S. H. (2001, December 2001). Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to tonal signals. Journal of the Acoustical Society of America, 110(5), 2749(A).

Finneran, J. J., Carder, D. A. & Ridgway, S. H. (2003a). Temporary threshold shift (TTS) measurements in bottlenose dolphins (*Tursiops truncatus*), belugas (*Delphinapterus leucas*), and California sea lions (*Zalophus californianus*). Presented at the Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, TX.

Finneran, J. J., Dear, R., Carder, D. A. & Ridgway, S. H. (2003b). Auditory and behavioral responses of California sea lions (*Zalophus californianus*) to single underwater impulses from an arc-gap transducer. Journal of the Acoustical Society of America, 114(3), 1667-1677.

Finneran, J. J., Carder, D. A., Schlundt, C. E. & Ridgway, S. H. (2005a). Temporary Threshold Shift in Bottlenose Dolphins (*Tursiops truncatus*) Exposed to Mid-frequency Tones. Journal of the Acoustical Society of America, 118(4), 2696-2705.

Finneran, J. J., Dear, R., Carder, D. A., Belting, T., McBain, J., Dalton, L. & Ridgway, S. H. (2005b). Pure Tone Audiograms and Possible Aminoglycoside-Induced Hearing Loss in Belugas (*Delphinapterus leucas*). Journal of the Acoustic Society of America, 117, 3936-3943.

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

Finneran, J. J., Carder, D. A., Schlundt, C. E. & Dear, R. L. (2010b). Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones (Vol. 127, pp. 3267-3272): ASA.

Finneran, J. J., Houser, D. S., Mase-Guthrie, B., Ewing, R. Y. & Lingenfelser, R. G. (2009). Auditory Evoked Potentials in a Stranded Gervais' Beaked Whale (*Mesoplodon europaeus*). Journal of Acoustical Society of America, 126(1), 484-490.

Finneran, J. & Jenkins, A. K. (2012). Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report. SPAWAR Marine Mammal Program, U.S. Navy.

Finneran, J. J. & Schlundt, C. E. (2004). Effects of intense pure tones on the behavior of trained odontocetes [Technical Report]. (Vol. TR 1913). San Diego, CA: SSC San Diego.

Finneran, J. J. & Schlundt, C. E. (2010). Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America, 128(2), 567-570. 10.1121/1.3458814

Finneran, J. J. & Schlundt, C. E. (2011). Subjective loudness level measurements and equal loudness contours in a bottlenose dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America (in review), 130(5), 3124-3136.

Finneran, J. J., Schlundt, C. E., Branstetter, B. & Dear, R. L. (2007). Assessing temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) using multiple simultaneous auditory evoked potentials. [Journal Article]. Journal of the Acoustical Society of America, 122(2), 1249–1264.

Finneran, J. J., Schlundt, C. E., Carder, D. A., Clark, J. A., Young, J. A., Gaspin, J. B. & Ridgway, S. H. (2000, July). Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. Journal of Acoustical Society of America, 108(1), 417-431.

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A. & Ridgway, S. H. (2002, June 2002). Temporary Shift in Masked Hearing Thresholds in Odontocetes After Exposure to Single Underwater Impulses from a Seismic Watergun. Journal of the Acoustical Society of America, 111(6), 2929-2940.

Finneran, J. J., Schlundt, C. E. & Ridgway, S. H. (2005, October). Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal of Acoustical Society of America, 118(4), 2696-2705.

Fitch, R., Harrison, J. & Lewandowski, J. (2011). Marine Mammal and Sound Workshop July 13 and 14, 2010: Report to the National Ocean Council Ocean Science and Technology Interagency Policy Committee Bureau of Ocean Energy Management (BOEM), Department of the Navy (DON) and National Oceanic and Atmospheric Administration (NOAA) (Eds.). Washington, D.C.

Foote, A. D., Osborne, R. W. & Hoelzel, A. R. (2004). Whale-call response to masking boat noise, Nature (Vol. 428, pp. 910-910).

Ford, J. K. B. (2008). Killer whale *Orcinus orca*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 650-657). San Diego, CA: Academic Press.

Ford, J.K.B., G.M. Ellis, & K.C. Balcomb. (1994). Killer whales: The natural history and genealogy of *Orcinus orca* in British Columbia and Washington State. Vancouver, British Columbia: UBC Press; and Seattle, Washington: University of Washington Press.

Forney, K.A. (2000). Environmental models of cetacean abundance: reducing uncertainty in population trends. *Conservation Biology,* 14, 1271-1286.

Forney, K.A. (2007). Preliminary estimates of cetacean abundance along the U.S. west coast and within four National Marine Sanctuaries during 2005. NOAA Tech Memo NMFS-SWFSC-406.

Forney, K. A. & Barlow, J. (1998). Seasonal patterns in the abundance and distribution of California cetaceans, 1991-1992. *Marine Mammal Science, 14*(3), 460-489.

Forney, K. & Kobayashi, D. (2007). Updated Estimates of Mortality and Injury of Cetaceans in the Hawaii-Based Longline Fishery, 1994-2005. NOAA Technical Memorandum NMFS-SWFSC-412: 35.

Forney K.A., Barlow J., & Carretta J.V. (1995) The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. *Fishery Bulletin,* 93: 15-26.

Forney K.A., M.C. Ferguson, E.A. Becker, P.C. Fiedler, J.V. Redfern, J. Barlow, I.L. Vilchis, T. Gerrodette, & L.T. Balance (2012). Habitat-based spatial models of cetacean density in the eastern Pacific Ocean. *Endangered Species Research*, 16, 113-133.

Frankel, A. S. & Clark, C. W. (2000). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. Journal of the Acoustical Society of America, 108(4), 1930-1937.

Fristrup, K. M., Hatch, L. T. & Clark, C. W. (2003). Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. Journal of the Acoustical Society of America, 113(6), 3411-3424.

Frantzis, A., Goold, J. C., Skarsoulis, E. K., Taroudakis, M. I. & Kandia, V. (2002). Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L). *Journal of the Acoustical Society of America, 112*(1), 34-37.

Fulling, G. L., Thorson, P. H. & Rivers, J. (2011). Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. *Pacific Science, 65*(3), 321-343. 10.2984/65.3.321.

Gabriele, C. M., A. S. Jensen, J. L. Neilson, and J. M. Straley. (2007). Preliminary Summary of Reported Whale-Vessel Collisions in Alaskan Waters: 1978-2006. Manuscript on file.

Gallo, J. P. (1994). Factors affecting the population status of Guadalupe fur seal, *Arctocephalus townsendi* (Merriam, 1897), at Isla de Guadalupe, Baja California, Mexico. Ph.D. Thesis, University of California, Santa Cruz, 199 p.

Gjertz, I. & Børset, A. (1992). Pupping in the most northerly harbor seal (*Phoca vitulina*). *Marine Mammal Science*, 8(2), 103-109.

Goertner, J. F. (1982). Prediction of Underwater Explosion Safe Ranges for Sea Mammals [Technical Report]. (NSWC TR 82-188, pp. 25). Dahlgren, VA: Naval Surface Weapons Center.

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

Goldbogen J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E.A. Falcone, G.S. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack (2013). Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society Bulletin 280: 20130657.

Green, G. A., Brueggeman, J. J., Grotefendt, R. A., Bowlby, C. E., Bonnell, M. L. & Balcomb, K. C., III. (1992). *Cetacean distribution and abundance off Oregon and Washington, 1989-1990*. (pp. 100). Los Angeles, CA: Minerals Management Service.

Gregory, P. R. & Rowden, A.A. (2001). Behaviour patterns of bottlenose dolphins (*Tursiops truncatus*) relative to tidal state, time-of-day, and boat traffic in Cardigan Bay, West Wales. *Aquatic Mammals* 27.2: 105-114.

Gregr, E. J. & Trites, A. W. (2001). Predictions of critical habitat for five whale species in the waters of coastal British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences, 58*, 1265-1285. doi: 10.1139/cjfas-58-7-1265.

Hamilton T.A., Redfern J.V., Barlow J., Ballance L.T., Gerrodette T., Holt R.S., Forney K.A., & Taylor, B.L. (2009). Atlas of cetacean sightings for Southwest Fisheries Science Center cetacean and ecosystem surveys: 1986-2005. (NOAA-TM-NMFS-SWFSC-440). La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center. 70 pp.

Handley, C. O. (1966). A synopsis of the genus *Kogia* (pygmy sperm whales). In K. S. Norris (Ed.), *Whales, Dolphins, and Porpoises* (pp. 62-69). University of California Press.

Hewitt, R. P. (1985). Reaction of dolphins to a survey vessel: Effects on census data. *Fishery Bulletin* 83(2): 187-193.

Hildebrand, J. A. (2005). Impacts of anthropogenic sound J. E. Reynolds (Ed.), *Marine Mammal Research: Conservation beyond Crisis* (pp. 101-124). The John Hopkins University Press.

Hildebrand, J. A., and M. A. McDonald. (2009). Beaked Whale Presence, Habitat, and Sound Production in the North Pacific. Unpublished technical report on file. (pp. 5).

Hildebrand, J., Bassett, H., Baumann, S., Campbell, G., Cummins, Amanda, Kerosky, S., Melcon, M., Merkens, K., Munger, L., Roch, M., Roche, L., Simonis, A., & Wiggins, S. (2011). High Frequency Acoustic Recording Package Data Summary Report January 31, 2010–March 26, 2010 SOCAL 37, Site N. Marine Physical Laboratory, Scripps Institution of Oceanography University of California San Diego, La Jolla, CA.

Hoelzel, A. R. (Ed.). (2002). *Marine Mammal Biology: An Evolutionary Approach* (pp. 448). Malden, MA: Blackwell Publishing.

Hoelzel, A. R., Dorsey, E. M. & Stern, J. (1989). The foraging specializations of individual minke whales. *Animal Behaviour, 38*, 786-794.

