REQUEST FOR LETTER OF AUTHORIZATION

FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM U.S. NAVY TRAINING ACTIVITIES IN THE GULF OF ALASKA TEMPORARY MARITIME ACTIVITIES AREA

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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
ALCOM	Alaskan Command
ALTRV	Altitude Reservation
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
AUTEC	Atlantic Undersea Test and Evaluation Center
BOMBEX	Bombing Exercise
CV	Coefficient of Variation
dB	decibel(s)
DICASS	Directional Command Activated Sonobuoy System
DPS	Distinct Population Segment
DS	Doppler Sonar
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
FA	Fathometer
FAA	Federal Aviation Administration
FR	Federal Register
ft.	feet
GOALS	Gulf of Alaska Line-Transect Survey
GUNEX	Gunnery Exercise
HARP	High-frequency Acoustic Recording Package
Helo	helicopter
HF	High-Frequency
HHS	Hand-held Sonar
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
IMS	Imaging Sonar
in.	inch(es)
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometers
lb.	pound(s)
LMR	Living Marine Resources
LOA	Letter of Authorization
m	meter(s)
msec	millisecond(s)
M	Acoustic Modem
MF	Mid-Frequency
MFA	Mid-Frequency Active
mi.	mile(s)
MINEX	Mining Exercise
MISSILEX	Missile Exercise
MIW	Mine Warfare
MMPA	Marine Mammal Protection Act
MPA	Maritime Patrol Aircraft
N	North
n/a	Not Applicable
NAEMO	Navy Acoustic Effects Model
Navy	U.S. Department of the Navy
NEW	Net Explosive Weight
nm	nautical mile(s)
nm^2	square nautical mile(s)
NMFS	National Marine Fisheries Service
NOTAM	Notice to Airmen
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OPAREA	Operating Area
OPNAV N45	Chief of Naval Operations Energy and Environmental Readiness
PCAD	Population Consequences of Acoustic Disturbance
PL	Public Law
PMRF	Pacific Missile Range Facility
PTS	Permanent Threshold Shift
R	Acoustic Release
R&D	Research and Development
re	referenced to
rms	root mean square
S	South
S-S	Surface-to-Surface
SAG	Scientific Advisory Group
SAR	Stock Assessment Report
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
SUS	Signal Underwater Sound
TMAA	Temporary Maritime Activities Area
TNT	Trinitrotoluene
TORP	Torpedo
TRACKEX	Tracking Exercise
TTS	Temporary Threshold Shift
USFWS	U.S. Fish and Wildlife Service
U.S.	United States
U.S.C.	United States Code

VHF	Very High-Frequency
W (1)	Warning Area
W (2)	West
yd.	yard(s)

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1 INTRODUCTION AND DESCRIPTION OF ACTIVITIES

1.1 Introduction

The United States (U.S.) Department of the Navy (Navy) has prepared this Letter of Authorization (LOA) for the incidental taking, as defined in Chapter 5 (Take Authorization Requested), of marine mammals during the conduct of training activities within the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) Study Area (hereafter referred to as the Study Area). The Navy activity to be authorized will occur from 2016 through 2021, and the Navy requests this 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 a Supplemental Environmental Impact Statement (EIS)/Overseas EIS (OEIS) for the GOA Study Area to evaluate all components of the proposed training activities. The Navy previously analyzed training activities in the Study Area in the Tactical Training Theater Assessment and Planning Program Phase I and specifically in the *Gulf of Alaska Navy Training Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy 2011a). For this letter of request, a description of the Study Area (Figure 1-1) is provided in Chapter 2 (Description of Proposed Action and Alternatives) of the GOA Supplemental EIS/OEIS, and in Chapter 2 (Duration and Location of Activities) of this LOA application. The proposed training activities are described in Table 1-4 of this LOA. This request for a LOA is based on the proposed training activities of the Navy's Proposed Action.

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 activities that have the potential to incidentally take marine mammals per the GOA Supplemental 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 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 GOA Supplemental 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.

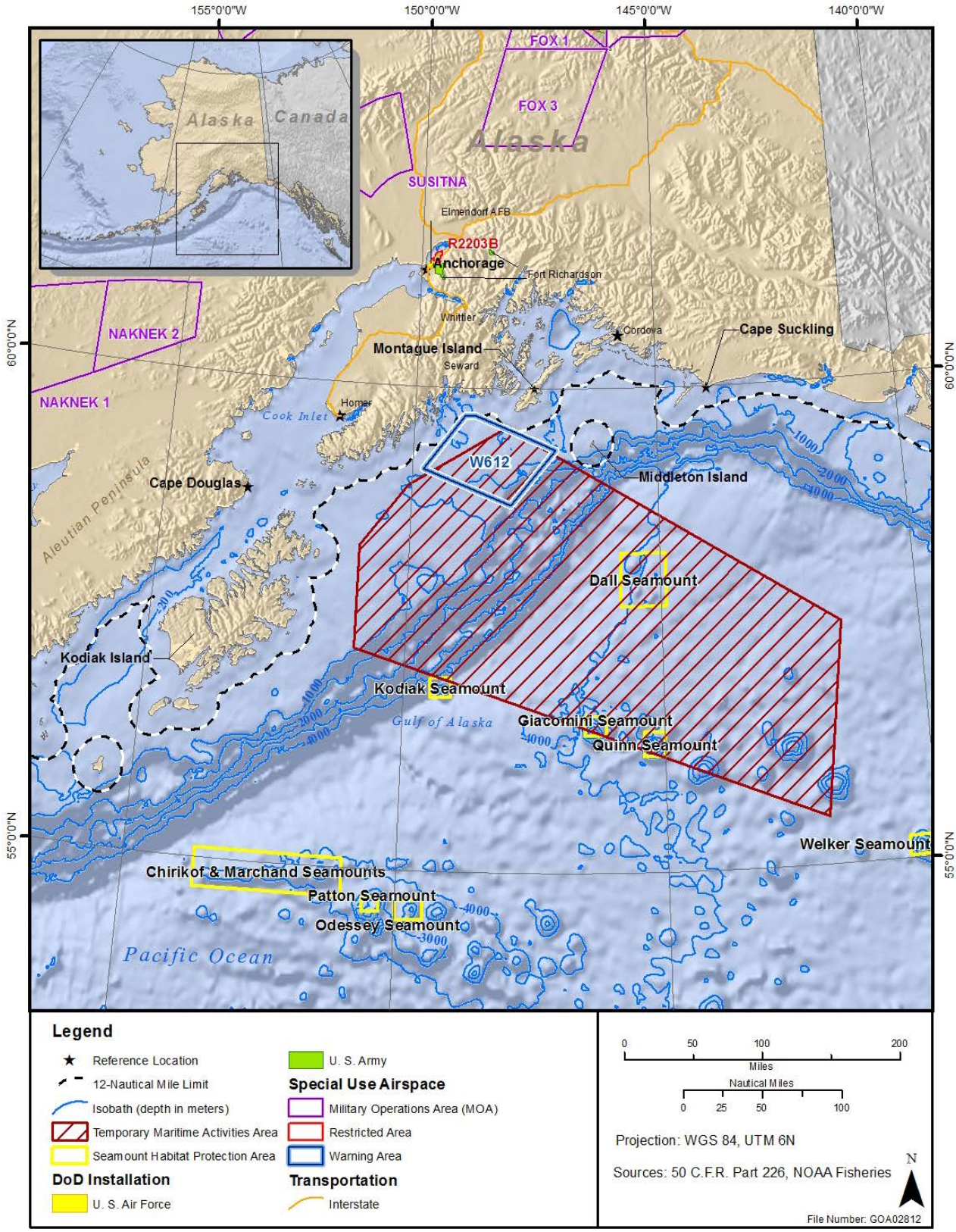

Figure 1-1: Gulf of Alaska Temporary Maritime Activities Area (Study Area)

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.

To meet training requirements, the Navy is preparing a Supplemental EIS/OEIS to assess the potential environmental impacts associated with ongoing and proposed naval training activities in the Study Area. The Navy is the lead agency for the GOA Supplemental EIS/OEIS, and National Marine Fisheries Service (NMFS) is a cooperating agency pursuant to 40 Code of Federal Regulations §§ 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 of the GOA Supplemental 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.[2]

1.3.1 Description of Current Training Activities within the Study Area

The Navy categorizes training activities into functional warfare areas called primary mission areas. Training activities fall into eight primary mission areas (Anti-Air Warfare; Amphibious Warfare; Strike Warfare; Anti-Surface Warfare [ASUW]; Anti-Submarine Warfare [ASW]; Electronic Warfare; 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 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. However, not all primary mission areas are conducted within the Study Area.

The Navy describes and analyzes the effects of its training activities within the GOA Supplemental 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 resulting 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

[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" 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.

stressors. The specific acoustic sources used in this LOA application are contained in the Navy's GOA Supplemental EIS/OEIS and are presented in the following sections based on the primary mission areas.

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 (S-S) missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

Anti-surface warfare training in the Study Area includes S-S gunnery and missile exercises (GUNEX and MISSILEX) and air-to-surface (A-S) bombing exercises (BOMBEX), GUNEX, and MISSILEX. Some of the small- and medium-caliber gunnery exercises analyzed include those conducted by the U.S. Coast Guard during a Navy training event. Also included in this mission area is a sinking exercise that may include S-S and A-S components.

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.

1.4 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 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.

1.4.1 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.

1.4.2 ORDNANCE/MUNITIONS

Most ordnance and munitions used during training 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 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.

1.4.3 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.

1.4.4 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 and Table 1-2. 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)

As described in the GOA Supplemental 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 Supplemental 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

1.4.5 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 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.

[3] Bins are based on the typical center frequency of the source. Although harmonics may be present, those harmonics would be several decibels (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 1 micropascal at 1 meter.

Table 1-1: Explosive Source Classes Analyzed

Source Class	Representative Munitions	Net Explosive Weight (pounds [lb.])
E5	5-inch projectiles	> 5–10
E6	AGM-114 Hellfire missile	> 10–20
E7	AGM-88 High-speed Anti-Radiation Missile	> 20–60
E8	250 lb. bomb	> 60–100
E9	500 lb. bomb	> 100–250
E10	1,000 lb. bomb	> 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 of Representative Source
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)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	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)
	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 testing 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)
	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	TORP2	Heavyweight torpedo (e.g., MK-48, electric vehicles)

Notes: dB = decibels, DICASS = Directional Command Activated Sonobuoy System, kHz = kilohertz

1.4.6 Source Classes Excluded From Quantitative Analysis for Training and Testing

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 based on system acoustic characteristics (i.e., short pulse length, narrow beamwidth, downward directed beam, etc.) and manner of system operation.
- The sources operate at frequencies greater than 200 kHz.
- The sources operate at source levels less than 160 dB.
- Bins contain sources needed for safe operation and navigation.

Table 1-3 presents a description of the sources and source bins that the Navy excluded from quantitative analysis and the reasons for those exclusions.

Table 1-3: Source Classes Excluded from Quantitative Analysis

Source Category	Source Bin	Description
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 because 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.
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.

Table 1-3: Source Classes Excluded from Quantitative Analysis (continued)

Source Category	Source Bin	Description
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 sonars 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 sonars 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.
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.
Small Impulsive Sources	Sources with explosive weights < 0.25 lb. NEW (< bin E1)	Quantitative modeling in multiple locations has validated that these low level impulsive sources are expected to cause no more than short-term and inconsequential responses in marine species due to the low explosive weight and corresponding very small zone of influence associated with these types of sources.

Notes: HF = high frequency, kHz = kilohertz, msec = millisecond, NEW = Net Explosive Weight, VHF = very high-frequency

1.5 Proposed Action

The Navy has been conducting training activities and exercises in the Study Area since the 1990s. The tempo and types of training 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 activities. The Navy analyzed many training activities in the Study Area in the Tactical Training Theater Assessment and Planning Program Phase I and earlier documents and specifically the following environmental planning documents: *Gulf of Alaska Navy Training Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy 2011a), and associated documents.

The activities analyzed in the GOA Navy Training Activities Supplemental EIS/OEIS have not changed since the completion of the 2011 GOA Final EIS/OEIS although use of sonar and other active acoustic sources has occurred since the GOA Navy Training Activities Record of Decision, MMPA Authorization, and ESA Biological Opinion were finalized in May 2011. Since the purpose of the Supplemental EIS/OEIS is to re-analyze the 2011 GOA Final EIS/OEIS based on new marine mammal data and a new acoustic modeling method, the alternatives considered in this Supplement EIS/OEIS are the same as the alternatives in the 2011 GOA Final EIS/OEIS.

Identical to the alternatives in the 2011 GOA Final EIS/OEIS, the No Action Alternative in the Supplemental EIS/OEIS consists of training activities of the types and levels of training intensity as conducted prior to 2011 and does not include ASW training activities involving the use of active sonar. Alternative 1, in addition to accommodating training activities addressed in the No Action Alternative, supports an increase in training activities. This increase would encompass conducting one large-scale carrier strike group exercise, as well as the inclusion of ASW activities and the use of active sonar, occurring over a maximum time period of up to 21 consecutive days during the summer months (April–October). Alternative 1 also proposes training required by force structure changes to be implemented for new weapons systems, instrumentation, and technology as well as new classes of ships, submarines, and new types of aircraft. In addition, specific training instrumentation enhancements would be implemented, to include development and use of the portable undersea tracking range. Alternative 2 would include all elements of Alternative 1 plus one additional carrier strike group exercise during the summer months. Alternative 2 was the Preferred Alternative chosen for implementation by the May 2011 GOA Navy Training Activities Record of Decision. This request for a LOA pursuant to the MMPA is based on the proposed training activities of the Navy's Preferred Alternative (Alternative 2) in the Supplemental EIS/OEIS. Alternative 2 was the Preferred Alternative chosen for implementation by the May 2011 GOA Navy Training Activities Record of Decision.

This request for authorization presents the analysis of potential underwater acoustic impacts on marine mammals that are found in the TMAA as a result of the continuation of the current training activities (those selected by the Record of Decision following the 2011 GOA Final EIS/OEIS). At-sea joint exercises in the Gulf of Alaska must continue to be conducted to support the training of combat-capable naval forces. The activities analyzed in this GOA Navy Training Activities Supplemental EIS/OEIS have not changed since the completion of the 2011 GOA Final EIS/OEIS. Use of sonar and other active acoustic sources has occurred since the GOA Navy Training Activities Record of Decision, MMPA Authorization, and ESA Biological Opinion were finalized in May 2011. Since the purpose of the Supplemental EIS/OEIS is to re-analyze the 2011 GOA Final EIS/OEIS based on new marine mammal data and a new acoustic

modeling method, the alternatives considered in this Supplement EIS/OEIS are the same as the alternatives in the 2011 GOA Final EIS/OEIS.

All stressors that may impact marine mammals were analyzed in the 2011 GOA Final EIS/OEIS. For stressors other than the acoustic stressors considered in the Supplemental EIS/OEIS (involving sonar and other active acoustic sources and explosives), there have been no changes to the Region of Influence, existing conditions, or species life histories which would otherwise change the analysis and conclusions presented in the 2011 GOA Final EIS/OEIS. Additionally, no new or additional Navy training activities are being proposed in the Supplemental EIS/OEIS that would affect marine mammals in the Study Area.

As described in Section 3.0.1 (Approach to Analysis) of the Supplemental EIS/OEIS, a comprehensive review of literature and scientific publications pertaining to marine mammals and the marine environment since completion of the 2011 GOA Final EIS/OEIS was undertaken. The literature cited and those publications reviewed and considered in the Supplemental EIS/OEIS have been presented in Section 3.8.8 (References Cited and Considered). In consideration of that material, it has been determined that there have been no substantive changes in the best available science that would necessitate any change in the findings presented in the 2011 GOA Final EIS/OEIS (see Section 3.8.3, Environmental Consequences) regarding the following stressors:

- Vessel noise, disturbance, and strikes
- Aircraft overflight noise
- Weapons firing noise
- Non-explosive ordnance use impact noise and strikes
- Electronic combat
- Discharges of expended materials (physical disturbance, strikes, entanglement, ingestion; sediments and water quality)

The focus of the Supplemental EIS/OEIS in Section 3.8.3 (Environmental Consequences) is the re-analysis of activities involving use of sonar and other active acoustic sources and explosives using the best available science and analytical methodologies that have become available since the 2011 GOA Final EIS/OEIS. Since training activities involving use of sonar and other active acoustic sources and explosives only occur in the TMAA, the re-analysis of acoustic stressor impacts for marine mammals will only address the TMAA portion of the 2011 GOA Final EIS/OEIS Study Area.