Holst, M., Greene, C., Richardson, J., McDonald, T., Bay, K., Schwartz, S., & Smith, G. (2011). Responses of Pinnipeds to Navy missile Launches at San Nicolas Island, California. *Aquatic Animals*, 37(2), 139-150. doi: 10.1578/AM.37.2011.139

Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K. & Veirs, S. (2008). Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. [Express Letters]. *Journal of the Acoustical Society of America*, 125(1), EL27-EL32.

Hooker, S. K., Metcalfe, T. L., Metcalfe, C. D., Angell, C. M., Wilson, J. Y., Moore, M. J., & Whitehead, H. (2007). Changes in persistent contaminant concentration and CYP1A1 protein expression in biopsy samples from northern bottlenose whales, *Hyperoodon ampullatus*, following the onset of nearby oil and gas development. Article in Press, *Environmental Pollution*, 1-12.

Hooker, S. K., Baird, R. W. and Fahlman, A. (2009). Could beaked whales get the bends? Effect of diving behaviour and physiology on modelled gas exchange for three species: *Ziphius cavirostris, Mesoplodon densirostris* and *Hyperoodon ampullatus*. Respir. Physiol. Neurobiol. 167, 235-246.

Hooker, S.K., A. Fahlman, M. J. Moore, N. Aguilar de Soto, Y. Bernaldo de Quiros, A. O. Brubakk, D. P. Costa, A. M. Costidis, S. Dennison, K. J. Falke, A. Fernandez, M. Ferrigno, J. R. Fitz-Clarke, M. M. Garner, D. S. Houser, P. D. Jepson, D. R. Ketten, P. H. Kvadsheim, P. T. Madsen, N. W. Pollock, D. S. Rotstein, T. K. Rowles, S. E. Simmons, W. Van Bonn, P. K. Weathersby, M. J. Weise, T. M. William, and P. L. Tyack. (2012). Deadly diving? Physiological and behavioural management of decompression stress in diving mammals. Proceedings of the Royal Society Bulletin: 279, 1041–1050.

Horwood, J. (1987). *The Sei Whale: Population Biology, Ecology, and Management* (pp. 375). New York, NY: Croom Helm.

Horwood, J. (1990). *Biology and exploitation of the minke whale*. Boca Raton, Florida: CRC Press.

Horwood, J. (2009). Sei whale *Balaenoptera borealis*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 1001-1003). San Diego, CA: Academic Press.

Houser, D., Howard, R. & Ridgway, S. (2001). Can Diving-inducted Tissue Nitrogen Supersaturation Increase the Chance of Acoustically Driven Bubble Growth in Marine Mammals? *Journal of Theoretical Biology*, 213, 183-195. 10.1006/jtbi.2001.2415 Retrieved from http://www.idealibrary.com

Houser, D. S., Gomez-Rubio, A., Finneran, J. J. (2008). Evoked potential adiometry of 13 Pacific bottlenose dolphins (*Tursiops Truncatus gilli*). *Marine Mammal Science, 24*(1): 28-41.

Houser, D. S., Dankiewicz-Talmadge, L. A., Stockard, T. K., & Ponganis, P. J. (2010). Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. *The Journal of Experimental Biology*, 213, 52-62.

Hui, C. A. (1985). Undersea topography and the comparative distribution of two pelagic cetaceans. *Fishery Bulletin, 83*, 472-475.

Hui, C. (2006) Carrying capacity, population equilibrium, and environment's maximal load. *Ecological Modelling*. 192:317–320. http://dx.doi.org/10.1016/j.ecolmodel.2005.07.001.

Hume, M. (2013). 'Miracle' whale leaves scientists elated – and relieved. The Globe and Mail, online newspaper article, June 21 2013. http://www.theglobeandmail.com/news/british-columbia/miracle-whale-leaves-scientists-elated-and-relieved/article12735936/

International Whaling Commission. (2013). Aboriginal whaling catch and catch limits accessed on Thursday March 7, 2013 at: http://iwc.int/catches#aborig. The table of historical catches was accessed on March 7, 2013 and is available at: http://iwc.int/table_aboriginal

Jaramillo-Legorreta, A. M., Rojas-Bracho, L. & Gerrodette, T. (1999). A new abundance estimate for vaquitas: First step for recovery. *Marine Mammal Science* 15(4): 957-973.

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

Jefferson, T. A., Webber, M. A. & Pitman, R. L. (2008). *Marine Mammals of the World: A Comprehensive Guide to their Identification* (pp. 573). London, UK: Elsevier.

Jeffries, S. & Allen, H. (2001). Wayfaring sea otter captured in McAllister Creek. Press Release. Olympia, Washington: Washington Department of Fish and Wildlife News Release–June 5, 2001.

Jeffries, S.J., P.J. Gearin, H.R. Huber, D.L. Saul, & D.A. Pruett. (2000). Atlas of seal and sea lion haulout sites in Washington. Olympia, Washington: Washington Department of Fish and Wildlife, Wildlife Science Division.

Jeffries, S.J., H.R. Huber, J. Calambokidis, and J.L. Laake. (2003). Trends and status of harbor seals in Washington State: 1978-1999. Journal of Wildlife Management, 67:207-218.

Jeffries, S.J., K.L. Laidre, R.J. Jameson, & H. Allen. (2005). Movements and foraging ecology of sea otters in coastal Washington. Page 141 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Jeffries, S.J. and Jameson, R.J. (2014). Results of the 2013 Survey of the Reintroduced Sea Otter Population in Washington State. Washington Department of Fish and Wildlife. Wildlife Science Program. Marine Mammal Investigations.

Jeffries, S. (2006). Personal communication between Steve Jeffries (Washington Department of Fish and Wildlife) and Alison Agness (Science Applications International Corporation) on December 14, 2006, regarding occurrence of marine mammals in Hood Canal.

Jeffries, S. (2012). Personal communication between Steve Jeffries (Washington Department of Fish and Wildlife) and Andrea Balla-Holden (Navy) over several dates in August 2012 regarding Steller sea lion haulout sites and numbers in Puget Sound.

Jeffries, S.J. (2013a). Personal communication in comments on pre-release draft version 2 of the NWTT EIS/OEIS.

Jeffries, S. (2013b). Aerial Surveys of Pinniped Haulout Sites in Pacific Northwest Inland Waters. Final Report, submitted to Naval Facilities Engineering Command, Northwest, Silverdale, WA.

Jemison, L.A., G.W. Pendleton, L.W. Fritz, K.K. Hastings, J.M. Maniscalco, A.W. Trites, and T.S. Gelatt. (2013). Inter-Population Movements of Steller Sea Lions in Alaska with Implications for Population Separation. PLoS ONE 8(8): e70167. doi: 10.1371/journal.pone.0070167.

Jensen, A. S. & Silber, G. K. (2003). Large Whale Ship Strike Database. U.S. Department of Commerce (Ed.).

Jepson, P., Arbelo, M., Beaville, R., Patterson, I., Castro, P., Baker, J., . . . Fernandez, A. (2003, October). Gas-bubble lesions in stranded cetaceans. Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? *Nature, 425*.

Jepson, P., Bennett, P., Deaville, R., Allchin, C. R., Baker, J. & Law, R. (2005). Relationships between polychlorinated Biphenyls and Health Status in Harbor Porpoises (*Phocoena Phocoena*) Stranded in the United Kingdom. *Environmental Toxicology and Chemistry*, 24(1), 238-248.

Johnson, C. S. (1967). Sound Detection Thresholds in Marine Mammals. *Marine Bioacoustics*. W. N. Tavolga. Oxford, Pergamon Press: 247-260.

Johnson, C. S. (1971). Auditory masking of one pure tone by another in the bottlenose porpoise. [Letters to the Editor]. Journal of the Acoustical Society of America, 49(4 (part 2)), 1317-1318.

Johnson, W. S. & Allen, D. M. (2005). Zooplankton of the Atlantic and Gulf Coasts: A Guide to Their Identification and Ecology (pp. 379). Baltimore, MD: Johns Hopkins University Press.

Jones, M. L. & Swartz, S.L. (2009). Gray whale *Eschrichtius robustus*. In: *Encyclopedia of Marine Mammals.* W. F. Perrin, B. Würsig and J. G. M. Thewissen, Academic Press: 503-511.

Kaschner, K., Watson, R., Trites, A. & Pauly, D. (2006, July 3). Mapping world-wide distributions of marine mammal species using a relative environmental suitability (RES) model. [electronic version]. Marine Ecology Progress Series, 316, 285-310.

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

Kastelein, R.A., de Haan, D., Vaughan, N., Staal, C., Schooneman, N.M. (2001). "The influence of three acoustic alarms on the behaviour of harbour porpoises (*Phocoena phocoena*) in a floating pen." Marine Environmental Research 52: 351-371.

Kastelein, R. A., Bunskoek, P. & Hagedoorn, M. (2002). Audiogram of a harbor porpoise (*Phocoena phocoena*) measured with narrow-band frequency-modulated signals. *Journal of Acoustical Society of America, 112*(1), 334-344.

Kastelein, R. A., Verboom, W. C., Muijsers, M., Jennings, N. V. & van der Heul, S. (2005). Influence of Acoustic Emissions for Underwater Data Transmission on the Behaviour of Harbour Porpoises (*Phocoena phocoena*) in a Floating Pen. *Marine Environmental Research*, 59, 287–307.

Kastelein, R.A., van der Heul, S., Verboom, W.C., Triesscheijn, R.J.V. & Jennings, N. (2006a). The influence of acoustic emissions for underwater data transmission on the behavior of harbor porpoises (*Phocena phocoena*) in a floating pen. Mar. Env. Res. 59, 287-307.

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

Kastelein, R. A., Gransier, R., Hoek, L. & Olthuis, J. (2012a). Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4k kHz. *Journal of the Acoustical Society of America*, 132(5), 3525-3537.