1.5.1 TRAINING

The training activities that the Navy proposes to conduct in the Study Area are described in Table 1-4. 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 Chapter 2 of the GOA Supplemental EIS/OEIS. The Navy's Proposed Activities are anticipated to meet training needs in the years 2016–2021.

Table 1-4: Training Activities within the Study Area

Category	Training Activity	Description	Weapons/Rounds/ Sound Source
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 include those conducted by the U.S. Coast Guard.	Small-, Medium-, and Large-caliber high explosive rounds
Impulsive	Sinking Exercise	Fixed-wing aircrews, surface ships and submarine firing precision-guided and non-precision weapons against a surface target.	High explosive bombs, missiles, Large-caliber rounds and torpedoes
Impulsive	Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.	High explosive bombs
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
Non-impulsive	Tracking Exercise – Surface (TRACKEX – Surface)	Surface ship searches for, tracks, and detects submarine(s).	Mid-frequency surface ship sonar, acoustic countermeasures, and high-frequency active sources
Non-impulsive	Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter searches, tracks, and detects submarine(s).	Mid-frequency dipping sonar systems and sonobuoys
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
Non-impulsive	Tracking Exercise – Maritime Patrol Aircraft (MAC Sonobuoys)	Maritime patrol aircraft crews search for, detect and track submarines using MAC sonobuoys.	mid-frequency MAC sonobuoys

Notes: DICASS = Directional Command Activated Sonobuoy System, MAC = Multistatic Active Coherent

1.5.2 SUMMARY OF IMPULSIVE AND NON-IMPULSIVE SOURCES

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

1.5.2.1 Training Sonar and Other Active Acoustic Source Classes

Table 1-5 provides a quantitative annual summary of training activities by sonar and other active acoustic source class analyzed in this LOA request.

Table 1-5: 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	541
	MF3	Hours	48
	MF4	Hours	53
	MF5	Items	25
	MF6	Items	21
	MF11	Hours	78
High-Frequency (HF): Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 100 kHz	**HF1**	Hours	24
	HF6	Hours	80
Anti-Submarine Warfare (ASW) Active ASW sources	**ASW2**	Hours	80
	ASW3	Hours	546
	ASW4	Items	4
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	**TORP2**	Items	5

1.5.2.2 Training and Testing Impulsive Source Classes

Table 1-6 provides a quantitative annual summary of training explosive source classes analyzed in this application.

Table 1-6: Annual Number of Training Explosive Source Detonations

Explosive Class Net Explosive Weight (pounds [lb.])	Annual In-Water Detonations Training
E5 (> 5–10 lb.)	112
E6 (> 10–20 lb.)	2
E7 (> 20–60 lb.)	4
E8 (> 60–100 lb.)	6
E9 (> 100–250 lb.)	142
E10 (> 250–500 lb.)	32
E11 (> 500–650 lb.)	2
E12 (> 650–1,000 lb.)	4

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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 activities would be conducted in the Study Area for up to 21 days per year to support a major joint training exercise in Alaska and off the Alaskan coast that involves the Departments of the Navy, Army, Air Force, and Coast Guard. The Service participants report to a unified or joint commander who coordinates the activities planned to demonstrate and evaluate the ability of the services to engage in a conflict and carry out plans in response to a threat to national security. The exercises would occur between the months of April and October of each year from 2016 to 2021.

The Study Area (see Figure 1-1) is entirely at sea and is composed of the established TMAA and a warning area in the Gulf of Alaska. The Navy is using "at-sea" to cover its training activities in the Study Area that occur (1) on the ocean surface, (2) beneath the ocean surface, and (3) in the air above the ocean surface. Navy training activities occurring on or over the land outside the TMAA are covered under separate environmental documentation prepared by the U.S. Air Force and the U.S. Army.

2.1 GULF OF ALASKA TEMPORARY MARITIME ACTIVITIES AREA

The TMAA is a temporary area established in conjunction with the Federal Aviation Administration (FAA) for up to 21 days per year that is a surface, undersea space, and airspace maneuver area within the Gulf of Alaska for ships, submarines, and aircraft to conduct required training activities. As depicted in Figure 1-1, the TMAA is a polygon roughly resembling a rectangle oriented from northwest to southeast, approximately 300 nautical miles (nm) in length by 150 nm in width, located south of Prince William Sound and east of Kodiak Island.

2.1.1 AIRSPACE OF THE TEMPORARY MARITIME ACTIVITIES AREA

The airspace of the TMAA overlies the surface and subsurface training area and is called an Altitude Reservation (ALTRV). This ALTRV is a temporary airspace designation, typically requested by the Air Force's Alaskan Command (ALCOM) and coordinated through the FAA for the duration of the exercise. This overwater airspace supports the majority of aircraft training activities conducted by Navy and Joint aircraft throughout the joint training exercise. The ALTRV over the TMAA typically extends from the ocean surface to 60,000 feet (ft.) (18,288 meters [m]) above mean sea level and encompasses 42,146 square nautical miles (nm^2) of airspace. For safety considerations, ALTRV information is sent via Notice to Airmen (NOTAM)/International NOTAM so that all pilots are aware of the area and that Air Traffic Control will keep known Instrument Flight Rules aircraft clear of the area.

Additionally, the TMAA overlies a majority of Warning Area (W)-612 located over Blying Sound, towards the northwestern quadrant of the TMAA. When not included as part of the TMAA, W-612 provides 2,256 nm^2 of special use airspace for the Air Force and U.S. Coast Guard (Coast Guard) to fulfill some of their training requirements. Air Force, Army, National Guard, and Coast Guard activities conducted as part of at-sea joint training within the TMAA are included in the Supplemental EIS/OEIS analysis. No Navy training activities analyzed in this document occur in the area of W-612 that is outside of the TMAA (see Figure 1-1).

2.1.2 SEA AND UNDERSEA SPACE OF THE TEMPORARY MARITIME ACTIVITIES AREA

The TMAA surface and subsurface areas are also depicted in Figure 1-1. Total surface area of the TMAA is 42,146 nm^2. Due to weather conditions, annual joint training activities are typically conducted during the summer months (April–October). The TMAA undersea area lies beneath the surface area as depicted in Figure 1-1. The undersea area extends to the seafloor.

The complex bathymetric and oceanographic conditions, including a continental shelf, submarine canyons, numerous seamounts, and fresh water infusions from multiple sources, create a challenging environment in which to search for and detect submarines in ASW training activities. In the summer, the TMAA provides a safe cold-water training environment.

The TMAA meets large-scale joint exercise training objectives to support naval and joint operational readiness by providing a “geographically realistic” training area for U.S. Pacific Command, Joint Task Force Commander scenario-based training, and supports the mission requirement of ALCOM to conduct joint training for Alaska-based forces. The strategic vision of the Commander, U.S. Pacific Fleet and the Commander, United States Fleet Forces is that the training area support naval operational readiness by providing a realistic, live-training environment for forces assigned to the Pacific Fleet and other users with the capability and capacity to support current, emerging, and future training requirements.

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 consistent with 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 stocks or species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which were extirpated because of factors such as nineteenth and twentieth century commercial exploitation). Several species that may be present in the Gulf of Alaska 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 beluga whale (*Delphinapterus leucas*), false killer whale (*Pseudorca crassidens*), short-finned pilot whale (*Globicephala macrorhynchus*), northern right whale dolphin (*Lissodelphis borealis*), and Risso's dolphin (*Grampus griseus*), and have been excluded from subsequent analysis for the reasons described in Section 3.1 below.

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

Common Name	Scientific Name[1]	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Family Balaenidae (right whales)					
North Pacific right whale	*Eubalaena japonica*	Eastern North Pacific	31 (0.23)	Rare	Endangered/ Depleted
Family Balaenopteridae (rorquals)					
Humpback whale	*Megaptera novaeangliae*	Central North Pacific	10,103 (n/a)	Likely	Endangered/ Depleted
		Western North Pacific	938 (n/a)	Likely	Endangered/ Depleted
Blue whale	*Balaenoptera musculus*	Eastern North Pacific	1,647 (0. 07)	Seasonal; highest likelihood July to December	Endangered/ Depleted
		Central North Pacific	81 (1.14)	Seasonal; highest likelihood July to December	Endangered/ Depleted
Fin whale	*Balaenoptera physalus*	Northeast Pacific	1,214 (minimum estimate) (n/a)	Likely	Endangered/ Depleted
Sei whale	*Balaenoptera borealis*	Eastern North Pacific	126 (0.53)	Rare	Endangered/ Depleted
Minke whale	*Balaenoptera acutorostrata*	Alaska	Not available	Likely	-
Family Eschrichtiidae (gray whale)					
Gray whale	*Eschrichtius robustus*	Eastern North Pacific	19,126 (0.07)	Likely: Highest numbers during seasonal migrations	-
		Western North Pacific	155	Rare: Individuals migrate through GOA	Endangered/ Depleted

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

Common Name	Scientific Name[1]	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Cetacea (continued)					
Suborder Odontoceti (toothed whales)					
Family Physeteridae (sperm whale)					
Sperm whale	*Physeter macrocephalus*	North Pacific	Not available	Likely; More likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/ Depleted
Family Delphinidae (dolphins)					
Killer whale	*Orcinus orca*	Alaska Resident	2,347 (n/a)	Likely	-
		Eastern North Pacific Offshore	211: includes known offshore killer whales along the U.S. west coast, Canada, and Alaska (n/a)	Infrequent: few sightings	-
		AT1 Transient	7	Rare; more likely inside Prince William Sound and Kenai Fjords	-
		GOA, Aleutian Island, and Bering Sea Transient	587	Likely	
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	North Pacific	26,880; specific to the GOA, not the management stock (n/a)	Likely	-
Family Phocoenidae (porpoises)					
Harbor porpoise	*Phocoena phocoena*	GOA	31,046 (0.21)	Likely in nearshore locations	-
		Southeast Alaska	11,146 (0.24)	Likely in nearshore locations	
Dall's porpoise	*Phocoenoides dalli*	Alaska	83,400 (0.097); based on survey data from 1987–1991	Likely	-
Family Ziphiidae (beaked whales)					
Cuvier's beaked whale	*Ziphius cavirostris*	Alaska	Not available	Likely	-
Baird's beaked whale	*Berardius bairdii*	Alaska	Not available	Likely	-
Stejneger's beaked whale	*Mesoplodon stejnegeri*	Alaska	Not available	Likely	-

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

Common Name	Scientific Name[1]	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Carnivora					
Suborder Pinnipedia[5]					
Family Otariidae (fur seals and sea lions)					
Steller sea lion	*Eumetopias jubatus*	Eastern U.S.	57,966 (minimum estimate) (n/a)	Likely	-
		Western U.S.	45,659 (minimum estimate) (n/a)	Likely	Endangered/ Depleted
California sea lion	*Zalophus californianus*	U.S.	296,750 (n/a)	Rare	-
Northern fur seal	*Callorhinus ursinus*	Eastern Pacific	639,545 (n/a)	Likely	Depleted
Family Phocidae (true seals)					
Northern elephant seal	*Mirounga angustirostris*	California Breeding	124,000 (n/a)	Likely	-
Harbor seal	*Phoca vitulina*	Aleutian Islands	3,579 (0.092)	Extralimital	-
		Pribilof Islands	232 (n/a)	Extralimital	-
		Bristol Bay	18,577 (0.058)	Extralimital	-
		N. Kodiak	4,509 (0.064)	Rare (inshore waters)	-
		S. Kodiak	11,117 (0.052)	Rare (inshore waters)	-
		Prince William Sound	31,503 (0.178)	Rare (inshore waters)	-
		Cook Inlet/Shelikof	22,900 (0.053)	Extralimital	-
		Glacier Bay/Icy Strait	5,042 (0.075)	Rare (inshore waters)	-
		Lynn Canal/ Stephens	8,870 (0.053)	Extralimital	-
		Sitka/Chatham	8,586 (0.052)	Rare (inshore waters)	-
		Dixon/Cape Decision	14,388 (0.060)	Rare (inshore waters)	-
		Clarence Strait	23,289 (0.042)	Extralimital	-
Ribbon seal	*Histriophoca fasciata*	Alaska	Not available	Rare	

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

Common Name	Scientific Name[1]	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Carnivora (continued)					
Suborder Pinnipedia[5] (continued)					
Family Mustelidae (otters)[6]					
Northern sea otter	*Enhydra lutris kenyoni*	Southeast Alaska	10,563	Rare	-
		Southcentral Alaska	15,090	Rare	-
		Southwest Alaska	47,676	Rare	Threatened

[1] Taxonomy follows Perrin et al. 2009.

[2] Stock names and abundance estimates from Allen and Angliss 2014 and Carretta et al. 2014 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 or acoustic detections.

LIKELY: Confirmed and regular sightings or acoustic detections of the species in the area year-round.

SEASONAL: Confirmed and regular sightings or acoustic detections of the species in the area on a seasonal basis.

[5] There are no data regarding the CV for some of the pinniped species given that abundance is determined by different methods than those used for cetaceans.

[6] There are no data regarding the CV for sea otter given that abundance is determined by different methods than those used for cetaceans.

Notes: m = meter(s), CV = coefficient of variation, ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act, U.S. = United States, n/a = not applicable, GOA = Gulf of Alaska

3.1 Species Unlikely to be Present in the Temporary Maritime Activities Area Study Area

3.1.1 Beluga Whale (*Delphinapterus leucas*)

There were 28 reported sightings of beluga whales in the GOA region from 1936 to 2000; however, all of these sightings were in the Cook Inlet or in very nearshore locations outside of the Study Area (Laidre et al. 2000; Goetz et al. 2012). The Cook Inlet stock of beluga whales was listed as endangered under the ESA on 22 October 2008 and was designated as depleted under the MMPA (National Oceanic and Atmospheric Administration 2008a). Rugh et al. (2010) found evidence that the Cook Inlet stock has exhibited range contraction towards the northeast, and that sightings in the southern inlet, closest to the Gulf of Alaska, have decreased. Critical habitat was designated for the Cook Inlet stock effective 11 May 2011 (National Oceanic and Atmospheric Administration 2011a), but the areas designated are far from the Study Area. Based on this information and the regulatory definition of the stock as those beluga whales confined to the waters of Cook Inlet (National Oceanic and Atmospheric Administration 2007, 2008a), this stock of beluga whales is not expected to be present in the Study Area. Due to the paucity of any beluga whale sightings in the Gulf of Alaska (Laidre et al. 2000), the occurrence of this species within the Study Area is considered extralimital.

3.1.2 False Killer Whale (*Pseudorca crassidens*)

False killer whales are found in tropical and temperate waters, generally between 50 degrees (°) South (S) and 50° North (N) latitude (Baird 1989; Odell and McClune 1999). Although they can occur as far north as the Study Area, false killer whales are uncommon north of the U.S.-Mexico border. Based on sighting data collected by Southwest Fisheries Science Center during systematic surveys in the northeast Pacific between 1986 and 2005, there were no sightings of false killer whales north of about 30°N (Hamilton et al. 2009). Norman et al. (2004) observed that most strandings for this species north of California occurred during or within a year of an El Niño event. For the MMPA stock assessment reports (SARs), there are five management stocks of false killer whale within the U.S. EEZ around the Pacific islands of Hawaii, Palmyra, and American Samoa (Carretta et al. 2014); there are no management stocks recognized for the U.S. west coast or Alaska waters. The occurrence of false killer whale within the Study Area is therefore considered extralimital.