Kastelein, R. A., Gransier, R., Hoek, L. & Olthuis, J. (2012b). Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4k kHz. *Journal of the Acoustical Society of America*, 132(5), 3525-3537.

Kasuya, T. (2009). Giant beaked whales *Berardius bairdii* and *B. arnuxii*. In: *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Würsig and J. G. M. Thewissen. Amsterdam, Academic Press: 498-500.

Kasuya, T., Brownell, R. L., Jr., & Balcomb, K. C., III (1997). Life history of Baird's beaked whales off the Pacific coast of Japan. *Reports of the International Whaling Commission*, 47, 969-980.

Keevin, T. M. & Hempen, G. L. (1997). The environmental effects of underwater explosions with methods to mitigate impacts. St. Louis, MO.

Kenney, R. D. & Winn, H. E. (1987). Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. *Continental Shelf Research, 7*, 107-114.

Kerosky, S.M., S. Baumann-Pickering, A. Širović, J.S. Buccowich, A.J. Debich, Z. Gentes, R.S. Gottlieb, S.C. Johnson, L.K. Roche, B. Thayre, S.M. Wiggins, and J.A. Hildebrand. (2013). Passive Acoustic

Monitoring for Marine Mammals in the Northwest Training Range Complex 2011-2012. Marine Physical Laboratory Technical Memorandum: MPL-TM 542, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92037.

Ketten, D. R. (1998). Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts. (NOAA Technical Memorandum NMFS-SWFSC-256, pp. 74). La Jolla, CA: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

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

Ketten, D. R. (2012). Marine Mammal Auditory System Noise Impacts: Evidence and Incidence. In: A. N. Popper and A. Hawkins (Eds.), The Effects of Noise on Aquatic Life Advances in Experimental Medicine and Biology (Advances in Experimental Medicine and Biology ed., Vol. 730, pp. 207-212). New York: Springer Science+Business Media.

Kjeld, M., Olafsson, O., Vikingsson, G. A. & Sigurjonsson, J. (2006). Sex hormones and reproductive status of the North Atlantic fin whales (*Balaenoptera physalus*) during the feeding season. *Aquatic Mammals, 32*(1), 75-84. doi: 10.1578/AM.32.1.2006.75

Kruse, S. (1991). The interactions between killer whales and boats in Johnstone Strait, B.C. In. Dolphin Societies: Discoveries and Puzzles. K. Pryor & K. S. Norris. Berkeley and Los Angeles, California, University of California Press: 149-159.

Kruse, S., Caldwell, D. K. & Caldwell, M. C. (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals*, (Vol. 6, pp. 183-212). San Diego, CA: Academic Press.

Kvadsheim, P. H., Miller, P. J. O., Tyack, P. L., Sivle, L. D., Lam, F. P. A. & Fahlman, A. (2012, May 10). Estimated tissue and blood N2 levels and risk of decompression sickness in deep-, intermediate-, and shallow-diving toothed whales during exposure to naval sonar. frontiers in Physiology, 3(Article 125). 10.3389/fphys.2012.00125; http://www.frontiersin.org/Physiology/editorialboard.

Laake, J.L., Punt, A.E., Hobbs, R., Ferguson, M., Rugh, D. & Breiwick, J. (2012). Gray whale southbound migration surveys 1967-2006: An integrated re-analysis. *Journal of Cetacean Research and Management* 12(3):287-306.

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

Lambourn, D.M., Jeffries S.J. & Huber, H.R. (2010). Observations of Harbor Seals in Southern Puget Sound during 2009. Washington Department of Fish and Wildlife, Wildlife Program, Wildlife Science Division. Contract Report for PO AB133F09SE2836F.

Lambourn, D.M., Jeffries, S.J., Wilkinson, K., Huggins, J., Rice, J., Duffield, D., & Raverty, S.A. (2012). 2007-2009 Pacific Northwest Guadalupe fur seal (*Arctocephalus townsendi*) Unusual Mortality Event (UME) Summary Report, Submitted to NOAA UME committee May 2012, manuscript on file, pp. 32.

Lambourn, D. (2013). Personal communication between Dyanna Lambourn (Washington Department of Fish and Wildlife) and Andrea Balla-Holden (Navy) on 24 Sept 2013 regarding Guadalupe fur seal occurrence in study area.

Lammers, M.O., Pack, A.A., Davis, L. (2003). Historical Evidence of Whale/Vessel Collision in Hawaiian Waters (1975-Present). U.S. Department of Commerce, NOAA OSI Technical Report. 25.

Leatherwood, S., Perrin, W. F., Kirby, V. L., Hubbs, C. L. & Dahlheim, M. (1980). Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific. *Fishery Bulletin, 77*(4), 951-963.

Lee, O.A., V. Burkanov, and W.N. Neil. 2014. Population trends of northern fur seals (*Callorhinus ursinus*) from a metapopulation perspective. Journal of Experimental Marine Biology and Ecology 451:25-34.

Lesage, V., Barrette, C., Kingsley, M. C. S., & Sjare, B. (1999). The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River estuary, Canada. *Marine Mammal Science,* 15(1), 65-84.

Li, S., Akamatsu, T., Wang, D., Wang, K., Dong, S., Zhao, X., & Brandon, J. R. (2008). Indirect evidence of boat avoidance behavior of Yangtze finless porpoises. *Bioacous*tics 17: 174-176.

Lidgard, D. C., Boness, D. J., Bowen, W. D. & McMillan, J. I. (2008). The implications of stress on male mating behavior and success in a sexually dimorphic polygynous mammal, the grey seal. Hormones and Behavior, 53, 241–248.

Littnan, C. L. (2010). Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex [Preliminary Report]. (Contribution No. 2003-013 to the Hawaii Biological Survey, pp. 9). Prepared by Hawaiian Monk Seal Research Program, Ocean Associates, Inc. Prepared for Hawaii Department of Land and Natural Resources, Hawaii Division of Aquatic Resources.

London, J.M., Ver Hoef, J.M., Jeffries, S.J., Lance, M.M., and Boveng, P.L. (2012) Haulout Behavior of Harbor Seals (Phoca vitulina) in Hood Canal, Washington. PLoS ONE 7(6): e38180. doi:10.1371/journal.pone.0038180

Lucke, K., Siebert, U., Lepper, P. A., & Blanchet, M.A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America*. doi: 10.1121/1.3117443. pp. 4060-4070.

Luksenburg, J. A. & E. C. M. Parsons (2009). The effects of aircraft on cetaceans: implications for aerial whalewatching, Department of Environmental Science and Policy, George Mason University: 10.

Lusseau, D., Bain, D. E., Williams, R. & Smith, J. C. (2009). Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endangered Species Research, 6*, 211–221. doi: 10.3354/esr00154

MacLeod, C. D. & D'Amico, A. (2006). A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management, 7*(3), 211-222.

MacLeod, C. D. & Mitchell, G. (2006). Key areas for beaked whales worldwide. *Journal of Cetacean Research and Management, 7*(3), 309-322.

MacLeod, K., Simmonds, M. P. & Murray, E. (2006a). Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. borealis*) amid oil exploration and development off northwest Scotland. *Journal of Cetacean Research and Management, 8*(3), 247-254.

MacLeod, C. D., Perrin, W. F., Pitman, R. L., Barlow, J., Ballance, L., D'Amico, A., Waring, G. T. (2006b). Known and inferred distributions of beaked whale species (Ziphiidae: *Cetacea*). *Journal of Cetacean Research and Management, 7*(3), 271-286.

Madsen, P. T., Johnson, M., Miller, P. J., Aguilar Soto, N., Lynch, J. & Tyack, P. (2006). Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags

during controlled exposure experiments. Journal of the Acoustical Society of America, 120(4), 2366-2379. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed &dopt=Citation&list_uids=17069331

Magalhães, S., R. Prieto, M. A. Silva, J. Gonçalves, M. Afonso-Dias, & R.S. Santos (2002). Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. *Aquatic Mammals, 28*(3), 267-274.

Malme, C. I., Würsig, B., Bird, J. E. & Tyack, P. (1988). Observations of feeding gray whale responses to controlled industrial noise exposure W. M. Sackinger, M. O. Jeffries, J. L. Imm and S. D. Tracey (Eds.), Port and Ocean Engineering Under Arctic Conditions (Vol. 2, pp. 55-73). Fairbanks, AK: Geophysical Institute, University of Alaska.

Malme, C. I., Würsig, B., Bird, J. E. & Tyack, P. (1986). Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling Outer Continental Shelf Environmental Assessment Program, Final Report of Principal Investigators. (Vol. 56, pp. 393–600). Report 6265 (OCS Study MMS 88-0048) by Bolt Beranek, & Newman, Inc., Cambridge, MA, for National Oceanic and Atmospheric Administration, Anchorage, AK: Available as NTIS PB88-249008 from U.S. National Technical Information Service, 5285 Port Royal Road, Springfield, VA.

May-Collado, L.J., and Quinones0Lebron, S.G. (2014). Dolphin changes in whistle structure with watercraft activity depends on their behavioral state. Journal of the Acoustic Society of America Express Letters 135(4):EL193-EL198. doi:10.1121/1.4869255

Marine Mammal Commission. (2002). Hawaiian monk seal (*Monachus schauinslandi*). Species of Special Concern, Annual Report to Congress, 2001. Bethesda, MD, *Marine Mammal Commission*: 63-76.

Marine Mammal Commission. (2006). Annual Report to Congress 2005. Bethesda, MD.

Marsh H. and D.F. Sinclair (1989) Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. Journal of Wildlife Management 53: 1017-1024.

Martin, S. W. and T. Kok. (2011). Report on Analysis for Marine Mammals Before, During and After the February 2011 Submarine Commanders Course Training Exercise. Pacific Fleet's 3022 Annual Monitoring Report NMFS: Appendix N.