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

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. 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). There are two records of this species in Alaskan waters. A short-finned pilot whale was taken near Katanak on the Alaska Peninsula in 1937, and a group of five short-finned pilot whales were sighted just southeast of Kodiak Island in May 1977 (U.S. Department of the Navy 2006). Stranding records for this species north of California waters are considered to be beyond the normal range of this species rather than an extension of its range (Norman et al. 2004). For the MMPA SARs, there are two management stocks of short-finned pilot whale within the Pacific U.S. EEZ, including stocks within: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters (Carretta et al. 2014). There is no management stock recognized for Alaska waters. The occurrence of short-finned pilot whale within the Study Area is therefore considered extralimital.

3.1.4 NORTHERN RIGHT WHALE DOLPHIN (*LISSODELPHIS BOREALIS*)

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° West (W) to 118° East and generally not as far north as the Bering Sea (Jefferson et al. 2008). There are two sighting records of northern right whale dolphins in the Gulf of Alaska, but these are considered extremely rare (U.S. Department of the Navy 2006; National Oceanic and Atmospheric Administration 2012b). For the MMPA SARs, there is a single management stock of northern right whale dolphin that includes animals found within the U.S. EEZ of California, Oregon, and Washington (Carretta et al. 2014); there is no management stock recognized for Alaska waters. The occurrence of northern right whale dolphin within the Study Area is therefore considered extralimital.

3.1.5 RISSO'S DOLPHIN (*GRAMPUS GRISEUS*)

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° Fahrenheit (F) (10° Celsius [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. There are a few records of this species near the Study Area. Risso's dolphins have been sighted near Chirikof Island (southwest of Kodiak Island) and offshore in the Gulf of Alaska, just south of the Study Area boundary (Consiglieri et al. 1980; Braham 1983). For the MMPA SARs, there are two management stocks of Risso's dolphin within the Pacific U.S. EEZ, including stocks within: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters (Carretta et al. 2014). There is no management stock recognized for Alaska waters. Further, the National Oceanic and Atmospheric Administration's Cetacean Density and Distribution Mapping Working Group considers the occurrence of Risso's dolphin in the Gulf of Alaska as "unknown" (National Oceanic and Atmospheric Administration 2012). The occurrence of Risso's dolphin within the Study Area is therefore considered extralimital.

3.2 NORTHERN SEA OTTER (*ENHYDRA LUTRIS KENYONI*)

The U.S. Fish and Wildlife Service provides management for and recognizes five stocks of sea otters in U.S. waters under MMPA guidelines. No further discussion of sea otters is presented in this letter of authorization request to National Marine Fisheries Service.

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 (3), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009). In addition, NMFS annually publishes SARs for all marine mammals in U.S. EEZ waters, including stocks that occur within the GOA Study Area (U.S. Pacific Marine Mammal Stock Assessments, Carretta et al. 2014; Alaska Marine Mammal Stock Assessments, Allen and Angliss 2014).

The Northern sea otter is managed by the U.S. Fish and Wildlife Service (USFWS). The potential for incidental takes of this species will be dealt with under separate correspondence with the USFWS.

4.1 NORTH PACIFIC RIGHT WHALE (*EUBALAENA JAPONICA*)

4.1.1 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. This species has been 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 (see National Oceanic and Atmospheric Administration 2008b), 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, thought to feed primarily in the Sea of Okhotsk (Allen and Angliss 2014). It is assumed that any North Pacific right whale in the Study Area would be from the eastern North Pacific stock.

4.1.2 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. 2011b). Far to the southwest of the TMAA (from 170 degrees East longitude west to Japan), Matsuoka et al. (2014) documented as many as 55 North Pacific right whale sightings representing 77 animals between 1994 to 2013; many of these were likely the same individuals re-sighted in subsequent years.

4.1.3 DISTRIBUTION

North Pacific 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). 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). 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; Gregr 2011; Ivashchenko and Clapham 2012).

Habitat modeling using historic whaling records suggests that the Gulf of Alaska currently provides suitable habitat for North Pacific right whales, although this has not been validated (Gregr 2011). 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). Recently, there are far fewer sightings of North Pacific right whales in the Gulf of Alaska than the Bering Sea (Brownell et al. 2001; Wade et al. 2011a). From the 1960s through 2002, there were only two documented sightings of North Pacific right whales in the Gulf of Alaska. In March 1979, there was an opportunistic sighting near Yakutat Bay in the eastern Gulf of Alaska (Shelden et al. 2005). A single North Pacific right whale was sighted southeast of Kodiak Island in July 1998 during an aerial survey and, subsequently, two passive acoustic recorders were placed in the northern Gulf of Alaska near Kodiak Island (Waite et al. 2003). Recordings from these instruments, and an additional five placed in the central Gulf of Alaska in 2000–2001, were later analyzed for North Pacific right whale calls. Very few right whale calls were positively identified, and all were detected on the westernmost recorder in the Gulf of Alaska during August and September (Moore et al. 2006).

From 2004 to 2006, there were an additional four sightings of North Pacific right whales in the Gulf of Alaska, all in the Barnabus Trough region on Albatross Bank, southeast of Kodiak Island (Wade et al. 2011a, b). These sightings triple the number of sightings in the Gulf of Alaska over the last 40 years and suggest that this area represents important habitat for the remaining animals in this population (Wade et al. 2011a). A portion of this area, located to the west/southwest of the Study Area, was designated as critical habitat in 2006.

During a marine mammal survey in July 2012, a lone North Pacific right whale was seen approximately 40 miles (mi.) south of the Study Area in deep water, approximately 130 mi. east of Kodiak Island (Matsuoka et al. 2013). In July 2013, during a second Navy-funded Gulf of Alaska Line-Transect Survey (GOALS II), three North Pacific right whales were acoustically detected in the Barnabus Trough region on Albatross Bank, southeast of Kodiak Island (Rone et al. 2014). This is the same area as the 2004–2006 sightings noted above (Wade et al. 2011a, b). A bottom moored passive acoustic monitoring device also detected North Pacific right whale calls between July and September 2013. This passive acoustic device was located in the extreme southeast edge of the GOA TMAA on Quinn Seamount (Debich et al. 2014). Given limitations of the passive acoustic detection technology deployed, it is unclear at this time if these detections were within or outside of the TMAA, however, the calls detected at Quinn Seamount had a relatively low signal-to-noise ratio indicating that the calling animal was not in the immediate vicinity of the hydrophone (Sirovic et al. 2014). Researchers analyzing these detections believe calls could have originated over 100 km (54 nm) from the sensor based on received levels at the hydrophone and simple propagation estimates (Debich et al. 2014). Previously, North Pacific right whales had not been detected on any of the passive acoustic buoys deployed in the shelf and slope regions of the Study Area, based on

recordings collected between July 2011 and June 2013 (Baumann-Pickering et al. 2012a, b; Debich et al. 2013).

Far to the south of the Study Area in June 2013, a single right whale was sighted in the waters off Haida Gwaii, British Columbia (Hume 2013). In October, another (different) single right whale was sighted off the mouth of San Juan de Fuca (Canada/Washington) with a group of humpback whales (Pynn 2013). These detections indicate at least two North Pacific right whales have recently ranged beyond the Bering Sea and Kodiak Island waters in the Gulf of Alaska if they are in fact part of the small North Pacific population of right whales as described by Wade et al. (2011b).

Given their current extremely low population numbers, and the general lack of sightings in the Gulf of Alaska, the occurrence of right whales in the Study Area is considered rare. North Pacific right whales have not been seen in the Study Area since at least the 1960s.

4.2 Humpback Whale (*Megaptera novaeangliae*)

4.2.1 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 for management purposes: (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). Whales from both the Central North Pacific and Western North Pacific stocks occur in the Study Area.

In addition to being listing as endangered, there are regulations that have been issued governing the approach to humpback whales "within 200 miles of the coast" in Alaska waters (National Marine Fisheries Service 2001). These regulations were issued to manage the threat caused by whale watching activities by: (1) prohibiting approach to within 100 yards (yd.) (91 m) of humpback whales, (2) implementation of a "slow safe speed" in proximity to humpbacks, and (3) creating exemptions for some vessels including military vessels engaged in "official duty" (training).

4.2.2 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 SPLASH (Structure of Populations, Levels of Abundance, and Status of Humpbacks) 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).

The current best estimate for the Western North Pacific stock is 938 individuals, based on data from their Asian wintering grounds (Allen and Angliss 2014). In summer, animals from this stock are found feeding mainly in waters off Russia, the Aleutian Islands, and the Bering Sea, although to a limited extent, they mix with whales from the Central North Pacific stock through the central Gulf of Alaska (Allen and Angliss 2014).

Based on sighting data collected during a Navy-funded line-transect survey of the Study Area in April 2009, there were 219 (CV = 0.57) and 56 (CV = 0.57) humpback whales in the inshore and offshore stratums, respectively (Rone et al. 2009). Data collected during line-transect surveys in shelf and nearshore waters from the Kenai Fjords in the Gulf of Alaska to the central Aleutian Islands during July and August 2001, 2002, and 2003 suggest that humpback whale populations in the Gulf of Alaska are increasing (Zerbini et al. 2006). During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area (Rone et al. 2014). Abundance estimates for unidentified large whales were pro-rated among blue, fin, and humpback whales within each stratum and proportionally incorporated into each species density estimate, resulting in the following abundance estimates for humpback whales: 2,927(CV = 0.74) inshore stratum, 65 (CV = 0.76) offshore stratum, 53 (CV = 0.64) seamount stratum, and 9 (CV = 1.03) slope stratum (Rone et al. 2014).

4.2.3 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). Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep water during migrations such as the route to and from the Hawaiian Islands (Calambokidis et al. 2001; Barlow et al. 2011). Migratory transits between the Hawaiian Islands and southeastern Alaska have been documented to take as little as 36–39 days (Gabriele et al. 1996; Calambokidis et al. 2001).

Identifications made between feeding areas and wintering areas indicate that the majority of humpbacks in the Gulf of Alaska winter in Hawaii (about 60 percent of the population), with the remainder wintering in Mexican waters around the Revillagigedo Islands, Baja, and the Mexican mainland (Calambokidis et al. 2008; Barlow et al. 2011). This suggests that whales migrating between breeding areas in Hawaii and feeding areas in northern British Columbia and southeast Alaska must cross paths with whales migrating between breeding areas near Mexico's offshore islands and feeding areas in the Gulf of Alaska (Barlow et al. 2011).

Prior to the SPLASH study, there had been few matches made between humpbacks in the western Pacific and any of the known feeding areas (Calambokidis et al. 2001). Barlow et al. (2011) found that

the whales wintering near Japan and the Philippines migrate primarily to Kamchatka and to some extent, the Aleutian Islands, Bering Sea, and Gulf of Alaska. However, approximately 15–17 percent of the whales identified in the western Gulf of Alaska could not be matched to known wintering areas, suggesting the existence of undocumented humpback wintering areas (Calambokidis et al. 2008).

There were eight on-effort humpback whale sightings during the Navy-funded line-transect survey of the Study Area in April 2009, and only one of these sightings was in the offshore stratum in waters deeper than 2,000 m (Rone et al. 2009). Results from a recent study of humpback whales in the Gulf of Alaska suggest that there may be regional feeding aggregations within the Gulf of Alaska (Witteveen et al. 2011). This study confirmed that humpback whale feeding aggregations exhibit high site fidelity and indicated that, while inshore and offshore aggregations of humpbacks off Kodiak Island and southeastern Alaska represent single feeding aggregations, inshore and offshore whale aggregations off Prince William Sound may be unique (Witteveen et al. 2011).

Humpback whales have been known to occur within the Gulf of Alaska primarily in summer and fall, migrating to southerly breeding grounds in winter and returning to the north in spring (Calambokidis et al. 2008). However, based on recordings from moored hydrophones deployed in six locations in the Gulf of Alaska from October 1999 to May 2002, humpback calls were most commonly detected during the fall and winter (Stafford et al. 2007). More recently, High-frequency Acoustic Recording Packages (HARPs) deployed in the shelf and slope regions of the Study Area confirmed that some humpbacks remain in the area throughout the winter (Baumann-Pickering et al. 2012b). Based on both sighting data and acoustic detections, humpback whales are now known to occur year-round in the Gulf of Alaska (Stafford et al. 2007; National Oceanic and Atmospheric Administration 2012b). Humpback whale occurrence in the Study Area during the summer time period is considered likely.

4.3 Blue Whale (*Balaenoptera musculus*)

4.3.1 Status and Management

The blue whale is listed as depleted under the MMPA and as endangered under the ESA, but there is no designated critical habitat for this species. Analyses of acoustic data suggest that blue whales in the North Pacific comprise two distinct stocks based on different call types, an eastern and western population (Stafford et al. 2001; Stafford 2003). Acoustic call types from both populations have been detected in the Gulf of Alaska (Stafford 2003; Stafford et al. 2007; Baumann-Pickering et al. 2012b). For the MMPA SARs, the Eastern North Pacific stock of blue whales includes animals that feed primarily off California and the Central (formerly Western) North Pacific stock includes animals found in waters off Hawaii during the winter (Carretta et al. 2014).

4.3.2 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 (Ŝirović et al. 2004; Branch et al. 2007, Monnahan et al. 2014). The current best available abundance estimate for the Eastern North Pacific stock of blue whales is 1,647 (CV = 0.07) (Carretta et al. 2014). 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 sighting data collected during a 2010 summer/fall shipboard line-transect survey of the entire Hawaiian Islands EEZ, the central North Pacific stock of blue whales is estimated at 81 animals (CV = 1.14) (Carretta et al. 2014). This is most likely an underestimate because the majority of blue whales are expected to be at

higher latitudes during summer and fall when the 2010 survey was conducted (Bradford et al. 2013; Carretta et al. 2014). Sighting data collected during a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA provided an abundance estimate for blue whales of 78 (CV = 1.22) based on pooled sightings from all strata and incorporation of pro-rated estimates for unidentified large whale species (Rone et al. 2014).

4.3.3 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 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. 2009).

Data indicate that whales from the Eastern North Pacific stock winter off Mexico, central America, and south to about 8°S (Stafford et al. 1999), and migrate to summer feeding grounds off the U.S. west coast and to a lesser extent to the Gulf of Alaska (Calambokidis et al. 2009). Blue whales observed in the spring, summer, and fall off California, Washington, and British Columbia are known to be part of a group that returns to feeding areas off British Columbia and Alaska (Calambokidis and Barlow 2004; Calambokidis et al. 2009). These animals have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis and Barlow 2004).

Blue whales from the Central North Pacific stock feed in summer off Kamchatka, the Aleutians, and in the Gulf of Alaska, and migrate to lower latitudes in the winter, including the Western Pacific and to a lesser degree the Central Pacific, including Hawaii (Stafford et al. 2001; Stafford 2003). Based on a photo-identification match of a blue whale observed during the 2013 GOALS II survey in the TMAA, Rone et al. (2014) determined the whale had been previously identified off Baja California, Mexico, in 2005.

There were no blue whale sightings during an August 1994 line-transect survey south of the Aleutian Islands that covered waters over the continental shelf, the Aleutian Trench, and the northern portion of the abyssal plains of the Gulf of Alaska (Forney and Brownell 1996). A large-scale, inter-disciplinary monitoring program for the North Pacific Ocean and the southern Bering Sea, conducted seasonally from June 2002 through October 2004, included surveys of marine birds and mammals. The cruises followed a survey track from British Columbia, Canada, to Hokkaido, Japan, crossing the Gulf of Alaska between roughly 51°N and 55°N (Sydeman et al. 2004). On six separate crossings, covering all seasons and including waters of all depths, no blue whales were seen (Sydeman et al. 2004). There also were no blue whale sightings during the Navy-funded survey of the Study Area in April 2009 (Rone et al. 2009). During the GOALS II survey, there were five on-effort blue whale sightings of seven individuals (Rone et al. 2014).

Despite the lack of sighting data, blue whale calls have been acoustically detected in the Gulf of Alaska from mid-July to mid-December, with peak occurrence from August through November (Moore et al. 2006). Calls from the Eastern North Pacific population are detected from late July to mid-December, and calls from the Western (now Central) North Pacific population are detected from mid-July to mid-December (Stafford et al. 2007). More recently, two Navy-funded HARPs were deployed in the shelf and slope regions of north-central Gulf of Alaska and recordings collected from July 2011 through February 2012 (Baumann-Pickering et al. 2012b). Blue whale calls were detected from both the Eastern North

Pacific and Central North Pacific stocks, although calls from the latter were substantially less common. Overall, blue whale calls were detected from the start of HARP deployment in July 2011 through early January 2012, when blue whale calling decreased dramatically (Baumann-Pickering et al. 2012b). The highest number of hours with calls occurred from mid-August until early December, indicating the presence of blue whales in the Study Area from summer through early winter. Blue whale occurrence in the Study Area is considered seasonally likely, primarily from July through December.

4.4 Fin Whale (*Balaenoptera physalus*)

4.4.1 Status and Management

The fin whale is listed as depleted under the MMPA and as 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) a Northeast Pacific stock; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014). Animals from the Northeast Pacific stock are those that are expected to occur in the Study Area.

4.4.2 Abundance

Currently there are no reliable population estimates for the Northeast Pacific stock of fin whales. A minimum estimate for the stock is 1,214, based on surveys west of the Kenai Peninsula which covered only a portion of the stock's range (Allen and Angliss 2014).

Based on sighting data collected during the Navy-funded line-transect survey of the Study Area in April 2009, there were 594 (CV = 0.29) and 889 (CV = 0.57) fin whales in the inshore and offshore stratums, respectively (Rone et al. 2009). Data collected during line-transect surveys in shelf and nearshore waters from the Kenai Fjords in the Gulf of Alaska to the central Aleutian Islands during July and August 2001, 2002, and 2003 suggest that fin whale populations in the Gulf of Alaska are increasing (Zerbini et al. 2006). During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area. Abundance estimates for unidentified large whales were pro-rated among blue, fin, and humpback whales within each stratum and proportionally incorporated into each species density estimate, resulting in the following abundance estimates for fin whales: 1,610 (CV = 0.49) inshore stratum, 1,265 (CV = 0.27) offshore stratum, 207 (CV = 0.39) seamount stratum, and 499 (CV = 0.21) slope stratum (Rone et al. 2014).

4.4.3 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. 2006; Mizroch et al. 2009). During the summer in the Pacific, fin whales are distributed from the southern Chukchi Sea (69°N) south to 32°N off the California coast (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. 2009). Location data from whales implanted with markers indicate that fin whales show local site fidelity, move consistently within and between summer feeding grounds (including the Gulf of Alaska), and undertake long migrations between the high-latitude summer grounds and the low-latitude winter grounds (Mizroch et al. 2009).

In previous years, fin whales have been acoustically detected in the Gulf of Alaska year-round, with highest call occurrence rates from August through December and lowest call occurrence rates from February through July (Moore et al. 2006; Stafford et al. 2007). More recently, two Navy-funded HARPs were deployed in the shelf and slope regions of north-central Gulf of Alaska and recordings collected from July 2011 through February 2012 (Baumann-Pickering et al. 2012b). Fin whale calls were recorded at both sites during all months, with a peak in calling from late August until the end of December.

There were 20 on-effort fin whale sightings (56 total animals) during the Navy-funded line-transect survey of the Study Area in April 2009; animals were distributed in both the inshore and offshore strata (Rone et al. 2009). During a 2012 survey in summer and early fall, Matsuoka et al. (2013) reported 149 fin whale sightings of 210 individuals. These sightings were made across both shelf and offshore strata within and adjacent to the Gulf of Alaska. During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area. Abundance estimates for unidentified large whales were prorated among blue, fin, and humpback whales within each stratum and proportionally incorporated into each species density estimate, resulting in the following abundance estimates for fin whales: 1,610 (CV = 0.49) inshore stratum, 1,265 (CV = 0.27) offshore stratum, 207 (CV = 0.39) seamount stratum, and 499 (CV = 0.21) slope stratum (Rone et al. 2014). Fin whale occurrence in the Study Area during the summer time period is considered likely.

4.5 Sei Whale (*Balaenoptera borealis*)

4.5.1 Status and Management

The sei whale is listed as depleted under the MMPA and as 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 2011d). Only a single Eastern North Pacific stock is recognized in the U.S. EEZ of the North Pacific (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).

4.5.2 Abundance

Estimates of sei whale abundance in the eastern North Pacific based on survey data are not available. 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). There are no abundance data specific to the Gulf of Alaska and no data available on current population trends.

4.5.3 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.

Whaling records from the 1900s indicate there were high densities of sei whales in the northwestern and northeastern portions (i.e., near Portlock Bank) of the Gulf of Alaska during May–August (U.S. Department of the Navy 2006). There were no sei whales sighted during the April 2009 survey of the Study Area (Rone et al. 2009). During a 2012 survey in summer and early fall, Matsuoka et al. (2013) reported 87 sei whale sightings of 1,647 individuals. The majority of these sightings were in the offshore waters in the central to southern Gulf of Alaska and adjacent eastern North Pacific south of the Gulf of Alaska. Hakamada and Matsuoka (2014) provided North Pacific sighting data for sei whales collected during surveys from 2010-2012 that included areas within the Gulf of Alaska, including a portion of the Navy's Study Area. There were no sightings of sei whales in the TMAA and all the sightings were south of 53 degrees N latitude, far south of the Navy's Study Area. During the 2013 GOALS II survey, although sei whales were acoustically detected there were no confirmed visual sightings of sei whale (Rone et al. 2014). Sei whale occurrence in the Study Area during the summer time period is considered rare.

4.6 MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*)

4.6.1 STATUS AND MANAGEMENT

The minke whale is protected under the MMPA and is not listed under the ESA. "Resident" minke whales from California to Washington appear behaviorally distinct from migratory whales farther north, so based on this distinction NMFS recognizes two minke whale stocks: (1) a California, Oregon, and Washington stock; and (2) an Alaska stock (Allen and Angliss 2014; Carretta et al. 2014). Animals from the Alaska stock are those that are expected to occur in the Study Area.

4.6.2 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). Data collected during line-transect surveys in shelf and nearshore waters from the Kenai Fjords in the Gulf of Alaska to the central Aleutian Islands during July and August 2001, 2002, and 2003 yielded an abundance estimate of 1,233 (CV = 0.34) for this region (Zerbini et al. 2006); however, this is considered an underestimate since correction factors for animals missed along the trackline were not incorporated.

4.6.3 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).

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).

There were a total of 72 on-effort sightings of minke whales during line-transect surveys in shelf and nearshore waters from the Kenai Fjords in the Gulf of Alaska to the central Aleutian Islands during July and August 2001, 2002, and 2003 (Zerbini et al. 2006). Most of the minke whale sightings from these surveys were in the Aleutian Islands in water depths of less than 200 m (Zerbini et al. 2006). There were two on-effort minke whale sightings (three total animals) during the Navy-funded line-transect survey of the Study Area in April 2009; both sightings were in the inshore stratum (Rone et al. 2009). During a recent (June and July 2013) Navy-funded line-transect survey in and around the Study Area, there were three sightings of six minke whales but only two sightings occurred within the TMAA: one in the slope stratum and one in the seamount stratum (Rone et al. 2014). Minke whales have not been detected on either of the HARPs deployed in the shelf and slope regions of the Study Area, based on recordings collected from July 2011 through February 2012 (Baumann-Pickering et al. 2012b). Minke whale occurrence in the Study Area during the summer time period is considered likely.

4.7 Gray Whale (*Eschrichtius robustus*)

4.7.1 Status and Management

There are currently two formally recognized North Pacific populations of gray whales: the Western North Pacific stock that is critically endangered and shows no apparent signs of recovery, and the Eastern North Pacific stock that appears to have recovered from exploitation and was removed from listing under the ESA in 1994 (Carretta et al. 2014; Swartz et al. 2006). Both populations (stocks) could be present in the Study Area (Mate et al. 2012; Carretta et al. 2014). The Western subpopulation, which was previously also known as the western north Pacific or the Korean-Okhotsk population, has recently been designated the Western North Pacific stock (Carretta et al. 2013). All gray whale populations are protected under the MMPA; the Western North Pacific stock is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species.

A group of approximately 200 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; Carretta et al. 2014; Weller et al. 2013). The group has been identified as far north as Kodiak Island, Alaska (Gosho et al. 2011), and has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al. 2014; Weller et al. 2013). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is demographically distinct from the Eastern North Pacific population (Calambokidis et al. 2010; Mate et al. 2010; Frasier et al. 2011). Currently, however, 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; Weller et al. 2013).

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 sets a quota allowing catch of gray whales annually from the eastern population for aboriginal subsistence. In 2007 the International Whaling Commission approved a 5-year quota (2008 to 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 (International Whaling Commission 2013). In 2013, a total of 127 gray whales were "struck" in subsistence whaling in the aboriginal harvest by Chukotka indigenous hunters from the Russian Federation (Ilyashenko and Zharikov 2014). Alaskan hunters no longer intentionally pursue gray whales, and the United States has not pursued a gray whale catch limit from the International Whaling Commission for Alaska hunters (Norberg 2013).

4.7.2 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). For stock assessment purposes, NMFS currently uses an abundance estimate of 19,126 animals (CV = 0.071; Carretta et al. 2014). The eastern population has increased, despite the 1999 event in which an unusually large number of gray whales stranded along the coast from Mexico to Alaska (Gulland et al. 2005; Carretta et al. 2014).

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

The Western North Pacific 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 to 165 whales; International Union for Conservation of Nature 2012).

4.7.3 DISTRIBUTION

The Eastern North Pacific stock of gray whales migrates along the U.S. west coast as they travel between summer arctic feeding grounds and coastal temperate and subtropical winter mating and calving grounds. Winter grounds extend from central California south along Baja California, the Gulf of California, and the mainland coast of Mexico. Beginning in the fall, whales start the southward migration from the northern summer feeding areas to the winter calving areas, mainly following the coast to Mexico. The trip averages 2 months. 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 (Herzing and Mate 1984; Jones and Swartz 2009).

Most of the Eastern North Pacific stock summers in the shallow waters of the northern Bering Sea, Chukchi Sea, and western Beaufort Sea, but as noted above, the Pacific Coast Feeding Group feeds along the Pacific coast throughout the summer and fall (Calambokidis et al. 2002). Gray whales are found along the shore in the northern Gulf of Alaska during migrations between the breeding and feeding grounds. The southbound migration begins in early October, when gray whales move from the Bering Sea through the Unimak Pass and along the coast of the Gulf of Alaska (Braham 1984). The southbound migration continues into the winter season between October and January. Migration of gray whales past Kodiak Island peaks in mid-December (Rugh et al. 2001). During the northbound migration, the peak of migration in the Gulf of Alaska is in mid-April (Braham 1984). As noted above, although most gray whales migrate to the Bering Sea to feed, some Pacific Coast Feeding Group whales do not complete the migration but feed in coastal waters in the Gulf of Alaska (Gosho et al. 2011).

Most gray whales follow the coast during migration and stay within 1.2 mi. (2 kilometers [km]) of the shoreline, except when crossing major bays, straits, and inlets from southeastern Alaska to the eastern

Bering Sea (Braham 1984). However, gray whales are known to move farther offshore between the entrance to Prince William Sound and Kodiak Island and between Kodiak Island and the southern part of the Alaska Peninsula (Consiglieri et al. 1982). Gray whales use the nearshore areas of the Alaska Peninsula during the spring and fall migrations and are often found within the bays and lagoons, primarily north of the peninsula, during the summer (U.S. Department of the Navy 2006). During the 2009 April survey of the Study Area, one group of two gray whales was sighted while on-effort within the Study Area (Rone et al. 2009). Outside of the TMAA, there was one off-effort sighting (25 individuals) southeast of Kodiak Island during the recent (June and July 2013) GOALS II survey of the central Gulf of Alaska (Rone et al. 2014).

Gray whale calls were detected during a single hour on a single day, 29 September 2012, at the HARP deployed in the slope region of north-central Gulf of Alaska (Baumann-Pickering et al. 2012b). Since gray whales tend to stay close to shore during their migration, the HARP deployment locations are likely too far offshore to capture more gray whale signals (Baumann-Pickering et al. 2012b). The occurrence of Eastern North Pacific gray whales in the Study Area during the summer time period is considered likely.

The migration routes of the Western North Pacific population of gray whale are poorly known (Weller et al. 2002). Previous sighting data suggested that the remaining population of gray whales in the western Pacific had a limited range extending 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 Island 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). The occurrence of Western North Pacific gray whales in the Study Area during the summer time period is considered rare.

4.8 Sperm Whale (*Physeter macrocephalus*)

4.8.1 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 managed as three stocks in the Pacific: (1) the Alaska/North Pacific stock; (2) the California, Oregon, and Washington stock; and (3) the Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014). Animals from the Alaska/North Pacific stock are those that are expected to occur in the Study Area.

4.8.2 Abundance

Currently there is no reliable abundance estimate for the Alaska/North Pacific stock of sperm whales and the number of animals occurring within Alaska waters is unknown (Allen and Angliss 2014). The number of sperm whales within the eastern temperate North Pacific was estimated at 26,300 (CV = 0.81) from visual surveys and 32,100 (CV = 0.36) from acoustic detections (Barlow and Taylor 2005). During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area. Based on acoustic detections collected during the survey, the following abundance estimates were derived for sperm whales: 112 (CV = 0.24) offshore stratum, 80 (CV = 0.48) seamount

stratum, and 132 (CV = 0.16) slope stratum (Rone et al. 2014). There were no sperm whale sightings or acoustic detections within the inshore stratum.

4.8.3 DISTRIBUTION

In the North Pacific, sperm whales appear to be nomadic, showing widespread movements between areas of concentration, and this suggests there are no divisions that would represent separate stocks (Mizroch and Rice 2013). Male sperm whales are found from tropical to polar waters in all oceans of the world, between approximately 70°N and 70°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 (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). Off the U.S. west coast, their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters (Becker et al. 2012b; Forney et al. 2012).

Summer surveys between 2001 and 2010 in the coastal waters around the central and western Aleutian Islands have found sperm whales to be the most frequently sighted large cetacean (Angliss and Allen 2014). Acoustic surveys have detected the presence of sperm whales year-round in the Gulf of Alaska, although about twice as many are present in summer as in winter (Mellinger et al. 2004; Moore et al. 2006). Sperm whale echolocation clicks were detected by two HARPs deployed in the shelf and slope region of north-central Gulf of Alaska in July 2011; however, there were much higher detection rates at the deeper site (Baumann-Pickering et al. 2012b). In contrast to the findings of Mellinger et al. (2004), Baumann-Pickering et al. (2012) found high numbers of sperm whale detections in November and December, with a drop off to low numbers of detections throughout January and February. During the 2009 April survey of the Study Area, there were no sperm whale sightings, but they were acoustically detected on 28 different occasions (Rone et al. 2009). During a 2012 survey in summer and early fall, Matsuoka et al (2013) reported 50 sightings of 57 individual sperm whales. All sightings were of large male sperm whales and distributed on the shelf and offshore waters of the Gulf of Alaska and adjacent areas of the eastern North Pacific. As noted above, during the 2013 GOALS II survey there were 19 sightings of sperm whales totaling 22 individuals and sperm whales were acoustically detected from the towed hydrophone array on 241 occasions (Rone et al. 2014). Sperm whale occurrence in the Study Area during the summer time period is considered likely.

4.9 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; Pilot et al. 2009; Morin et al. 2010). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits (Morin et al. 2010). In the North Pacific, these recognizable geographic forms are variously known as ''residents,'' ''transients," and "offshore" ecotypes (Hoelzel et al. 2007).