Masaki, Y. (1976). Biological studies on the North Pacific sei whale. *Bulletin of the Far Seas Fisheries Research Laboratory, 14*, 1-104

Masaki, Y. (1977). The separation of the stock units of sei whales in the North Pacific. *Reports of the International Whaling Commission* (Special Issue 1) 71-79.

Mate, B. (2013). Offshore Gray Whale Satellite Tagging in the Pacific Northwest. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii.

Mate, B. and J. Urban-Ramirez (2003). A note on the route and speed of a gray whale on its northern migration from Mexico to central California, tracked by satellite-monitored radio tag. Journal of Cetacean Research 5(2): 155—l57.

Mate, B. R., B. A. Lagerquist, & Calambokidis, J. (1999). Movements of north Pacific blue whales during the feeding season off Southern California and their southern fall migration. *Marine Mammal Science,* 15(4), 1246-1257.

Mate, B.R., Lagerquist, B. and Irvine, L. (2010). Feeding habitats, migration, and winter reproductive range movements derived from satellite-monitored radio tags on eastern North Pacific gray whales.

Paper SC/62/BRG21 presented to the International Whaling Commission Scientific Committee. 22 pp.

Mate, B. (2013). Personal communication between Bruce Mate (Oregon State University) and Andrea Balla-Holden (Navy) via email on 19 September 2013 regarding sighting of North Pacific right whale in 1980s.

Matsuoka, K., S. Mizroch, and H. Komiya. (2013). "Cruise report of the 2012 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER)." Report of the International Whaling Commission Scientific Committee, SC/64/IA5, pp. 27.

Mattson, M. C., Thomas, J. A. & St. Aubin, D. (2005). Effects of boat activity on the behavior of bottlenose dolphins (*Tursiops truncatus*) in waters surrounding Hilton Head Island, South Carolina. *Aquatic Mammals,* 31(1), 133-140.

May-Collado, L. J. & Wartzok, D. (2008). A comparison of bottlenose dolpin whistles in the atlantic ocean: factors promoting whistle variation. *Journal of Mammalogy*, 89(5), 1229-1240.

McAlpine, D. F. (2009). Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed.) (pp. 936-938). Academic Press.

McCarthy, E., Moretti, D., Thomas, L., DiMarzio, N., Morrissey, R., Jarvis, S., . . . Dilley, A. (2011). Changes in spatial and temporal distribution and vocal behavior of Blainville's beaked whales (*Mesoplodon densirostris*) during multiship exercises with mid-frequency sonar. Marine Mammal Science, no-no. 10.1111/j.1748-7692.2010.00457.x

McCauley, R. D., Jenner, M. N., Jenner, C., McCabe, K. A. & Murdoch, J. (1998). The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal, 692-706.

McDonald, M., Hildebrand, J. & Wiggins, S. (2006, August). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America, 120(2), 711-718.

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

McSweeney, D. J., Baird, R. W. & Mahaffy, S. D. (2007). Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the Island of Hawaii. *Marine Mammal Science, 23*(3), 666-687. doi: 10.1111/j.1748-7692.2007.00135.x

McSweeney, D. J., Baird, R. W., Mahaffy, S. D., Webster, D. L., Schorr, G.S. (2009). "Site fidelity and association patterns of a rare species: Pygmy killer whales (*Feresa attenuata*) in the main Hawaiian Islands." Marine Mammal Science 25(3): 557-572.

Mead, J. G. (1981). First records of *Mesoplodon hectori* (Ziphiidae) from the Northern Hemisphere and a description of the adult male. *Journal of Mammalogy*, 62(2), 430-432.

Mead, J. G. (1989). Beaked whales of the genus *Mesoplodon*. In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals,* (Vol. 4, pp. 349-430). San Diego, CA: Academic Press.

Mead, J. G. & Baker, A.N. (1987). Notes on the rare beaked whale, *Mesoplodon hectori* (Gray). *Journal of the Royal Society of New Zealand,* 17(3), 303-312.

Mead, J. G., Walker, W. A., & Houck, W. J. (1982). Biological observations on *Mesoplodon carlhubbsi* (Cetacea: Ziphiidae). *Smithsonian Contributions to Zoology*, 344, 1-25.

Mellinger, D. K., Carson, C. D. & Clark, C. W. (2000). Characteristics of minke whale (*Balaenoptera acutorostrata*) pulse trains recorded near Puerto Rico. *Marine Mammal Science, 16*(4), 739-756.

Melcón ML, Cummins AJ, Kerosky SM, Roche LK, Wiggins SM, et al. (2012) Blue Whales Respond to Anthropogenic Noise. PLoS ONE 7(2): e32681. doi: 10.1371/journal.pone.0032681

Miksis, J. L., Connor, R. C., Grund, M. D., Nowacek, D. P., Solow, A. R. & Tyack, P. L. (2001). Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (*Tursiops truncatus*). Journal of Comparative Psychology, 115(3), 227-232.

Miksis-Olds, J. L., Donaghay, P. L., Miller, J. H., Tyack, P. L., & Reynolds, J. E., III. (2007). Simulated vessel approaches elicit differential responses from manatees. *Marine Mammal Science,* 23(3), 629-649.

Miller, J. (1994). Review of the physical oceanographic conditions within the designated sanctuary. In K. Des Rochers (Ed.), A Site Characterization Study for the Hawaiian Islands Humpback Whale National Marine Sanctuary. (HAWAU-T-94-001 C2, pp. 9-18). Prepared by University of Hawaii Sea Grant Program. Prepared for U. S. Department of Commerce, National Oceanic and Atmospheric Administration.

Miller, P., Antunes, R., Alves, A. C., Wensveen, P., Kvadsheim, P., Kleivane, L., . . . Tyack, P. (2011). The 3S experiments: studying the behavioural effects of naval sonar on killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), and long-finned pilot whales (*Globicephala melas*) in Norwegian waters Scottish Oceans Inst. Tech. Rept., SOI-2011-001.

Miller, P., Johnson, M., Madsen, P., Biassoni, N., Quero, M. & Tyack, P. (2009, July). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep Sea Research I, 56(7), 1168-1181. 10.1016/j.dsr.2009.02.008.

Miller, P. J. O., Biassoni, N., Samuels, A. & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. Nature, 405(6789), 903.

Mintz, J. & Filadelfo, R. (2011). Exposure of Marine Mammals to Broadband Radiated Noise. Specific Authority N0001-4-05-D-0500. CNA Analysis & Solutions: 42.

Mizroch, S. A., Rice, D. W., Zwiefelhofer, D., Waite, J. M., & Perryman, W. L. (2009). Distribution and movements of fin whales in the North Pacific Ocean. *Mammal Review*, 39, 193-227.

Monnahan C.C., Branch T.A., Stafford K.M., Ivashchenko Y.V., & Oleson E.M. (2014). Estimating Historical Eastern North Pacific Blue Whale Catches Using Spatial Calling Patterns. PLoS ONE 9(6): e98974. doi:10.1371/journal.pone.0098974.

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

Mooney, T. A., Nachtigall, P. E. & Vlachos, S. (2009b). Sonar-induced temporary hearing loss in dolphins. Biology letters, 5, 565-567. 10.1098/rsbl.2009.0099

Moore, J. E. & Barlow, J. (2011). Bayesian state-space model of fin whale abundance trends from a 1991-2008 time series of line-transect surveys in the California Current. Journal of Applied Ecology, 1-11. 10.1111/j.1365-2664.2011.02018.x

Moore, J.E., & Barlow, J.P. (2013). Declining Abundance of Beaked Whales (Family *Ziphiidae*) in the California Current Large Marine Ecosystem. PLoS ONE 8(1):e52770. doi: 10.1371/journal.pone.0052770.

Moore, J.E & Barlow, J.P. (2014). Improved abundance and trend estimates for sperm whales in the eastern North Pacific from Bayesian hierarchical modeling. Endangered Species Research 25, 141-150. doi: 10.3354/esr00633.

Moore, S.E., J.M. Waite, L.L. Mazzuca, & R.C. Hobbs. (2000). Mysticete whale abundance and observations of prey associations on the central Bering Sea shelf. *Journal of Cetacean Research and Management*, 2(3), 227-234.

Moore, M. J., Bogomolni, A. L., Dennison, S. E., Early, G., Garner, M. M., Hayward, B. A., . . . Rotstein, D. S. (2009). Gas bubbles in seals, dolphins, and porpoises entangled and drowned at depth in gillnets. Veterinary Pathology, 46, 536–547.

Moran, J. R., S. D. Rice, & S. F. Teerlink. (2009). Humpback Whale Predation on Pacific Herring in Southern Lynn Canal: Testing a Top-down Hypothesis. Abstract, Alaska Marine Science Symposium, Anchorage, AK, Jan 2008.

Moretti, D., Marques, T.A., Thomas, L., DiMarzio, N., Dilley, A., Morrissey, R., McCarthy, E., Ward, J., Jarvis, S. (2010). A dive counting density estimation method for Blainville's beaked whale (*Mesoplodon densirostris*) using a bottom-mounted hydrophone field as applied to a Mid-Frequency Active (MFA) sonar operation. Applied Acoustics 71: 1036-1042.

Moretti, D., DiMarzio, N., Morrissey, R., McCarthy, E., Jarvis, S. & Dilley, A. (2009, 7-10 December). An opportunistic study of the effect of sonar on marine mammals, marine mammal monitoring on navy ranges (M3R). Presented at the 2009 ONR Marine Mammal Program Review, Alexandria, VA.

Nachtigall, P. E., Pawloski, J. L. & Au, W. W. L. (2003). Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America, 113(6), 3425-3429. doi: 10.1121/1.1570438

Nachtigall, P. E., Supin, A. Y., Pawloski, J. & Au, W. W. L. (2004). Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using evoked auditory potentials. Marine Mammal Science, 20(4), 673-687.