4.9.1 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 as endangered under the ESA. The AT1 Transient stock of killer whales is also designated as depleted under the MMPA but is not listed under the ESA; this stock's current abundance estimate is seven animals (Allen and Angliss 2014), and extinction appears likely for this population (Matkin et al. 2012). 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 (Washington state through part of southeastern Alaska); (5) the West Coast Transient stock (California through southeastern Alaska); (6) the Eastern North Pacific Offshore stock (California to Alaska); (7) the Southern Resident stock (mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from Southeast Alaska through California); and (8) the Hawaii stock (Allen and Angliss 2014; Carretta et al. 2014). Killer whales most likely to occur in the Study Area based on dominant distribution patterns include the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock and the Alaska Resident stock; while whales from the AT1 Transient stock and the Eastern North Pacific Offshore stock could also occur in the Study Area, occurrence is considered rare and infrequent, respectively.

4.9.2 ABUNDANCE

The current best available abundance estimates for the four killer whale stocks that occur or rarely occur in the Study Area are as follows: Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock = 587 animals; the AT1 Transient stock = 7 animals; Alaska Resident stock = 2,347 animals (Allen and Angliss 2014); and the Eastern North Pacific Offshore stock = 211 animals (Carretta et al. 2014). The estimate for the Eastern North Pacific Offshore stock reflects the number of offshore killer whales that occur along the U.S. west coast, Canada, and Alaska; since this is a trans-boundary stock, an abundance estimate specific to Alaska waters is not available (Carretta et al. 2014).

Line-transect surveys conducted in coastal waters of the Gulf of Alaska and Aleutian Islands in July and August 2001, 2002, and 2003 yielded a total of 41 on-effort sightings of killer whales (Zerbini et al. 2007). Sighting data from these surveys were used to derive abundance estimates for the different killer whale ecotypes. The abundance estimate for resident killer whales was 991 (CV = 0.52) and for transients was 200 (CV = 0.48). There were insufficient data (a total of two sightings) to estimate abundance for the offshore ecotype (Zerbini et al. 2007). These estimates were based on ecotype and were not necessarily directly applicable to the different stocks occurring in the Study Area, since ecotype estimates could include members from different stocks (e.g., as noted above, at least four different stocks of transient killer whales may occur in the Study Area during the summer time period During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area, and resulted in the following abundance estimates for killer whales: 117 (CV = 0.60) inshore stratum, 107 (CV = 0.77) seamount stratum, and 726 (CV = 1.93) slope stratum (Rone et al. 2014).

4.9.3 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). 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.

Sightings of killer whales are widely distributed, mostly occurring in waters over the continental shelf, but also quite frequently in offshore waters. Based on sightings, strandings, and acoustic detections, all three killer whale ecotypes (residents, transients, and offshore) are known to occur in the Gulf of Alaska (Forney and Wade 2006; Zerbini et al. 2007; Dahlheim et al. 2008; Barbieri et al. 2013). Individuals belonging to the Alaska Resident stock and the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock are the killer whales most likely to occur in the Study Area (Allen and Angliss 2014). The range of the Alaska Resident stock extends across the Gulf of Alaska from Southeast Alaska to the Aleutian Islands, and into the Bering Sea. The Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock has a range that includes all of the U.S. EEZ in Alaska, although sightings in Southeast Alaska are uncommon (Allen and Angliss 2014).

AT1 transients are seen primarily in Prince William Sound and in the Kenai Fjords region, and given their limited numbers and more limited distribution, are less likely to occur in the Study Area (Matkin et al. 2012). Eastern North Pacific Offshore killer whales are most commonly sighted off the coasts of California and Oregon, and less frequently in Southeast Alaska (Carretta et al. 2014), but have been identified in the western Gulf of Alaska near Kodiak Island (Dahlheim et al. 2008; Zerbini et al. 2007). Based on sightings of killer whales along the U.S. west coast and Alaska from 1976 to 2006, only 59 sightings of offshore killer whales have been documented, and of these, 40 have occurred off California (Dahlheim et al. 2008).

During the April 2009 survey of the Study Area, six groups of killer whales totaling 119 animals were sighted, and there were an additional 16 acoustic detections (Rone et al. 2009). During a 2012 survey in summer and early fall, Matsuoka et al. (2013) reported only 17 sightings of 99 killer whales although ecotype was unknown. Sightings were made on the near shore shelf, within the TMAA, and in the very southern part of the Gulf of Alaska south through the eastern North Pacific. In the 2013 GOALS II survey, killer whales were sighted visually and acoustically detected on both sonobuoys and the towed-hydrophone array (Rone et al. 2014). Killer whales were detected at both HARPs deployed in the shelf and slope region of north-central Gulf of Alaska (Baumann-Pickering et al. 2012b). Based on the analysis of recordings from July 2011 through early January 2012, peak presence was during mid-July and mid-August, with sporadic detections during the rest of the recording period. Initial evaluation indicates that the burst pulses and whistles most likely were generated from the resident ecotype, but further investigation is required for confirmation (Baumann-Pickering et al. 2012b). Killer whale occurrence in the Study Area during the summer time period is considered likely.

4.10 Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)

4.10.1 Status and Management

The Pacific white-sided dolphin is protected under the MMPA and 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 analyses suggest the 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: (1) in the offshore waters of Baja California, (2) in the offshore waters of California to Oregon, (3) offshore of British Columbia and Alaska, and (4) 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 in the field. Thus, populations occurring in the U.S. Pacific EEZ are managed by NMFS as the two stocks noted above. Animals from the Alaska/North Pacific stock are those that are expected to occur in the Study Area.

4.10.2 Abundance

There is currently no reliable population estimate for the Alaska/North Pacific stock of Pacific white-sided dolphins (Allen and Angliss 2014). However, based on sighting data collected from surveys north of 45°N from 1987 to 1990, an abundance estimate specific to the Gulf of Alaska is 26,880 animals (Allen and Angliss 2014). There were no Pacific white-sided dolphin sightings during a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA (Rone et al. 2014).

4.10.3 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).

Pacific white-sided dolphins occur regularly year-round throughout the Gulf of Alaska, with peak abundance between July and August (U.S. Department of the Navy 2006). Cetacean surveys near Kenai Peninsula, within Prince William Sound and around Kodiak Island in summer 2003, reported sighting two large groups (an average group size of 56) just off Kenai Peninsula (Waite 2003). During the April 2009 survey of the Study Area, Pacific white-sided dolphins were sighted only once (a group of 60 individuals), although the location of the sighting was outside the Study Area and inside the shelf break to the southeast of Kodiak Island (Rone et al. 2009). Pacific white-sided dolphin clicks were not detected during passive acoustic monitoring from two HARPs deployed in the shelf and slope region of north-central Gulf of Alaska from July 2011 to January 2012 (Baumann-Pickering et al. 2012b). There were no Pacific white-sided dolphin sightings during a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA (Rone et al. 2014). Pacific white-sided dolphin occurrence in the Study Area during the summer time period is considered likely.

4.11 Harbor Porpoise (*Phocoena phocoena*)

4.11.1 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, six off the U.S. west coast (Carretta et al. 2014) and three off Alaska: (1) a Bering Sea stock, occurring throughout the Aleutian Islands and waters north of Unimak Pass; (2) a Gulf of Alaska stock, occurring from Cape Suckling to Unimak Pass; and (3) a Southeast Alaska stock, occurring from the northern border of British Columbia to Cape Suckling (Allen and Angliss 2014). Harbor porpoise from both the Gulf of Alaska and southeast Alaska stocks may occur in the Study Area. For the Gulf of Alaska stock, the estimated minimum annual mortality rate incidental to U. S. commercial fisheries is 71.4 harbor porpoises (Allen and Angliss 2014).

4.11.2 ABUNDANCE

The most recent abundance estimates for harbor porpoise stocks that may occur in the Study Area are as follows: Gulf of Alaska stock = 31,046 individuals (CV = 0.21) and Southeast Alaska stock = 11,146 individuals (CV = 0.24; Allen and Angliss 2014). These estimates were derived from aerial survey data collected in summer 1997 in Southeast Alaska and 1998 in the Gulf of Alaska and include correction factors for both perception and availability bias (Hobbs and Waite 2010).

4.11.3 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; Hobbs and Waite 2010).

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 the Gulf of Alaska and occur most frequently in waters less than 328 ft. (100 m) deep (Hobbs and Waite 2010). The majority of the Study Area is offshore and beyond the normal habitat range for harbor porpoise. During the April 2009 survey of the Study Area, there were 30 harbor porpoise sightings (a total of 89 individuals); however, only one of the sightings was within the Study Area and in one of the shallowest regions (Rone et al. 2009). The remaining sightings were in shallow waters south of Kodiak Island and the Alaska Peninsula. During the recent (June and July 2013) survey of the Study Area, there were a total of eight harbor porpoise sightings in the inshore stratum and on the shelf in the slope stratum (Rone et al. 2014). Harbor porpoise occurrence in the nearshore areas of the Study Area during the summer time period is considered likely.

4.12 DALL'S PORPOISE (*PHOCOENOIDES DALLI*)

4.12.1 STATUS AND MANAGEMENT

Dall's porpoise 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). Dall's porpoise from the Alaska stock occur in the Study Area.

4.12.2 ABUNDANCE

Dall's porpoises are very abundant, probably one of the most abundant small cetaceans in the cooler waters of the North Pacific Ocean. However, population structure within North American waters has not been well studied. The estimate for the Alaska stock of Dall's porpoise reported in the 2011 SAR was 83,400 animals (CV = 0.97), corrected for vessel attraction behavior (Allen and Angliss 2012). This estimate is now considered unreliable since it is based on survey data that are more than 21 years old (Allen and Angliss 2014). During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area, and resulted in the following abundance estimates for Dall's porpoise: 4,873 (CV = 0.50) inshore stratum,1,658 (CV = 0.52) offshore stratum, 486 (CV = 0.41) seamount stratum, and 4,907 (CV = 0.36) slope stratum (Rone et al. 2014).

4.12.3 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; Becker et al. 2012b; Forney et al. 2012).

Fiscus et al. (1976) suggested that Dall's porpoise was probably the most common cetacean from the northeast Gulf of Alaska to Kodiak Island. During an August 1994 line-transect survey south of the Aleutian Islands, there were 151 sightings of Dall's porpoise, comprising 59 percent of all cetacean sightings (Forney and Brownell 1996). The region covered by this survey abuts the Study Area, extending between Kodiak Island to the west and covering waters over the continental shelf, the Aleutian Trench, and the northern portion of the abyssal plains of the Gulf of Alaska. Dall's porpoise sightings were widespread across this survey region, occurring in all water depths (Forney and Brownell 1996).

A large-scale, inter-disciplinary monitoring program for the North Pacific Ocean and the southern Bering Sea, conducted seasonally from June 2002 through October 2004, included surveys of marine birds and mammals. The cruises followed a survey track from British Columbia, Canada to Hokkaido, Japan, crossing the Gulf of Alaska between roughly 51°N and 55°N (Sydeman et al. 2004). On six separate crossings, covering all seasons, Dall's porpoise was the most frequently sighted marine mammal, accounting for 48 to 76 percent of the sightings on each cruise, and occurring in waters of all depths (Sydeman et al. 2004).

During the April 2009 survey in the Study Area, 10 groups of Dall's porpoise were sighted, totaling 59 individuals in both inshore and offshore strata (Rone et al. 2009). During a 2012 survey in summer and early fall (Matsuoka et al 2013), Dall's porpoise was the most commonly seen dolphin/porpoise species with 132 sightings of 636 individual. Sightings occurred throughout their survey area and included shelf and offshore water within and adjacent to the Gulf of Alaska. During the 2013 GOALS II survey, there were 320 on-effort sightings of Dall's porpoise totaling 859 individuals (Rone et al. 2014). Unidentified porpoise echolocation clicks, likely Dall's porpoise, were detected at the HARP deployed in the shelf region of north-central Gulf of Alaska (Baumann-Pickering et al. 2012b). The clicks were detected in low numbers from the start of deployment in mid-July 2011 through August 2011. There was a gap in detections until October 2011, when clicks were detected in high numbers, with decreased detections in early November 2011 followed by another gap through early February 2012 (Baumann-Pickering et al. 2012b). Seasonal movements of Dall's porpoise in the Gulf of Alaska are largely unknown. Dall's porpoise occurrence in the Study Area during the summer time period is considered likely.

4.13 CUVIER'S BEAKED WHALE (*ZIPHIUS CAVIROSTRIS*)

4.13.1 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). Cuvier's beaked whales in the Study Area are assumed to be from the Alaska stock.

4.13.2 Abundance

There is currently no reliable abundance estimate for the Alaska stock of Cuvier's beaked whale (Allen and Angliss 2014).

4.13.3 Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Pitman et al. 1988; Barlow and Gisiner 2006; Ferguson et al. 2006b; Jefferson et al. 2008;). A single population likely exists in offshore waters of the eastern North Pacific, ranging from Alaska south to Mexico, and there are no apparent seasonal changes in distribution (Pitman et al. 1988; Mead 1989; Carretta et al. 2014). Little is known about potential migration. 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).

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 3,280 ft. (1,000 m) (Jefferson et al. 2008; Falcone et al. 2009). 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). Rice and Wolman (1982) observed a group of six Cuvier's beaked whales in deep waters of approximately 17,716 ft. (5,400 m) southeast of Kodiak Island. During surveys off the Aleutian Islands in August 1994, Forney and Brownell (1996) made one sighting of Cuvier's beaked whale in waters with a bottom depth of 13,123–16,404 ft. (4,000–5,000 m). Waite (2003) reported one sighting of a group of four Cuvier's beaked whales at the shelf break within the Study Area.

There were no beaked whales detected acoustically or visually during the April 2009 survey of the Study Area (Rone et al. 2009). Cuvier's beaked whales were detected only three times during passive acoustic monitoring from the HARP deployed in the slope region of north-central Gulf of Alaska from July 2011 to February 2012 (Baumann-Pickering et al. 2012b). Acoustic detections were made in October 2011 and January and February 2012. All detections were made at the passive acoustic recording site deployed in the slope region, consistent with this species apparent preference for deep waters (Baumann-Pickering et al. 2012b). During the recent (June and July 2013) survey of the Study Area, one individual Cuvier's beaked whale was identified in the offshore stratum, although there were five additional sightings of unidentified beaked whales (Rone et al. 2014). Cuvier's beaked whale occurrence in the Study Area during the summer time period is considered likely.

4.14 Baird's Beaked Whale (*Berardius bairdii*)

4.14.1 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 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). Baird's beaked whales in the Study Area are assumed to be from the Alaska stock.

4.14.2 Abundance

There is currently no reliable abundance estimate for the Alaska stock of Baird's beaked whale (Allen and Angliss 2014).

4.14.3 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 throughout 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). In the North Pacific, the range of Baird's beaked whale extends from Cape Navarin (62°N) and the central Sea of Okhotsk (57°N) to St. Matthew Island, the Pribilof Islands in the Bering Sea, and the northern Gulf of Alaska (Rice 1998; Kasuya 2009; Allen and Angliss 2014).

During surveys off the Aleutian Islands in August 1994, Forney and Brownell (1996) made one sighting of Baird's beaked whale, in waters with a bottom depth of 13,123–16,404 ft. (4,000–5,000 m). Waite (2003) reported a group of four Baird's beaked whales at the shelf break to the east of the Study Area. There were no beaked whales detected acoustically or visually during the April 2009 survey of the Study Area (Rone et al. 2009). Baird's beaked whales were detected regularly from September through February during passive acoustic monitoring from the HARP deployed in the slope region of north-central Gulf of Alaska from July 2011 to February 2012 (Baumann-Pickering et al. 2012b). Higher numbers of detections occurred during November 2011 through January 2012. Acoustic detections were not made at the passive acoustic recording site deployed in the shelf region, consistent with this species apparent preference for deep waters (Baumann-Pickering et al. 2012b). During the recent (June and July 2013) survey of the Study Area, there were six on-effort Baird's beaked whale sightings of a total of 49 individuals (Rone et al. 2014). Baird's beaked whale occurrence in the Study Area during the summer time period is considered likely.