Nagorsen, D. W. & Stewart, G. E. (1983). A dwarf sperm whale (*Kogia simus*) from the Pacific coast of Canada. Journal of Mammalogy, 64(3), 505-506.

National Institute for Occupational Safety and Health (NIOSH). (1998). Criteria for a Recommended Standard: Occupational Noise Exposure (Revised Criteria 1998). (DHHS (NIOSH) Publication No. 98-126, pp. 83). Cincinnati, Ohio: United States Department of Health and Human Services, Centers for Disease Control and Prevention.

National Marine Fisheries Service & Office of Protected Resources. (2005a). Assessment of Acoustic Exposures on Marine Mammals in Conjunction with USS Shoup Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Harro Strait, Washington. (pp. 13).

National Marine Fisheries Service. (2006). Final Rule, for Conducting the Precision Strike Weapon (PSW) Testing and Training by Eglin Air Force Base. *Federal Register 71*, No. 226, 67810-67824.

National Marine Fisheries Service. (2007). Conservation plan for the Eastern Pacific stock of northern fur seal (Callorhinus ursinus). National Marine Fisheries Service, Juneau, Alaska. 110 p.

National Marine Fisheries Service. (2008a). Final Rule for the shock trial of the USS Mesa Verde, (LPD-19). Federal Register, Department of Commerce, NOAA Fisheries, Vol. 73, No. 145.

National Marine Fisheries Service. (2008b, July 24). Taking and Importing Marine Mammals; Taking Marine Mammals Incidental to a U.S. Navy Shock Trial. Federal Register, 73(143), 43130-43138.National Marine Fisheries Service. (2009a, 12 August). Endangered and threatened species; initiation of a status review for the humpback whale and request for information. *Federal Register, 74*(154), 40568.

National Marine Fisheries Service. (2009b). *Sperm Whale (Physeter macrocephalus): 5-Year Review: Summary and Evaluation*. (pp. 42). Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources.

National Marine Fisheries Service. (2010) Taking and Importing Marine Mammals; Navy Training Activities Conducted Within the Northwest Training Range Complex; Final Rule. Federal Register, Wednesday, November 10, 2010, 75(215):69296-39326.

National Marine Fisheries Service. (2011). Taking and Importing Marine Mammals; U.S. Navy's Research, Development, Test, and Evaluation Activities Within the Naval Sea Systems Command Naval Undersea Warfare Center Keyport Range Complex; Final Rule. Federal Register, Tuesday, April 12, 2011, 76(70):20257-20278.

National Oceanic and Atmospheric Administration. (1997). North Atlantic Right Whale Protection. Federal Register, 62(30), 6729-6738.

National Oceanic and Atmospheric Administration. (2010). National Marine Fisheries Service's Final Biological Opinion for the Proposed Issuance of a United States Coast Guard Permit to the St. George Reef Lighthouse Preservation Society to Maintain the St. George Reef Lighthouse as a Private Aid to Navigation and its Effect on the Federally Threatened Eastern Distinct Population Segment of Steller Sea Lion and Designated Critical Habitat. (pp. 106) National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2011). Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Pile Replacement Project. Federal Register Volume 76, No. 100. Tuesday, May 24, 2011. pp. 30130-30139.

National Oceanic and Atmospheric Administration. (2013). Endangered and Threatened Species; Delisting of the Eastern Distinct Population Segment of Steller Sea Lion under the Endangered Species Act; Amendment to Special Protection Measures for Endangered Marine Mammals. Federal Register 78 (206).

National Oceanic and Atmospheric Administration. (2014a). Listing Endangered and Threatened Species: 90-Day Finding on a Petition to Revise the Critical Habitat Designation for the Southern Resident Killer Whale. Federal Register 79(80):22933-22935.

National Oceanic and Atmospheric Administration. (2014b). Southern Resident Killer Whales: 10 Years of Research and Conservation. Downloaded from [http://www.nwfsc.noaa.gov/news/features/killer_whale_report/index.cfm], 27 March 2015, 28 pages.

National Research Council of the National Academies. (2003). Ocean Noise and Marine Mammals. In Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals (Ed.), *Ocean Noise and Marine Mammals* (pp. 24): National Research Council of the National Academies.

National Research Council of the National Academies. (2005). Marine Mammal Populations and Ocean Noise Determining when Noise Causes Biologically Significant Effects. In National Research Council of the National Academies (Ed.). Washington DC: The National Academies Press.

Noren, D.P., A. H. Johnson, D. Rehder, and A. Larson (2009). Close approaches by vessels elicit surface active behaviors by southern resident killer whales. Endangered Species Research (17): 179–192.

Norman, S.A., C.E. Bowlby, M.S. Brancato, J. Calambokidis, D. Duffield, P.J. Gearin, T.A. Gornall, M.E. Gosho, B. Hanson, J. Hodder, S.J. Jeffries, B. Lagerquist, D.M. Lambourn, B. Mate, B. Norberg, R.W. Osborne, J.A. Rash, S. Riemer, & J. Scordino. (2004). Cetacean strandings in Oregon and Washington between 1930 and 2002. *Journal of Cetacean Research and Management*, 6(1), 87-99.

Nowacek, D.P. (2005). Acoustic ecology of foraging bottlenose dolphins (*Tursiops truncatus*), habitat-specific use of three sound types. Marine Mammal Science 21(4): 587-602.Nowacek, D., Johnson, M. & Tyack, P. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London, 271(B), 227-231. 10.1098/rspb.2003.2570

Nowacek, D., Johnson, M., & Tyack, P. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London*, 271(B), 227-231.

Nowacek, D., Thorne, L. H., Johnston, D. & Tyack, P. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review, 37*(2), 81-115.

Olesiuk, P.F. 2012. Habitat utilization by northern fur seals (*Callorhinus ursinus*) in the Northeastern Pacific Ocean and Canada. Fisheries and Oceans Canada. Research Document 2012/040. 27 p

Oleson, E.M., J. Calambokidis, Erin Falcone, and Greg Schorr and J.A. Hildebrand. (2009). Acoustic and visual monitoring for cetaceans along the outer Washington coast- Technical Report, July 2004-September 2008. Prepared for U.S. Navy, Naval Postgraduate School, Monterey, CA. NPS-OC-09-001. 45 pp.

Oleson, E. and J. Hildebrand. (2012). Marine mammal demographics off the outer Washington coast and near Hawaii. Prepared for U.S. Navy, Naval Postgraduate School, Monterey, CA. NPS-OC-12-001CR April 2012. 69 pp.

Ortiz, R. M. & Worthy, G. A. J. (2000). Effects of capture on adrenal steroid and vasopressin concentrations in free-ranging bottlenose dolphins (*Tursiops truncatus*). Comparative Biochemistry and Physiology A, 125(3), 317-324.

Osborne, R. (2003). Historical Information on Porpoise Strandings in San Juan County Relative to the May 5th Navy Sonar Incident: The Whale Museum News and Events.

Osborne, R., J. Calambokidis, & E.M. Dorsey. (1988). A guide to marine mammals of Greater Puget Sound. Anacortes, WA: Island Publishers.

Parks, S. E. (2009). Assessment of acoustic adaptations for noise compensation in marine mammals. 2009, *ONR Marine Mammal Program Review*, Alexandria, VA.

Parks, S. E., Clark, C. W., & Tyack, P. L. (2007). Short-and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Acoustical Society of America*. doi: 10.1121/1.2799904. pp.3725-3731.

Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Würsig, B., & Greene, C. R., Jr. (2002). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science,* 18(2), 309-335.

Payne, P. M. & Heinemann, D. W. (1993). The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978-1988. *Reports of the International Whaling Commission, Special Issue 14*, 51-68.

Perrin, W.F. and R.L. Brownell. (2002). Minke whales *Balaenoptera acutorostrata* and *B. bonaerensis*. Pages 750-754 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press.

Perrin, W. & Geraci, J. (2002). Stranding. In*: Encyclopedia of Marine Mammals*. W. Perrin, B. Würsig and J. Thewissen. San Diego, Academic Press: 1192-1197.

Perrin, W. F., Baker, C. S., Berta, A., Boness, D. J., Brownell, R. L., Jr., Dalebout, M. L., Domning, D.P., Hamner, R. M., Jerfferson, T. A., Mead, J. G., Rice, D. W., Rosel, P. E., Wang, J. Y., & Yamada, T. (2009). Marine Mammal Species and Subspecies. *Society of Marine Mammalogy Committee and Taxonomy*. 2010.

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

Pierce, G. J., Santos, M. B., Smeenk, C., Saveliev, A. & Zuur, A. F. (2007). Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies. *Fisheries Research, 87*(2-3), 219-228. doi: 10.1016/j.fishres.2007.06.001.

Pirotta, E., Milor, R., Quick, N., Moretti, D., Di Marzio, N., Tyack, P., Boyd, I. & Hastie, G. (2012). Vessel Noise Affects Beaked Whale Behavior: Results of a Dedicated Acoustic Response Study.

Pirotta, E., Merchant, N. D., Thompson, P. M., Barton, T. R., & Lusseau, D. (2015). Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. Biological Conservation, 181:82-89, doi: 10.1016/j.biocon.2014.11.003; 8 pages.Pitman, R. (2008). Indo-Pacific beaked whale *Indopacetus pacificus*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 600-602). Academic Press.

Pitman, R. L., Au, D. W. K., Scott, M. D. & Cotton, J. M. (1988). *Observations of Beaked Whales (Ziphiidae) from the Eastern Tropical Pacific Ocean.* (SC/40/SM14) International Whaling Commission.

Pitman, R. L., Fearnbach, H., LeDuc, R., Gilpatrick, J. W., Jr, Ford, J. K. B. & Ballance, L. T. (2007). Killer whales preying on a blue whale calf on the Costa Rica Dome: Genetics, morphometrics, vocalisations and composition of the group. *Journal of Cetacean Research and Management, 9*(2), 151-157.

Polacheck, T. & L. Thorpe (1990). The swimming direction of harbor porpoise in relationship to a survey vessel. *Reports of the International Whaling Commission*, 40, 463-470.

Punt, A. E. and Wade, P.R. (2012). Population status of the eastern North Pacific stock of gray whales in 2009. *Journal of Cetacean Research and Management* 12(1): 15-28.

Punt, A.E., and J. E. Moore. (2013). Seasonal Gray Whales in the Pacific Northwest: An Assessment of Optimum Sustainable Population Level for the Pacific Coast Feeding Group. NOAA Technical Memorandum NMFS-SWFSC-518, La Jolla, CA.

Pynn, L. (2013). Rare whale sighting stuns B.C. researchers. The Vancouver Sun, 1 Nov 2013, accessed at http://www.vancouversun.com/technology/Rare+whale+sighting+stuns+researchers/9111771/story .html. on 4 Nov 2013.

Rankin, S. & Barlow, J. (2005). Source of the North Pacific "boing" sound attributed to minke whales. *The Journal of the Acoustical Society of America, 118*(5), 3346. 10.1121/1.2046747

Read, J., Jones, G., & Radford, A.N. (2014). Fitness costs as well as benefits are important when considering responses to anthropogenic noise. Behavioral Ecology 25(1):4-7.

Reeves, R. R., Leatherwood, S., Stone, G. S. & Eldredge, L. G. (1999). *Marine Mammals in the Area Served by the South Pacific Regional Environment Programme (SPREP)* (pp. 48). New York, NY: Croom Helm.

Reeves, R. R., Stewart, B. S., Clapham, P. J. & Powell, J. A. (2002). *National Audubon Society Guide to Marine Mammals of the World* (pp. 527). New York, NY: Alfred A. Knopf.

Reilly, S. B. (1990). Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific*. Marine Ecology Progress Series, 66*, 1-11.

Reynolds, J. E., III & Rommel, S. A. (1999). *Biology of Marine Mammals* (pp. 578). Washington, DC: Smithsonian Institution Press.

Rice, D. W. (1989). Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals*, (Vol. 4, pp. 177-234). San Diego, CA: Academic Press.

Rice, D. W. (1998). *Marine mammals of the world: systematics and distribution*. (Special Publication Number 4, pp. 231). Lawrence, KS: Society for Marine Mammology.

Rice, D.W., A.A. Wolman, B.R. Mate, & Harvey, J.T. (1986). A mass stranding of sperm whales in Oregon: Sex and age composition of the school. *Marine Mammal Science*, 2(1), 64-69.

Richardson, W. J. (1995). Marine mammal hearing. In W. J. Richardson, C. R. Greene, Jr., C. I. Malme and D. H. Thomson (Eds.), Marine Mammals and Noise (pp. 205-240). San Diego, CA: Academic Press.

Richardson, W. J., C.R.J. Green, C.I. Malme and D.H. Thomson. (1995). *Marine Mammals and Noise.* San Diego, CA, Academic Press.

Richmond, D. R., Yelverton, J. T. & Fletcher, E. R. (9383). (1973). Far-field underwater-blast injuries produced by small charges. (DNA 3081T, pp. 108). Washington, DC: Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency.

Richter, C., Dawson, S. & Slooten, E. (2006). Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. Marine Mammal Science, 22(1), 46-63. doi: 10.1111/j.1748-7692.2006.00005.x

Richter, C. F., Dawson, S. M. & Slooten, E. (2003). Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalization patterns. Science for Conservation, 219, 78.

Rick, T. C., R. L. Delong, J. M. Erlandson, T. J. Braje, T. L. Jones, D. J. Kennett, T. A. Wake, and P. L. Walker (2009). A trans-Holocene archaeological record of Guadalupe fur seals (*Arctocephalus townsendi*) on the California coast. Marine Mammal Science, 25(2): 487–502.

Ridgway, S. H. and Howard, R. (1979). Dolphin lung collapse and intramuscular circulation during free diving: evidence from nitrogen washout. Science 206, 1182- 1183.

Riedman, M. L. and J. A. Estes. (1990). *The Sea Otter (*Enhydra lutris*): Behavior, Ecology, and Natural History*. Washington, D.C., U.S. Department of the Interior, Fish and Wildlife Service: 126.

Ritter, F. (2002). Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. *Aquatic Mammals, 28*(1), 46-59.

Rolland, R. M., S. E. Parks, K. E. Hunt, M. Castellote, P. J. Corkeron, D. P. Nowacek, S. K. Wasser, and S. D. Kraus. (2012). Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society Bulletin, 279, 2363–2368.

Romano, T., Keogh, M., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., . . . Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposures. Canadian Journal of Fisheries and Aquatic Sciences, 61, 1124-1134.

Rowlett, R.A., G.A. Green, C.E. Bowlby, & M. Smultea. (1994). The first photographic documentation of a northern right whale off Washington State. *Northwestern Naturalist,* 75,102-104.

Saez, L., D. Lawson, M. DeAngelis, S. Wilkin, E. Petras, & C. Fahy (2012). Co-occurrence of Large Whales and Fixed Commercial Fishing Gear: California, Oregon, and Washington. Poster presented at: 2012 Southern California Marine Mammal Workshop, 3-4 February 2012, Newport Beach, CA.

Saez, L., D. Lawson, M. DeAngelis, S. Wilkin, E. Petras, & C. Fahy (2013). Understanding the Co-occurrence of Large Whales and Commercial Fixed Gear Fisheries off the West Coast of the United States. NOAA-TM-NMFS-SWR-044, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Long Beach, California, USA 90802-4213.

Salvadeo, C., D. Lluch-Belda, S. Lluch-Cota, and M. Mercuri (2011). Review of Long Term Macro-Fauna Movement by Multi-Decadal Warming Trends in the Northeastern Pacific IN: Climate Change - Geophysical Foundations and Ecological Effects, Dr Juan Blanco (Ed.), ISBN: 978-953-307-419-1.

Saunders, K. J., P. R. White, T. G. Leighton. (2008). Models for Predicting Nitrogen Tensions and Decompression Sickness Risk in Diving Beaked Whales. Proceedings of the Institute of Acoustics, 30(5), pp.8.

Scarpaci, C., S. W. Bigger, et al. (2000). Bottlenose dolphins (Tursiops truncatus) increase whistling in the presence of 'swim-with-dolphin' tour operations. *Journal of Cetacean Research and Management,* 2(3), 183-185.

Scheifele, P. M., Andrew, S., Cooper, R. A., Darre, M., Musiek, F. E. & Max, L. (2005). Indication of a Lombard vocal response in the St. Lawrence River beluga. *Journal of the Acoustical Society of America,* 117(3), 1486–1492.

Schilling, M. R., Seipt, I., Weinrich, M. T., Frohock, S. E., Kuhlberg, A. E. & Clapham, P. J. (1992). Behavior of individually identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. *Fishery Bulletin, 90*, 749-755.

Schlundt, C. E., Finneran, J. J., Carder, D. A. & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America, 107(6), 3496-3508.

Schlundt, C. E., Dear, R. L., Carder, D. A. & Finneran, J. J. (2006). Growth and Recovery of Temporary Threshold Shifts in a Dolphin Exposed to Midfrequency Tones with Durations up to 128 s. Presented at the Fourth Joint Meeting: ASA and ASJ.

Schorr, G., E. Falcone, and J. Calambokidis. (2013). Summary of Tag Deployments on Cetaceans off Washington, May 2010 to May 2013. Prepared by: Cascadia Research Collective, Olympia, for Commander, US Pacific Fleet, Pearl Harbor, Hawaii.

Shane, S. H. (1995). Relationship between pilot whales and Risso's dolphins at Santa Catalina Island, California, USA. *Marine Ecology Progress Series,* 123, 5-11.

Shane, S. H., R. S. Wells, et al. (1986). Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science,* 2(1), 34-63.

Sirovic, A., Hildebrand, J. A., Wiggins, S. M., McDonald, M. A., Moore, S. E. & Thiele, D. (2004). Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula. *Deep Sea Research II, 51*(17-19), 2327-2344. doi: 10.1016/j.dsr2.2004.08.005

Širović, A., E.M. Oleson, J. Calambokidis, S. Baumann-Pickering, A. Cummins, S. Kerosky, L. Roche, A. Simonis, S. M. Wiggins, & J.A. Hildebrand. (2012a). Acoustic Monitoring for Marine Mammals off Washington. In: Oleson, E. and J. Hildebrand, eds. 2012. Marine mammal demographics off the outer Washington coast and near Hawaii. Prepared for U.S. Navy. Naval Postgraduate School, Monterey, CA. NPS-OC-12-001CR April 2012. 69 p.

Širović, A., J.A. Hildebrand, S. Baumann-Pickering, J. Buccowich, A. Cummins, S. Kerosky, L. Roche, A.S. Berga, S. M. Wiggins. (2012b). Passive Acoustic Monitoring for Marine Mammals in the Northwest Training Range Complex 2011. Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA. MPL TECHNICAL MEMORANDUM: MPL-TM 535. 57 pp.

Smultea, M.A., & C.E. Bacon. (2013). Marine Mammal Aerial Density Surveys Conducted in the Pacific Northwest Inland Puget Sound Waters 30 August – 4 September 2013. Preliminary Report. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Northwest (NAVFAC NW), Silverdale, WA 98315-1101 under Contract No. N62470-10-D-3011-CPO issued to HDR, Inc., San Diego, CA 92123. 1 October 2013.

Smultea, M.A, A.B. Douglas, C.E. Bacon, T.A. Jefferson, and L. Mazzuca. (2013). Bryde's Whale (*Balaenoptera brydei/edeni*) Sightings in the Southern California Bight. Aquatic Mammals 38(1), 92-97, doi: 10.1578/AM.38.1.2012.92.