4.15 STEJNEGER'S BEAKED WHALE (*MESOPLODON STEJNEGERI*)

4.15.1 STATUS AND MANAGEMENT

Stejneger's beaked whale is protected under the MMPA but is not listed under the ESA. In the Study Area, Stejneger's beaked whales are recognized as an Alaska stock (Allen and Angliss 2014; Carretta et al. 2014).

4.15.2 ABUNDANCE

There is currently no reliable abundance estimate for the Alaska stock of Stejneger's beaked whale (Allen and Angliss 2014).

4.15.3 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. 2006b; MacLeod and Mitchell 2006; Pitman 2008). They are occasionally reported in waters over the continental shelf (Pitman and Stinchcomb 2002). Stejneger's beaked whale appears to prefer cold temperate and subpolar waters (Loughlin and Perez 1985; MacLeod et al. 2006). This species has been observed in waters ranging in depth from 2,395 to 5,120 ft. (730 to 1,560 m) on the steep slope of the continental shelf (Loughlin and Perez 1985). The farthest south this species has been recorded in the eastern Pacific is Cardiff, California (33°N), but this is considered an extralimital occurrence (Loughlin and Perez 1985; Mead 1989; MacLeod et al. 2006).

Stejneger's beaked whales were detected almost continually during passive acoustic monitoring from the HARP deployed in the slope region of north-central Gulf of Alaska from July 2011 to February 2012 (Baumann-Pickering et al. 2012b). Acoustic detection rates were at a peak in August 2011 and occurred at a gradual decrease until February 2012 (Baumann-Pickering et al. 2014). Acoustic detections were not made at the passive acoustic recording site deployed in the shelf region, consistent with this species apparent preference for deep waters (Baumann-Pickering et al. 2012b). No Stejneger's beaked whales were identified during the recent (June and July 2013) survey of the Study Area, although five unidentified beaked whale sightings were reported (Rone et al. 2014). Stejneger's beaked whale occurrence in the Study Area during the summer time period is considered likely.

4.16 Steller Sea Lion (*Eumetopias jubatus*)

4.16.1 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); and (2) the Eastern U.S. stock, consisting of populations east of Cape Suckling, Alaska. Both stocks of Steller sea lions occur within the Study Area (Jemison et al. 2013). The Western U.S. stock of Steller sea lions is listed as depleted under the MMPA and endangered under the ESA. The Eastern U.S. stock of Steller sea lions is listed as depleted under the MMPA. In October 2013, NMFS removed the eastern distinct population segment (DPS) (the eastern U.S. stock) of Steller sea lion from the List of Endangered and Threatened Wildlife because they had met the recovery criteria (National Oceanic and Atmospheric Administration 2013). There is "strong evidence" that western stock females have permanently emigrated to the east of 144°W as well as evidence of males mixing between the two stocks and making long distance movements (Jemison et al. 2013; see also Allen and Angliss 2014 regarding unpublished data documenting mixing of these stocks).

For Alaskan waters, critical habitat has been defined for Steller sea lions in the Aleutian Islands and Western Alaska. At this time, there has been no change in the designation of critical habitat despite the recent delisting of the eastern DPS (National Oceanic and Atmospheric Administration 2013). There is no Steller sea lion critical habitat present in the Study Area; as a conservation measure, the TMAA boundary was specifically drawn to exclude any nearby critical habitat and associated terrestrial, air, or aquatic zones.

For the Western U.S. stock, the minimum estimated mortality rate incidental to U. S. commercial fisheries is 29.6 sea lions per year and the mean annual subsistence harvest is estimated at 199 of Steller sea lions per year (Allen and Angliss 2014). For the Eastern U.S. stock, the minimum estimated mortality rate incidental to U. S. and Canadian commercial fisheries is 49 sea lions per year and the mean annual subsistence harvest is estimated at 12 of Steller sea lions per year (Allen and Angliss 2014).

4.16.2 Abundance

The most recent comprehensive estimate (pups and non-pups) of abundance of the western stock of Steller sea lions in Alaska is based on aerial surveys of non-pups conducted in June–July 2008–2011 and aerial and ground-based pup counts conducted in June–July 2009–2011 (Allen and Angliss 2014). The combination of the survey results yielded a minimum abundance estimate of 45,659 Steller sea lions (Allen and Angliss 2014), an increase from the minimum estimate of 38,988 individuals reported in the 2009 GOA Final EIS/OEIS (as reported in the 2008 SAR; Angliss and Allen 2009).

The most recent minimum population estimate of abundance of the eastern stock of Steller sea lions is 52,966 individuals (Allen and Angliss 2014), with approximately half of the individuals being reported at southeast Alaska trend sites (the rest being counted at trend sites in British Columbia, Washington, Oregon, and California). Counts of Steller sea lion pups from 2005 to 2011 indicate an upward trend in number of pups counted, with 9,950 pups reported in 2005 and 11,547 pups counted in 2011 (DeMaster 2011). Between 1979 and 2009, the Eastern DPS increased at a rate of approximately 4.18 percent per year (NOAA 2013a).

4.16.3 Distribution

Given the wide dispersal of individuals, both the western DPS and eastern DPS may occur in the Study Area (Allen and Angliss 2014). Steller sea lions do not migrate, but they often disperse widely outside of the breeding season. An area of high occurrence extends from the shore to water depths of 273 fathoms (500 m). In the Gulf of Alaska, foraging habitat is primarily shallow, nearshore, and continental shelf waters 4.3–13 nm offshore with a secondary occurrence inshore of the 3,280 ft. (1,000 m) isobath, and a rare occurrence seaward of the 3,280 ft. (1,000 m) isobath. Six groups of Steller sea lions, which totaled 28 individuals, were sighted during the April 2009 survey of the Study Area, in both the inshore and offshore strata (Rone et al. 2009). No Steller sea lions were identified during the recent (June and July 2013) survey of the Study Area, although there were six sightings of unidentified pinnipeds (Rone et al. 2014). Steller sea lion occurrence in the Study Area during the summer time period is considered likely.

4.17 California Sea Lion (*Zalophus californianus*)

4.17.1 Status and Management

The California sea lion is protected under the MMPA and is not listed under the ESA. In the North Pacific, NMFS recognizes a single California sea lion stock, the U.S. stock (Carretta et al. 2014).

4.17.2 Abundance

The estimated abundance of the U.S. stock of California sea lions is 296,750 individuals (Carretta et al. 2014). This number is from counts of animals that were ashore at the four major rookeries in Southern California and at haul-out sites north to the Oregon/California border during the 2008 breeding season. Sea lions that were at sea or were hauled out at other locations were not counted. The general trend for this stock is that the population is growing (Carretta et al. 2014).

Sighting data collected during the Navy-funded line-transect survey of the Study Area in April 2009 did not include any confirmed sightings of California sea lions, although four unidentified pinnipeds were reported (Rone et al. 2009). No California sea lions were identified during the recent (June and July 2013) survey of the Study Area, although there were six sightings of unidentified pinnipeds (Rone et al. 2014).

4.17.3 Distribution

The primary rookeries for California sea lions are located on the California Channel Islands, far to the south of the Study Area. California sea lions appear to be extending their feeding range farther north, and increasing numbers of sightings are recorded in Alaskan waters (Maniscalco et al. 2004), which are positively correlated with the growth of the California sea lion population.

California sea lions have been sighted throughout Alaska from Forrester Island in southeast Alaska to St. Matthews Bay, Prince William Sound, and St. Paul Island in the Bering Sea. Both male and female

California sea lions have been observed as far north as the Pribilof Islands in the Bering Sea in recent years (Maniscalco 2002; U.S. Department of the Navy 2006). The few California sea lions recorded in Alaska usually are observed at Steller sea lion rookeries and haul-out sites, with most sightings recorded between March and May, although they may be found in the Gulf of Alaska throughout the year (Maniscalco et al. 2004; U.S. Department of the Navy 2006). However, between 1973 and 2003, only 52 sightings of California sea lions were reported (Maniscalo et al. 2004). California sea lion occurrence in the Study Area during the summer time period is considered rare.

4.18 Northern Fur Seal (*Callorhinus ursinus*)

4.18.1 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 (Mexico) populations. Animals from the Pribilof Islands are recognized as the Eastern Pacific stock, and those from San Miguel Island are the San Miguel Island stock (Allen and Angliss 2014; Carretta et al. 2014). The Eastern Pacific stock of northern fur seals is listed as depleted under the MMPA and not listed under the ESA. The San Miguel Island stock of northern fur seals is not listed as depleted under the MMPA and not listed under the ESA. Animals from Eastern Pacific stock are the only ones that may occur in the Study Area during the summer time period.

Between 2007 and 2011, there was an annual average of 496 northern fur seals harvested per year in the subsistence harvest and an estimated minimum annual mortality rate of 4.6 fur seals per year incidental to commercial fisheries (Allen and Angliss 2014).

4.18.2 Abundance

The Eastern Pacific stock of northern fur seals includes the Pribilof Island breeding group in the Bering Sea. The most recent population estimate for this stock based on pup counts on Bogoslof Island, on Sea Lion Rock, and on St. Paul and St. George Islands, is 639,545 individuals (Allen and Angliss 2014). During a recent (June and July 2013) Navy-funded line-transect survey in and around the TMAA, sighting data were collected from four survey strata designed to sample the diverse habitat present in the Study Area, and resulted in the following abundance estimates for northern fur seals: 345 (CV = 0.28) inshore stratum, 1,013 (CV = 0.35) offshore stratum, 256 (CV = 0.31) seamount stratum, and 156 (CV = 0.39) slope stratum (Rone et al. 2014).

The most recent population (2011) estimate for the San Miguel Island stock of northern fur seals is 12,368 individuals (Carretta et al. 2014). It is unlikely that individuals of the San Miguel Island stock of northern fur seals would be present in the Study Area.

4.18.3 Distribution

Northern fur seals occur from Southern California north to the Bering Sea and west to the Okhotsk Sea and Honshu Island, Japan (Carretta et al. 2014). They are a coldwater species, and when at sea they are usually sighted in foraging areas along the continental shelf and slope and 38–70 nm from land (Kajimura 1984). The Eastern Pacific stock spends May–November in northern waters and at northern breeding colonies (north of the Gulf of Alaska). There are no rookeries or haul-out sites in the vicinity of the Study Area. In late November, females and young begin to arrive in offshore waters of California, with some animals moving south into continental shelf and slope waters. Adult males from the Eastern Pacific stock generally migrate only as far south as the Gulf of Alaska (Kajimura 1984). Olesiuk (2012) reported that evidence from various sources indicates that juvenile and non-breeding northern fur seal

are virtually ubiquitous throughout the Northeastern Pacific Ocean, albeit in densities lower than at the coastal margins. 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 the Study Area. Northern fur seals were not sighted during the 2009 survey of the Study Area (Rone et al. 2009) but there were 69 on-effort northern fur seal sightings (74 individuals) during the 2013 GOALS II survey (Rone et al. 2014). Northern fur seal occurrence in the Study Area during the summer time period is considered likely.

4.19 Northern Elephant Seal (*Mirounga angustirostris*)

4.19.1 Status and Management

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

4.19.2 Abundance

The California Breeding stock of northern elephant seal has recovered from near extinction in the early 1900s to an estimated 124,000 in 2005 (Carretta et al. 2014). Current census data suggest an increasing population trend, although the population estimate for this stock has not been updated.

4.19.3 Distribution

Northern elephant seals are endemic to the North Pacific Ocean, occurring almost exclusively in the eastern and central North Pacific. Adult males and females segregate while foraging and migrating (Stewart and DeLong 1995). Adult females mostly range east to about 173°W, between the latitudes of 40°N and 45°N, remaining far to the west of the Study Area. In contrast, adult males range further north and east into the Gulf of Alaska and along the Aleutian Islands to between 47°N and 58°N (Stewart and Huber 1993; Stewart and DeLong 1995; Le Boeuf et al. 2000).

Northern elephant seal males regularly occur in the Gulf of Alaska year-round. Adults stay offshore during migration, while juveniles and subadults are often seen along the coasts of Oregon, Washington, and British Columbia. Northern elephant seals were not sighted during the 2009 survey of the Study Area (Rone et al. 2009). This result is not wholly unexpected, as the elephant seal pupping/breeding season occurs from December through March on the rookeries in California and Mexico, and the survey was conducted in April. During the recent (June and July 2013) survey of the Study Area, there were 15 on-effort sightings of northern elephant seals (Rone et al. 2014). Northern elephant seal occurrence in the Study Area during the summer time period is considered likely.

4.20 Harbor Seal (*Phoca vitulina*)

4.20.1 Status and Management

The harbor seal is protected under the MMPA and is not listed under the ESA. NMFS currently recognizes 12 stocks of harbor seals in Alaskan waters (Aleutian Islands, Pribilof Islands, Bristol Bay, N. Kodiak, S. Kodiak, Prince William Sound, Cook Inlet/Shelikof, Glacier Bay/Icy Strait, Lynn Canal/Stephens, Sitka/Chatham, Dixon/Cape Decision, and Clarence Strait) and three additional stocks associated with the Pacific Northwest (Washington Inland Waters stock, Washington and Oregon Coast stock, and California stock). This represents a significant increase in the number of harbor seal stocks from the three stocks (Bering Sea, Gulf of Alaska, and Southeast Alaska) previously recognized in Alaskan waters. The Northern Kodiak, Southern Kodiak, Prince William Sound, Glacier Bay/Icy Strait, Sitka/Chatham, and Dixon/Cape Decision stocks would be considered rare in the inshore waters of the

Study Area, whereas the Aleutian Islands, Pribilof Islands, Bristol Bay, Cook Inlet/Shelikof, Lynn Canal/Stephens, and Clarence Strait stocks would be considered extralimital in the Study Area.

4.20.2 Abundance

The current statewide abundance estimate for Alaskan harbor seals is 152,602 (Allen and Angliss 2014). This is a summation of population estimates from the 12 Alaska stocks from aerial surveys made from 2003 to 2007. The most recent estimates for the individual stocks are: Aleutian Islands (3,579), Pribilof Islands (232), Bristol Bay (18,577), N. Kodiak (4,509), S. Kodiak (11,117), Prince William Sound (31,503), Cook Inlet/Shelikof (22,900), Glacier Bay/Icy Strait (5,042), Lynn Canal/Stephens (8,870), Sitka/Chatham (8,586), Dixon/Cape Decision (14,388), and Clarence Strait (23,289).

4.20.3 Distribution

The harbor seal is one of the most widespread of the pinniped species, distributed from the eastern Baltic Sea, west across the Atlantic and Pacific Oceans to southern Japan, along the coast and offshore islands of the Gulf of Alaska. Harbor seals are coastal animals that primarily occur within 11 nm from shore. In Alaska, harbor seals range from the Dixon Entrance to Kuskokwim Bay, are widely distributed along the coastal Gulf of Alaska (Allen and Angliss 2014), and are also found at haul-out sites on offshore islands. The harbor seal's preferred coastal habitat does not extend into the waters of the Study Area. Studies using satellite tags have documented the movements and home range of harbor seals in the vicinity of the Study Area (Lowry et al. 2001; Small et al. 2005). Although these tagging studies have documented harbor seal movement into deep water (beyond the shelf break) in the Gulf of Alaska, these movements are the exception. One of these exceptions was noted during the April 2009 line-transect survey (Rone et al. 2009), during which two harbors seals were observed. One sighting was along the shelf break west of Kodiak Island, and the other was in the west-central portion of the Study Area, well offshore of the shelf break. No harbor seals were identified during the recent (June and July 2013) survey of the Study Area, although there were six sightings of unidentified pinnipeds (Rone et al. 2014). Harbor seal occurrence in the Study Area during the summer time period is considered likely.