Smultea, M., Mobley, J., Fertl, D., & Fulling, G. (2008). Short Communication An Unusual Reaction and Other Observations of Sperm Whales Near Fixed-Wing Aircraft. *Gulf and Caribbean Research*, 20, 75-80.

Smultea, M. A., Jefferson, T. A. & Zoidis, A. M. (2010). Rare sightings of a Bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i. *Pacific Science, 64*, 449-457.

Sousa-Lima, R. S. & Clark, C. W. (2008). Modeling the effect of boat traffic on the fluctuation of humpback whale singing activity in the Abrolhos National Marine Park, Brazil. *Canadian Acoustics*, 36(1), 174-181.

Southall, B. L., Schusterman, R. J. & Kastak, D. (2000). Masking in three pinnipeds: underwater, low-frequency critical ratios. Journal of the Acoustical Society of America, 108(3), 1322-1326.

Southall, B. L., Schusterman, R. J. & Kastak, D. (2003). Auditory masking in three pinnipeds: Aerial critical ratios and direct critical bandwidth measurements. Journal of the Acoustical Society of America, 114(3), 1660-1666.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., . . . Tyack, P. L. (2007). Marine mammal noise and exposure criteria: initial scientific recommendations. *Aquatic Mammals, 33*, 411-521.

Southall, B. B., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., . . . Winokur, R. (2009a). *Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U. S. Federal Agencies*. (pp. 72). Washington, DC: Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology.

Southall, B. L., Tyack, P. L., Moretti, D., Clark, C., Claridge, D. & Boyd, I. (2009b). Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds, 18th Biennial Conference on the Biology of Marine Mammals. Quebec City, Quebec, Canada.

Southall, B., Calambokidis, J., Tyack, P., Moretti, D., Hildebrand, J., Kyburg, C., Carlson, R., Friedlaender, A. S., Falcone, E. A., Schorr, G. S., Douglas, A., Deruiter, S. L., Goldbogen, J. A. & Barlow, J. (2011). Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 ("SOCAL-10") *SOCAL-BRS* [Project Report]. (pp. 29).

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow. (2012). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 (“SOCAL-11”),* Final Project Report, 8 March 2012.

Stafford, K. M., Nieukirk, S. L. & Fox, C. G. (2001). Geographic and seasonal variation of blue whale calls in the North Pacific. *Journal of Cetacean Research and Management, 3*(1), 65-76.

St. Aubin, D. J. (2002). Hematological and serum chemical constituents in pantropical spotted dolphins (*Stenella attenuata*) following chase and encirclement. (Vol. LJ-02-37C, pp. 1-47) Southwest Fisheries Science Center.

St. Aubin, D. J. & Geraci, J. R. (1988). Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whales *Delphinapterus leucas*. Physiological Zoology 61(2), 170-175.

St. Aubin, D. J. & Geraci, J. R. (1989). Adaptive changes in hematologic and plasma chemical constituents in captive beluga whales, *Delphinapterus leucas*. Canadian Journal of Fisheries and Aquatic Sciences, 46, 796-803.

St. Aubin, D. J., Ridgway, S. H., Wells, R. S. & Rhinehart, H. (1996). Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *Tursiops truncatus*, and influence of sex, age, and season. Marine Mammal Science, 12(1), 1-13.

St. Aubin, D. J. & Dierauf, L. A. (2001). Stress and Marine Mammals L. A. Dierauf and F. M. D. Gulland (Eds.), *Marine Mammal Medicine* (second ed., pp. 253-269). Boca Raton: CRC Press.

Stensland, E. & P. Berggren (2007). Behavioural changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. *Marine Ecology Progress Series* 332: 225-234.

Sterling J.T., A.M. Springer, S.J. Iverson, S.P. Johnson, N.A. Pelland, D.S. Johnson, M-A. Lea, and N.A. Bond. 2014. The Sun, Moon, Wind, and Biological Imperative-Shaping Contrasting Wintertime Migration and Foraging Strategies of Adult Male and Female Northern Fur Seals (*Callorhinus ursinus*). PLoS ONE 9(4): e93068. doi:10.1371/journal.pone.0093068

Stern, S. J. (1992). Surfacing rates and Surfacing Patterns of Minke Whales (*Balaenoptera acutorostrata*) off Central California and the Probability of a Whale Surfacing within Visual Range. Reports of the International Whaling Commission, 42, 379-385.

Stern, J. (2005). Personal communication between Dr. Jon Stern (The Northeast Pacific Minke Whale Project, San Rafael, California) and Ms. Dagmar Fertl (Geo-Marine Inc., Plano, Texas) via email 11 November regarding minke whale occurrence in the study area.

Stock, M. K., Lanphier, E. H., Anderson, D. F., Anderson, L. C., Phernetton, T. M. & Rankin, J. H. (1980). Responses of fetal sheep to simulated no-decompression dives (Vol. 48, pp. 776-780).

Stockin, K., Lusseau, D., Binedell, V., Wiseman, N. & Orams, M. (2008, February 26). Tourism affects the behavioural budget of the common dolphin Delphinus sp. in the Hauraki Gulf, New Zealand. [electronic version]. Marine Ecology Progress Series, 355, 287-295. 10.3354/meps07386.

Swartz, S. L., Taylor, B. L., & Rugh, D. J. (2006). Gray whale *Eschrichtius robustus* population and stock identity. *Mammal Review,* 36(1): 66-84.

Tannenbaum, B.R., M. Bhuthimethee, L. Delwiche, G. Vedera, & J.M. Wallin. (2009). Naval Base Kitsap at Bangor 2008 Marine Mammal Survey Report. Prepared by Science Applications International Corporation, Bothell, WA. Prepared for BAE Systems Applied Technologies, Inc., Rockville, MD.

Terhune, J. M. & Verboom, W. C. (1999). Right whales and ship noises. *Marine Mammal Science*, 15(1), 256-258.

Thompson, P.M., D. Lusseau, T. Barton, D. Simmons, J. Rusin, and H. Bailey. (2010). Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin 60: 1200-1208.

Todd, S., Stevick, P., Lien, J., Marques, F. & Ketten, D. (1996). Behavioural effects of exposure to underwater explosions in humpback whales (*Megaptera novaeanlgiae*). Canadian Journal of Zoology, 74, 1661-1672.

Trites, A. W. & D. E. Bain (2000). *Short- and long-term effects of whale watching on killer whales (Orcinus orca) in British Columbia*. Adelaide, Australia, International Whaling Commission.

Twiss, J. R., Jr. & Reeves, R. R. (Eds.). (1999). *Conservation and Managment of Marine Mammals* (pp. 471). Washington, D.C.: Smithsonian Institution Press.

Tyack, P. L. (2009, November). Human-generated sound and marine mammals. *Physics Today*, 39-44.

Tyack, P., Zimmer, W., Moretti, D., Southall, B., Claridge, D., Durban, J., Boyd, I. (2011). *Beaked Whales Respond to Simulated and Actual Navy Sonar.* [electronic version]. PLoS ONE, 6(3), 15. doi: 10.1371/journal.pone.0017009.

Tyack, P. L., Johnson, M., Aguilar Soto, N., Sturlese, A. & Madsen, P. T. (2006). Extreme deep diving of beaked whales. Journal of Experimental Biology, 209, 4238-4253. doi: 10.1242/jeb.02505

Ulrich, R. (2004). *Development of a sensitive and specific biosensor assay to detect Vibrio vulnificus in estuarine waters.* (Partial fulfillment of the requirements for the degree of Master of Science Department of Biology college of Arts and Sciences). University of South Florida.

U.S. Department of the Navy. (1988). Southeast Alaska Acoustic Measurement Facility Environmental Impact Statement. Prepared by U.S. Department of the Navy.

U.S. Department of the Navy. (1991). Environmental Assessment for the Naval Sonobuoy Testing in Southeast Alaska. Naval Avionics Center, U.S. Navy.

U.S. Department of the Navy. (2004). Report on the reslts of the inquiry into allegations of marine mammal impacts surrounding the use of active sonar by USS SHOUP (DDG 86) in the Haro Strait on or about 5 May 2003.

U.S. Department of the Navy. (2010a). Northwest Training Range Complex Environmental Impact Statement. Prepared by U.S. Pacific Fleet.

U.S. Department of the Navy. (2010b). Naval Sea Systems Command Naval Undersea Warfare Center Keyport Range Complex Extension Environmental Impact Statement. Prepared by U.S. Department of the Navy.

U.S. Department of the Navy. (2011a). Annual Range Complex Monitoring Report – Year 1 from 12 November 2010 to 1 May 2011 for the U.S. Navy's Northwest Training Range Complex. Final 1 July 2011.

U.S. Department of the Navy. (2011b). Annual Range Complex Exercise Report – Year 1 from 12 November 2010 to 1 May 2011 for the U.S. Navy's Northwest Training Range Complex. Final 1 July 2011.

U.S. Department of the Navy. (2012a). Annual Range Complex Monitoring Report – Year 2 from 2 May 2011 to 1 May 2012 for the U.S. Navy's Northwest Training Range Complex. Final 1 July 2012.

U.S. Department of the Navy. (2012b). Annual Range Complex Exercise Report – Year 2 from 2 May 2011 to 1 May 2012 for the U.S. Navy's Northwest Training Range Complex. Final 1 July 2012.

U.S. Department of the Navy. (2012c). Annual Range Complex Monitoring Report – Year 1 from 12 April 2011 to 8 November 2011 for the U.S. Navy's NAVSEA NUWC Keyport Range Complex. Final January 2012.

U.S. Department of the Navy. (2012d). Annual Range Complex Monitoring Report – Year 2 from 1 September 2011 to 31 August 2012 for the U.S. Navy's NAVSEA NUWC Keyport Range Complex. Final November 2012.

U.S. Department of the Navy. (2013a). Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement (Final EIS/OEIS).

U.S. Department of the Navy. (2013b). Annual Range Complex Monitoring Report – Year 3 from 2 May 2012 to 1 May 2013, titledMarine Mammal Strandings Associated with U.S. Navy Sonar Activities (version 02.20.2013). Space and Naval Warfare Systems Center Pacific, San Diego. 42p

U.S. Department of the Navy. (2013c). Comprehensive Exercise and Marine Species Monitoring Report for The U.S. Navy's Southern California Range Complex. U.S. Pacific Fleet, Pearl Harbor, Hawaii. Final.

U.S. Department of the Navy. (2013d). Annual Range Complex Monitoring Report – Year 3 (2 May 2012 to 1 May 2013) titled, "Marine Species Monitoring Report for the U.S. Navy's Northwest Training Range Complex." U.S. Pacific Fleet, Pearl Harbor, Hawaii. Final July 1, 2013.

U.S. Department of the Navy. (2013e). Annual Range Complex Monitoring Report – Year 3 for the U.S. Navy's NAVSEA NUWC Keyport Range Complex.

U.S. Department of the Navy. (2014a). Northwest Training and Testing Draft Environmental Impact Statement/Overseas Environmental Impact Statement (Draft EIS/OEIS).

U.S. Department of the Navy. (2014b, in press). Pacific Navy Marine Species Density Database. Naval Facilities Engineering Command Pacific, Technical Report, Makalapa, Hawaii.

U.S. Department of the Navy. (2014c). Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Northwest Training and Testing. Technical report prepared by Navy Marine Mammal Program, SPAWAR.

Van Parijs, S.M. (2015). Letter of Introduction to the Biologically Important Areas Issue. Aquatic Mammals 41(1), 1, DOI 10.1578/AM.41.1.2015.1; 1 p.

Van Waerebeek, K., Baker, A. N., Felix, F., Gedamke, J., Iñiguez, M., Sanino, G. P., . . . Wang, Y. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the southern hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals, 6(1), 43-69.

Visser, I. N. & Fertl, D. (2000). Stranding, resighting, and boat strike of a killer whale (Orcinus orca) off New Zealand. *Aquatic Mammals,* 26.3, 232-240.

Wade, P. (2005). Personal communication between Dr. Paul Wade (NMFS) and Ms. Dagmar Fertl (Geo-Marine Inc., Plano, Texas) via email 3-6 October 2005 regarding fin whale occurrence in the study area.

Wade, P., M.P. Heide-Jørgensen, K. Shelden, J. Barlow, J. Caretta, J. Durban, R. LeDuc, L. Munger, S. Rankin, & C. Stinchcomb. (2006). Acoustic detection and satellite-tracking leads to discovery of rare concentration of endangered North Pacific right whales. *Biology Letters* 2:417–419, doi: 10.1 098/rsbl. 2006.0460.

Wade, P.R., A. Kennedy, R.G. LeDuc, J. Barlow, J.C. Carretta, K. Shelden, W. Perryman, R. Pitman, K. Robertson, B. Rone, J.C. Salinas, A. Zerbini, R.L. Brownell Jr., and P.J. Clapham. (2011a). The world's smallest whale population? Biology Letters, 7(1):83–85.

Wade, P.R., A. De Robertis, K. R. Hough, R. Booth, A. Kennedy, R. G. LeDuc, L. Munger, J. Napp, K. E. W. Shelden, S. Rankin, O. Vasquez, and C. Wilson. (2011b). Rare detections of North Pacific right whales in the Gulf of Alaska, with observations of their potential prey. Endangered Species Research, 13: 99-109.

Waring, G. T., Hamazaki, T., Sheehan, D., Wood, G. & Baker, S. (2001). Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. *Marine Mammal Science, 17*(4), 703-717.

Wartzok, D., Popper, A. N., Gordon, J. & Merrill, J. (2003). Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal, 37(4), 6-15.

Watkins, W. A., Daher, M. A., DiMarzio, N. A., Samuels, A., Wartzok, D., Fristrup, K. M., . . . Spradlin, T. R. (1999). Sperm whale surface activity from tracking by radio and satellite tags. *Marine Mammal Science*, 15(4), 1158-1180.

Watkins, W. A. (1981). Reaction of three species of whales *Balaenoptera physalus, Megaptera novaeangliae*, and *Balaenoptera edeni* to implanted radio tags. Deep-Sea Research, 28A(6), 589-599.

Watkins, W. A. (1986, October 1986). Whale reactions to human activities in Cape Cod waters. Marine Mammal Science, 2(4), 251-262.

Watkins, W. A., Moore, K. E. & Tyack, P. (1985). Sperm whale acoustic behavior in the southeast Caribbean. Cetology, 49, 1-15.

Watkins, W. A. & Schevill, W. E. (1975). Sperm whales (*Physeter catodon*) react to pingers. Deep-Sea Research, 22, 123-129.

Weller, D. W., Burdin, A. M., Würsig, B., Taylor, B. L. & Brownell, R. L. (2002). The western gray whale: a review of past exploitation, current status and potential threats. *Journal of Cetacean Research and Management, 4*(1), 7-12.

Weller, D. W., A. L. Bradford, H. Kato, T. Bando, S. Otani, A. M. Burdin and J. Brownell, R. L (2008). "A photographic match of a western gray whale between Sakhalin Island, Russia, and Honshu, Japan: the first link between the feeding ground and a migratory corridor." Journal of Cetacean Research and Management 10(1): 89-91.

Weller, D. W., A. Klimek, A. L. Bradford, J. Calambokidis, A. R. Lang, B. Gisborne, A. M. Burdin, W. Szaniszlo, J. Urbán, A. Gomez-Gallardo Unzueta, S. Swartz and R. L. Brownell (2012). "Movements of gray whales between the western and eastern North Pacific." Endangered Species Research 18(3): 193-199.

Weller, D.W., Bettridge, S., Brownell, R.L., Jr., Laake, J.L., Moore, J.E., Rosel, P.E., Taylor, B.L and Wade, P. R. (2013). Report of the National Marine Fisheries Service gray whale stock identification workshop. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-SWFSC-507.

Wells, R. S. & Scott, M. D. (1997). Seasonal incidence of boat strikes on bottlenose dolphins near Sarasota, Florida. *Marine Mammal Science*, 13(3), 475-480.

Whitehead, H. (2002). Estimates of the current global population size and historical trajectory for sperm whales. *Marine Ecology Progress Series,* 242, 295−304.

Whitehead, H. (2003). *Sperm Whales: Social Evolution in the Ocean* (pp. 431). University of Chicago Press.

Whitehead, H., Coakes, A., Jaquet, N. & Lusseau, S. (2008). Movements of sperm whales in the tropical Pacific. *Marine Ecology Progress Series, 361*, 291-300. 10.3354/meps07412

Williams, R. & Thomas, L. (2007). Distribution and abundance of marine mamals in the coastal waters of British Columbia, Canada. *Journal of Cetacean Research and Management,* 9(1), 15-28.

Williams, R., D. E. Bain, R., Bain, D. E., Ford, J. K. B., & Trites, A. W (2002). Behavioural responses of male killer whales to a "leapfrogging" vessel. *Journal of Cetacean Research and Managemen*t, 4(3), 305-310.

Williams, R., D. Lusseau, and P. S. Hammond. (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). Biological Conservation 133: 301–311.

Williams, R., Bain, D.E., Smith, J.C., & Lusseau D. (2009). Effects of vessels on behaviour patterns of individual southern resident killer whales *Orcinus orca*. *Endangered Species Research,* 6, 199-209.

Williams, R., E. Asheb, and P.D. O'Harad. (2011a). Marine mammals and debris in coastal waters of British Columbia, Canada. Marine Pollution Bulletin 62(6): 1303-1316.

Williams, R., Ashe, E., Sandilands, D., & Lusseau, D. (2011b). Stimulus-dependent response to disturbance affecting the activity of killer whales. The Scientific Committee of the International Whaling Commission. Document: SC/63/WW5, 27 pages.

Williams, R., Clark, C.W., Ponirakis, D., & Ashe, E. (2013). Acoustic quality of critical habitats for three threatened whale populations. Animal Conservation 17:174-185.

Williams, R., Ashe, E., Blight, L., Jasny, M., & Nowlan, L. (2014a). Marine mammals and ocean noise: Future directions and information needs with respect to science, policy and law in Canada. Marine Pollution Bulletin 86: 29-38.

Williams, R., Erbe, C., Ashe, E., Beerman, A. and Smith, J. (2014b). Severity of killer whale behavioral responses to ship noise: A dose–response study. Marine Pollution Bulletin 79:254-260. doi: 10.1016/j.marpolbul.2013.12.004

Williams, T., Fuiman, L., Kendall, T., Berry, P., Richter, B., Noren, S., Thometz, N., Shattock, M., Farrell, E., Stamper, A., & Davis, R. (2015) Exercise at Depth Alters Bradycardia and Incidence of Cardiac Anomalies in Deep-Diving Marine Mammals. Nature Communications, 6(6055):1-9, doi:10.1038/ncomms7055, 9 pages.

Willis, P.M. & Baird, R.W. (1998). Sightings and strandings of beaked whales on the west coast of Canada. *Aquatic Mammals*, 24(1): 21-25.

Würsig, B., S. K. Lynn, S.K., Jefferson, T.A. & Mullin, K.D. (1998). Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals,* 24(1), 41-50.

Zerbini, A.N., Waite, J.M., Laake, J.L., & Wade, P.R. (2006). Abundance, trends and distribution of baleen whales off western Alaska and the central Aleutian Islands. *Deep-Sea Research* Part I:1772-1790.

Zimmer, W. M. X., and P. L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whales. Marine Mammal Science 23:888–925.