4.21 Ribbon Seal (*Histriophoca fasciata*)

4.21.1 Status and Management

NMFS currently recognizes a single stock of ribbon seal in the north Pacific and Bering Sea, the Alaska stock. The Alaska stock of ribbon seal is not designated as depleted under the MMPA and is not listed as endangered or threatened under the ESA. A petition to list the ribbon seal under the ESA was received by NMFS in late 2007. Following the publication of a finding on that petition (73 Federal Register [FR] 16617), NMFS determined in 2013 that the ribbon seal does not currently warrant listing under the ESA (73 FR 79822). However, the ribbon seal remains designated as a Species of Concern under the ESA, which means that NMFS has some concerns regarding status and threats, but insufficient information is available to indicate a need for listing.

Subsistence harvest data are no longer collected, although the subsistence harvest database previously indicated an annual harvest of 193 ribbon seals per year (Allen and Angliss 2014).

4.21.2 Abundance

Due to a lack of available data, there currently are no reliable abundance estimates for the ribbon seal. However, the overall population size is estimated to be near 200,000 (Boveng et al. 2008), and a provisional estimate of 61,000 ribbon seals (95% CI 35,200-189,300) in the eastern and central Bering

Sea is based on aerial surveys conducted in portions of the Bering Sea in 2003, 2007, and 2008 (Allen and Angliss 2014).

4.21.3 DISTRIBUTION

The distribution of ribbon seals is restricted to the northern North Pacific Ocean and adjoining sub-Arctic and Arctic seas, where they occur most commonly in the Sea of Okhotsk and Bering Sea in the open sea and on pack ice (Boveng et al. 2008). From January to May, adults generally remain with the pack ice of the Bering, Chukchi, and western Beaufort seas, moving with the ice farther south in colder years. Ribbon seals are strongly associated with sea ice during the breeding season (March–June) and are not known to breed on shore. Additional telemetry results presented by Boveng et al. (2008) indicated that outside of the breeding season, ribbon seals disperse widely, from remaining in the Bering Sea to following the seasonal ice to the Bering Strait, Chukchi Sea, or Arctic Basin. Some reported tracks of ribbon seals ventured to the south of the Aleutian Islands, although these were in the minority. Ribbon seals were not observed during the April survey of the Study Area (Rone et al. 2009) or the recent June/July 2013 GOALS II survey (Rone et al. 2014). Ribbon seal occurrence in the Study Area during the summer time period is considered rare.

5 TAKE AUTHORIZATION REQUESTED

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

In this application, the 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 April 2016 through April 2021.

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 activities within the Study Area constitute military readiness activities as that term is defined in PL 107–314 because training activities constitute "training and operations of the Armed Forces that relate to combat." 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 GOA Supplemental EIS/OEIS considered all training activities proposed to occur in the Study Area that have the potential to result in the MMPA-defined take of marine mammals. These activities have not changed since completion of the 2011 GOA Final EIS/OEIS and the receipt of the MMPA LOA and Biological Opinion in May 2011. The acoustic stressors associated with these activities that may result in the inadvertent taking of marine mammals include the following:

- Sonar and other active acoustic sources
- Explosives

Based on new marine mammal density data for the TMAA Study Area (Rone et al. 2014), new impact criteria and thresholds (Finneran and Jenkins 2012), a new modeling method (Marine Species Modeling Team 2014), and results from the monitoring of the proposed training activities in other range complexes, the Navy determined in consultation with NMFS that previous analysis of these acoustic stressors in the 2011 GOA Final EIS/OEIS needed to be supplemented using the new science that has emerged since 2011.

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 (2 exercises occurring over a 7-month period [April–October]) and the summation over a 5-year period (2 exercises occurring over a 7-month period [April–October] for a total of 10 exercises).

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	Explosives	0	0
Level A	Sonar and other active acoustic sources; explosives	5 (Dall's porpoise only as shown in Table 5-2)	25 (Dall's porpoise only as shown in Table 5-2)
Level B	Sonar and other active acoustic sources; explosives	36,522 (Species specific data shown in Table 5-2)	182,610 (Species specific data shown in Table 5-2)

5.1.1 IMPULSIVE AND NON-IMPULSIVE SOURCES

Table 5-2 provides details on the Navy's final take request for training activities by species from the acoustic effects modeling estimates. Derivations of the numbers presented in Table 5-2 are described in more detail within Chapter 6. Level A effects are only predicted to occur for Dall's porpoises. There are no mortalities predicted for any of the proposed training activities.

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

Species	Stock	Annual		5-Year	
		Level B	Level A	Level B	Level A
North Pacific right whale	Eastern North Pacific	7	0	35	0
Humpback whale	Central North Pacific	129	0	645	0
	Western North Pacific	10	0	50	0
Blue whale	Eastern North Pacific	95	0	475	0
	Central North Pacific	0	0	0	0
Fin whale	Northeast Pacific	2,582	0	12,910	0
Sei whale	Eastern North Pacific	13	0	65	0
Minke whale	Alaska	87	0	435	0
Gray whale	Eastern North Pacific	0	0	0	0
	Western North Pacific	0	0	0	0
Sperm whale	North Pacific	197	0	985	0
Killer whale	Alaska Resident	564	0	2,820	0
	Eastern North Pacific Offshore	53	0	265	0
	AT1 Transient	1	0	5	0
	GOA, Aleutian Island, and Bearing Sea Transient	144	0	720	0
Pacific white-sided dolphin	North Pacific	1,963	0	9,815	0
Harbor porpoise	Gulf of Alaska	5,484	0	27,420	0
	Southeast Alaska	1,926	0	9,630	0
Dall's porpoise	Alaska	16,244	5	81,220	25
Cuvier's beaked whale	Alaska	2,544	0	12,720	0
Baird's beaked whale	Alaska	401	0	2,005	0
Stejneger's beaked whale	Alaska	1,153	0	5,765	0
Steller sea lion	Eastern U.S.	671	0	3,355	0
	Western U.S.	572	0	2,860	0
California sea lion	U.S.	5	0	25	0
Northern fur seal	Eastern Pacific-Alaska	1,428	0	7,140	0
Northern elephant seal	California Breeding	245	0	1,225	0
Harbor seal	Aleutian Islands	0	0	0	0
	Pribilof Islands	0	0	0	0
	Bristol Bay	0	0	0	0
	North Kodiak	1	0	5	0
	South Kodiak	1	0	5	0
	Prince William Sound	2	0	10	0
	Cook Inlet/ Shelikof	0	0	0	0
	Glacier Bay/Icy Strait	0	0	0	0
	Lynn Canal/ Stephens	0	0	0	0
	Sitka/ Chatham	0	0	0	0
	Dixon/ Cape Decision	0	0	0	0
	Clarence Strait	0	0	0	0
Ribbon seal	Alaska	0	0	0	0
TOTALS		**36,522**	**5**	**182,610**	**25**

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. The 22 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 serious injury or mortality for the Navy training 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 used off Newfoundland during demolition of an offshore oil rig platform (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 6.3.6, 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 (e.g., 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. 2013). 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 et al. 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 (MFA) sonar (Jepson et al. 2003; Fernández et al. 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).

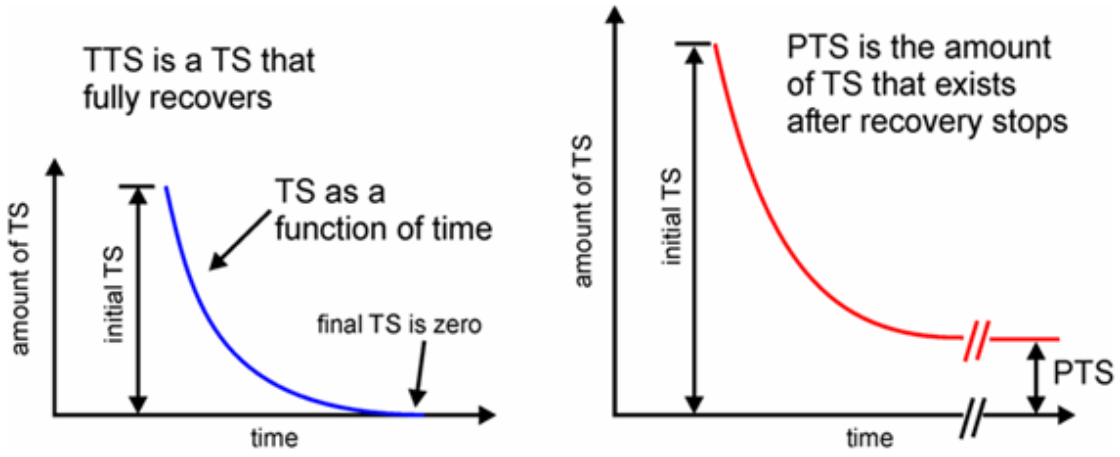
A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possibly arise from the formation of bubbles in 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 or loss of hearing sensitivity. The meaning of the term “hearing loss” does not equate to “deafness.” The type of hearing loss discussed in the analysis of marine mammal impacts is called a

noise-induced threshold shift, or simply a threshold shift (Miller 1974). 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 result is a loss in hearing sensitivity. The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift or loss of sensitivity following a sound exposure. If the threshold shift eventually returns to zero (hearing returns to the pre-exposure "normal"), 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, b). 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 (loss in hearing sensitivity), 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 the Supplemental 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, b; 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.

Loss of hearing sensitivity 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 a loss of hearing sensitivity 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. Melcón 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 MFA sonar (De Ruiter 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" (De Ruiter 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), De Ruiter 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.

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; Noren et al. 2009). For example, in an analysis of energy costs to killer whales, Williams et al. (2009) suggested that whale-watching in the Johnstone Strait (British Columbia, Canada) 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 and/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). De Ruiter et al. (2013b) presented results from two Cuvier's beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the southern California behavioral response study. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA 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 6.3.6 (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 MFA 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 to 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 (see Southall et al. 2007).

Miller et al. (2011, 2014) reported on behavioral responses of pilot whales and killer whales off Norway to a transducer with outputs including the mid-frequency 1-2 kHz and 6-7 kHz ranges (see also Kvadsheim et al. 2011). However, there were methodological issues with the exposure experiment which confound the usefulness of the data. Notably, the sound sources had significant frequency output outside the intended 1-2 kHz and 6-7 kHz ranges, there were additional stressors that may have resulted in reactions including high frequency sources being used to track the whales and the close vessel approaches themselves, and each exposure was treated as independent even though the samples were often collected from the same animal(s) via multiple approaches within a 24-hr period.

Because the two primary sources had output frequencies much broader than characterized (see Fig 4.8 Kvadsheim et al 2011 and Figure 9 Miller et al. 2012), it calls into question the control of the exposures and the reported results. The authors note that "we cannot rule out that the higher source level itself or different patterns of reverberation and/or harmonics, were salient features of the source to which the subject whales were more likely to respond with higher severity levels". It is also unclear from the data if reactions were could have been from the vessel itself, without sonar on, or from additional whale observing boats that were separate from the sonar source vessel. The sample size used to derive their results was very small (4 individual killer whales). The experiments also made use of prolonged, continued, and repeated approaches often to relatively close ranges to killer whale pods. The practice of continually heading towards the target whale (and course correcting to ensure that the source vessel was always heading towards the whale) also confounds the interpretation of the response. The methodology of this study makes implementation of the proposed risk function difficult. Navy vessels do not in training conditions continually adjust their heading to maintain an approach on individual whales. Therefore, the responses interpreted by the authors are a result of conditions that would not occur during Navy training and testing exercises. Using the risk function proposed in Miller et al. (2014) to estimate exposure impacts would likely lead to an inaccurate overestimate of avoidance responses.

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).

6.3.5.2 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.

6.3.5.3 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; Melcón et al. 2012). 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). 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 (see also, Hatch et al. 2012).

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, Melcón 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 2010).

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 a half-mile 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 and/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 have 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.

Williams et al. (2014) reported moderate responses by northern resident killer whales to large ship traffic in Johnstone Strait, Canada. The authors did caveat their work by stating the evaluation of response was highly influenced by a subjective decision about the severity score used to indicate a response.

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 in most cases (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). Guerra et al. (2014) demonstrated that bottlenose dolphins subjected to chronic noise from tour boats responded to "boat noise" by alterations in group structure and in vocal behavior but also found the dolphins reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed.

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). 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.

6.3.5.4 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 and/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).

6.3.5.5 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 et al. 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center (AUTEC) 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.

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; Marine Mammal 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).

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. 2013).

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, 2012b; 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). That training area offshore of San Diego has been used for underwater demolitions training for at least 3 decades without incident. During the 4 March 2011 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) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, the 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. While there are no similar training activities planned for the Study Area, discussions of procedures associated with these and other training and testing events are

presented in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), which details all mitigations.

In comparison to 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). These impacts 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 where training 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.

Establishing a causal link between anthropogenic noise, animal communication, and individual impacts as well as population viability over the long term is difficult to quantify and assess (McGregor et al. 2013, Reed et al. 2014). Reed et al. (2014) for instance reviewed select terrestrial literature on individual and population response to sound as well as discuss a necessary framework in order to assess future direct and indirect fitness impacts. The difficulty with assessing marine behavioral noise effects individually and cumulatively is the confounding nature of the issue where there may or may not be indirect effects with a complex interactive dependence based on age class, prior experience, and behavioral state at the time of exposure, as well as influences by other non-sound related factors (Kight and Swaddle 2011, Ellison et al. 2012, Goldbogen et al. 2013, McGregor et al. 2013, Reed et al. 2014, Williams et al. 2014). McGregor et al. (2013) summarized some studies on sound impacts and described two types of possible effects based on the studies they reviewed: 1) an apparent effect of noise on communication, but with

a link between demonstrated proximate cost and ultimate cost in survival or reproductive success being inferred rather than demonstrated, and 2) studies showing a decrease in population density or diversity in relation to noise, but with a relationship that is usually a correlation, so factors other than noise or its effect on communication might account for the relationship (McGregor et al. 2013). Within the ocean environment, there is a complex interaction of considerations needed in terms of defining cumulative anthropogenic impacts that has to also be considered in context of natural variation and climate change (Boyd and Hutchins 2012). These can include environmental enhancers that improve fitness, additive effects from two or more factors, multiplicity where response from two or more factors is greater than the sum of individual effects, synergism between factors and response, antagonism as a negative feedback between factors, acclimation as a short-term individual response, and adaptation as a long-term population change (Boyd and Hutchins 2012). To address determination of cumulative effects and responses change due to processes such as habituation, tolerance, and sensitization, future experiments over an extended period of time still need further research (Bejder et al. 2009, Blickley et al. 2012, Reed et al 2014).

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 of the National Academies (2005). The Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council of the National Academies 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 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. Other research findings related to the general topic of long-term impacts (De Ruiter et al. 2013b; Goldbogen et al. 2013; Melcón et al. 2012; Moore and Barlow 2013; Claridge 2013; New et al. 2013) are discussed in the following paragraphs.

Regarding long-term impacts on blue whales, Goldbogen et al. (2013) reported on the results of an ongoing Navy-funded behavioral response study in the waters of Southern California (see Southall et al.

2012 for additional details on the behavioral response study). 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." However, research along the U.S. west coast and Baja California reported by Calambokidis et al. (2009b) 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. 2013). 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 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. 2009b; Berman-Kowalewski et al. 2010) of blue whales in the area where sonar use has been occurring for decades. Additionally, although there has not been evidence to suggest an increase in the eastern North Pacific blue whale population, data provided by Monnahan et al. (2014) indicate that population may have recovered near to its estimated pre-whaling size.

Blue whales responded to a mid-frequency sound source at a received sound level up to 160 dB by exhibiting generalized avoidance responses. These included changes to dive behavior, horizontal displacement, orientation, and other metrics (Goldbogen et al. 2013) monitored during CEE. 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 sound 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. Furthermore, the more dramatic reactions reported by Goldbogen et al. (2013) were from non-sonar like signals, a pseudorandom noise that could likely have been a novel signal to blue whales.

Melcón et al. (2012) documented that blue whales decreased the proportion of time spent producing certain types of calls when mid-frequency simulated sonar was present. Melcón et al. (2012) also documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Blue whale feeding/social calls were found to increase when seismic exploration was underway (Di Iorio and Clark 2010), indicative of a potentially compensatory response to the increased noise level. 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 MFA sonar (De Ruiter et al. 2013b). The responses to exposures between species were variable and are indicative of variability in species sensitivity. After hearing each MFA signal, false killer whales were found to have "increase[d] their whistle production rate and made more-MFA-like whistles" (De Ruiter et al. 2013b). 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 Southall et al. 2007 for review), DeRuiter et al. (2013b) found the responses were variable by species and with the context of the sound exposure.

De Ruiter et al. (2013a) also presented results from two Cuvier's beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the Southern California

behavioral response study (note that preliminary results from the same behavioral response study in Southern California waters have been presented for the 2010–2011 field season (Southall 2011). One of the 2011 tagged whales was also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa rms, respectively. Both tagged 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 from 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 stopped foraging when exposed to sonar during British training exercises (Defence Science and Technology Laboratory 2007). In the Bahamas, Blainville's beaked whales located on the range moved off-range during sonar use and returned 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).

The concern with displacements from foraging areas is the displacement is likely to have long-term consequences for an animal or populations. Moore and Barlow (2013) 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. Moore and Barlow (2013) suggest that one reason for the decline in beaked whales from Canada to Mexico may be as a result of anthropogenic sound, including the use of sonar by the U.S. Navy in the fraction of the U.S. Pacific coast overlapped by the SOCAL Range Complex. The Navy trains and tests in the small fraction of that area in Southern California off San Diego. Although Moore and Barlow (2013) have noted a decline in the overall beaked whale population along the Pacific coast, in the small fraction of that area where the Navy has been training and testing with sonar and other systems for decades (the Navy's SOCAL Range Complex), higher densities and long-term residency by individual Cuvier's beaked whales suggest that the decline noted elsewhere is not apparent where Navy sonar use is most intense. Navy sonar training and testing is not conducted along a large part of the US West Coast from which Moore and Barlow (2013) drew their survey data. In Southern California, based on a series of surveys from 2006 to 2008 and a high number encounter rate, Falcone et al. (2009) 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 suggests that Cuvier's beaked whales may have population sub-units with higher than expected residency, particularly in Navy's instrumented Southern California Anti-Submarine Warfare Range. Photo-identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 15 percent having been seen in more than 1 year, and sightings span 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' broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Moore and Barlow (2013) recognized the inconsistency between their hypothesis and the abundance trends in the region of SOCAL Range Complex, stating, "High densities are not obviously consistent with a hypothesis that declines are due to military sonar, but they do not refute the possibility that declines have occurred in these areas (i.e., that densities were previously even higher)." While it is possible that the high densities of beaked whale currently inhabiting the Navy's range were even higher before the Navy began training with sonar, there is no data available to test that hypothesis. Furthermore, the

decline of beaked whales Moore and Barlow (2013) assert for other areas of the US West Coast where the Navy does not conduct sonar training or testing limits the validity of their speculation about the effects of sonar on beaked whale populations.

For over three decades, the ocean west of San Clemente Island 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. It is clear that 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 beaked whales and other marine species (involving visual survey, passive acoustic recordings, and tagging studies) will continue in Southern California to develop additional data towards a clearer understanding of marine mammal abundance trends within the Navy's range complexes (Falcone et al. 2009, Falcone and Schorr 2012, 2013, Hildebrand and McDonald 2009).

Claridge (2013) used photo-recapture methods to estimate population abundance and demographics of Blainville's beaked whale (*Mesoplodon densirostris*) at two study sites in the Bahamas, one of which is regularly used for MFA sonar exercises. Claridge hypothesized that the reason a lower abundance was found at the site located within the bounds of the AUTEC than at the site off Abaco Island is due either to reduced prey availability at AUTEC or due to population level effects from the exposure to mid-frequency active sonar at AUTEC. However, Claridge sampled half as frequently at AUTEC as at Abaco over the 5-year study period (102 versus 235 surveys), with only 20 encounter days at AUTEC from March–October versus 34 at Abaco. The estimated annual abundances at each location (31 [22–42] at AUTEC, 49 [38–62] at Abaco) was almost identical to the number of distinct (and therefore identifiable by photographic identification) individuals observed annually at each site (30 including 1 calf at AUTEC, 48 including 4 calves at Abaco). In fact, in the full 15-year study at Abaco (1997–2011), the estimated annual density was 42, and this population was considered to be part of a larger "parent" population in the area of approximately 135 whales.

All of the resighted whales at both sites were female. This leads to heterogeneity in the capture probability due to an age/sex bias, which can compromise the model fit and lead to negative bias in the estimation of abundances (Claridge 2013). The two study sites were each 300 km^2, an area that is small for known Blainville's beaked whale home ranges, based on tag data (e.g., Schorr et al. 2009). In addition, the population models for both sites were best described as an open population with re-immigration. At Abaco, over the 15-year study, many of the resighted females had sighting gaps of 5–10 years, but most of the animals were only observed in 1 year. This gap in resights is equal to or longer than the duration of the study at AUTEC. These results indicate that there is both temporary and permanent emigration from the population at both sites, and that even over 15 years of research, the entire population (either the "parent" population or the smaller one at Abaco) was not entirely sampled (as indicated by the lack of an asymptote in the discovery curve of individuals from Abaco). In addition, beaked whales at AUTEC are known to leave the area for a few days following sonar activity (McCarthy et al. 2011; Tyack et al. 2011), so depending on the timing of the photo-id surveys, many animals may not have even been present to be sampled. Therefore, while Claridge did find a lower abundance at AUTEC than at Abaco, the results are biased by reduced effort and a shorter overall study period that was not long enough to capture some of the emigration/immigration trends discovered at Abaco. In addition, while Claridge makes no mention of the "parent" population in Chapter 1 while comparing the study sites, she easily attributes the low site fidelity and small population size at Abaco to the larger movement patterns of these whales throughout the area, which could just as easily be done for the population at AUTEC.

Finally, when comparing only the 5-year study period between AUTEC and Abaco, the estimated abundance at Abaco appears to be almost double that of the AUTEC population; however, when the full 15-year dataset at Abaco is presented, the estimated annual abundance is approximately 7 animals fewer (42 compared to 49), which is then only about 11 animals greater than the estimated annual abundance at AUTEC (31). Therefore the presentation of these population abundances as markedly different is questionable, and to attribute the difference largely to the presence of navy sonar without considering ecological factors is poorly supported.

In an effort to understand beaked whale responses to stressors, New et al. (2013) developed a mathematical model simulating a functional link between foraging energetics and requirements for survival and reproductions for 21 species of beaked whale. New et al. (2013) report "reasonable confidence" in their model although approximately 29 percent (6 of 21 beaked whale species modeled) failed to survive or reproduce, which the authors attribute to possible inaccuracies in the underlying parameter values. Based on the model simulation, New et al. (2013) determined that if habitat quality and "accessible energy" (derived from the availability of either plentiful prey or prey with high energy content) are both high, then survival rates are high as well. If these variables are low, then adults may survive but calves will not. The simulations suggested that adults will survive but not reproduce if anthropogenic disturbances resulted in them being displaced to areas of "impaired foraging."

Ecological modeling provides an important tool for exploring the properties of an animal's use of the environment and the factors that drive or contribute to survivorship and reproduction. The ability of any model to accurately predict real ecological processes is partly dictated by the ability of the modeler to correctly parameterize the model and incorporate assumptions that do not violate real-world conditions. Assumptions and parameters identified by New et al. (2013) that likely have a large effect on the model output include the period of reproduction (i.e. inter-calf interval) and prey selection (i.e. energy acquisition). Although New et al. (2013) concluded that anthropogenic disturbances might impair foraging through animal displacement and ultimately impact reproduction, the parameter values need to be revisited, as do assumptions that habitat capable of sustaining a beaked whale is limited in proximity to where any disturbance has occurred (i.e. beaked whales are likely not always in the most optimal foraging location).

While the New et al. (2013) model provides an test case for future research, the model has little of the critical data necessary to form conclusions applicable to current management decisions. There remains significant scientific uncertainty from which to infer modeled impacts to any marine species, especially reclusive beaked whales. For each population and sub-population, critical demographic data gaps still exist (adult survival, calf survival, juvenile survival, annual probability of calving, age at first calving, longevity, and an indication of likely levels of variation between years). The authors note the need for more data on prey species and reproductive parameters including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain. Given this level of uncertainty, the Navy will continue to follow developments in the mathematical modeling of energetics to estimate specific sensitivity to disturbance. The Navy continues to fund the research and monitoring (such as the Behavioral Response Studies in the Bahamas and Southern California) specifically to better understand, via direct field observations, the potential for anthropogenic activities to disturb marine mammals. In cooperation with NMFS, the Navy will continue to develop the most effective management and conservation actions to needed to protect marine mammals while accomplishing the Navy's mission to train and test safely and effectively. The Navy has continued to review emergent science and fund research to better assess the potential impacts that may result from the continuation of ongoing

training and testing in the historically used range complexes worldwide as summarized below in Section 6.3.8 (Summary of Observations During Previous Navy Activities). The Navy's assessment based on that compendium of data is that it is unlikely there would be impacts to populations of marine mammals having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy. This assessment of likelihood is based on four indicators from areas 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.[5]

While there is evidence that shows increases and/or viability of marine mammal populations there is, however, no direct evidence from years of monitoring on Navy ranges that indicate any long-term consequences to marine mammal populations as a result of ongoing training and testing. Barring any evidence to the contrary, therefore, what limited and preliminary evidence there is from the Navy's 80+ monitoring 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 grave impacts and result in countless numbers of marine mammals being injured or killed. Examples to the contrary where the Navy has conducted training and testing activities for decades can be found throughout the scientific literature.

Work by Moore and Barlow (2011) indicate that, since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes offshore waters of the U.S. west coast 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 Schorr (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. 2009b). 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 SOCAL Range Complex) was at the highest count since 1992. Similar findings have also documented the seasonal range expansion and increasing presence of Bryde's whales south of Point Conception in Southern California (Kerosky et al. 2012). For humpback whales that winter in the Hawaiian Islands, research has confirmed that the overall humpback whale population in the North Pacific has continued to increase and is now greater than some prior estimates of prewhaling abundance (Barlow et al. 2011).

The Hawaiian Islands, where the Hawaii Range Complex has been located for decades, continue to function as a critical breeding, calving, and nursing area for this endangered species. In a similar manner, the beaches and shallow water areas within the Pacific Missile Range Facility (PMRF) at Kauai (in the main Hawaiian Islands) continue to be an important haul-out and nursing area for endangered Hawaiian Monk 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

[5] 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 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.

(Littnan 2010). In similar findings and after years of recovery, surveys of harbor seals in Hood Canal, Washington 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 and/or residence of marine mammal individuals and populations would also seem to suggest a lack of long-term or detrimental effects from Navy training and testing historically occurring in the same locations. For example, photographic records spanning more than two decades demonstrated there had been resightings 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 a localized minke whale and found there did not appear to be a significant reaction by the minke whale to the mid-frequency sonar transmissions (although overall minke calling rates were reduced during the training event), and the training activity in general did not appear to affect the presence of other detected species on or near the range. In subsequent analysis of the data set, Manzano-Roth et al. (2013) determined that beaked whales (tentatively identified as Blainville's beaked whales) continued to make foraging dives at estimated distances of 13 to 52 km from active mid-frequency sonar, but that the animals shifted to the southern edge of the range with differences in the dive vocal period duration, and dive rate.

To summarize, while the evidence covers most marine mammal taxonomic suborders (Barlow et al. 2011; Calambokidis et al. 2009b; Falcone et al. 2009; 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), 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 2013), Ketten (2012) has 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 including data developed in the series of more than 80 monitoring reports submitted to NMFS, the Navy believes that long-term consequences for individuals or populations are unlikely to result from Navy training activities in the TMAA Study Area.

6.3.8 SUMMARY OF OBSERVATIONS DURING PREVIOUS NAVY ACTIVITIES

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.

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. The 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.

The majority of the training activities the Navy is proposing for the next 5 years are similar, if not identical, to activities that have been occurring in the TMAA since the early 1990s and in other locations for over 40 years. For example, the mid-frequency sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities.

6.3.8.1 Alaska Specific Monitoring and Research

During the LOA development process for the 2011 GOA Final EIS/OEIS, the Navy and NMFS agreed that monitoring in the Gulf of Alaska should focus on augmenting existing baseline data, since regional data on species occurrence and density are extremely limited. There have been four reports to date covering work in the Gulf of Alaska (U.S. Department of the Navy 2011c, 2011d, 2012, 2013f). Before these reports, there have been no previous dedicated monitoring efforts during Navy training activities in the TMAA with the exception of deployed HARPs. Collecting baseline data was deemed a priority prior to focusing on exercise monitoring and behavioral response as is now being done in other Navy OPAREAs and ranges. Research undertaken by the Navy in the Gulf of Alaska includes the following:

[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.

- Deployment (July 2011) of two long-term bottom-mounted passive acoustic monitoring buoys resulting in over 5,756 hours of passive acoustic data (Baumann-Pickering et al. 2012b, 2013; Debich et al. 2013; U.S. Department of the Navy 2013f)
- An additional passive acoustic monitoring buoy deployed (September 2012) at Pratt Seamount (U.S. Department of the Navy 2013f)
- Two additional passive acoustic monitoring buoys deployed in June 2013 within the TMAA Study Area (U.S. Department of the Navy 2013f)
- Line transect survey (GOALS) conducted by NMFS in April 2009 (see Rone et al. 2010)
- An additional line-transect survey in the TMAA Study Area (GOALS II) in summer 2013 (Rone et al. 2014)

The Navy is committed to structuring the Navy-sponsored research and monitoring program to address both NMFS' regulatory requirements as part of any MMPA authorizations while at the same time making significant contributions to the greater body of marine mammal science (see U.S. Department of the Navy 2013f).

6.3.8.2 Pacific Northwest Cetacean Tagging

A Navy-funded effort in the Pacific Northwest is not programmed, affiliated, or managed as part of the GOA TMAA monitoring, and is a separate regional project, but has provided information on marine mammals and their movements that has application to the Gulf of Alaska. Navy monitoring in the Pacific Northwest is ongoing and involves attaching long-term satellite tracking tags to migrating gray whales off the coast of Oregon and northern California (U.S. Department of the Navy 2013e). This study is being conducted by the University of Oregon and includes tagging of other large whale species such as humpback whales, fin whales, and killer whales.

In one effort 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 remained attached and continued to transmit for approximately 3 months. The tracking data began with the animal as part of a pod off Washington at Grays Harbor Canyon. The whale then traveled a distance of approximately 4,700 nm, which included time spent in the nearshore margins of the TMAA in the Gulf of Alaska where it would be considered part of the Offshore stock (for stock designations, see Allen and Angliss 2014). In a second effort between 2012 and 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 2013b). The Navy's 2013 annual monitoring report for the Northwest Training and Testing Range contains the details of the findings from both research efforts described above (U.S. Department of the Navy 2013e).

6.3.8.3 Monitoring and Research at Pacific Navy Range Complexes

In the Pacific, the vast majority of scientific field work, research, and monitoring efforts have occurred in Southern California and Hawaii where the Navy has historically concentrated training and testing activities. In the TMAA (which is a transient designation), because Major Training Events have been infrequent, are of a short duration, and not supported by nearby Navy installation, the majority of Navy's research effort has been focused elsewhere.

Since 2006 across all Navy Range Complexes (in the Atlantic, Gulf of Mexico, the Pacific, and the Gulf of Alaska), there have been over 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).

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, Aug 2010–Aug 2011
		Marine Mammal Monitoring, 2011 Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, Aug 2010–Feb 2011
		Marine Species Monitoring, Annual Report, 2011
	Keyport Range Complex	Annual Range Complex Exercise Report, Year 1, Apr 2011–Sept 2011
		Annual Range Complex Monitoring Report, Year 1, Apr 2011–Nov 2011
	Northwest Training Range Complex	Annual Range Complex Exercise Report, Year 1, Nov 2010–May 2011
		Annual Range Complex Monitoring Report, Year 1, Nov 2010–May 2011
	Gulf of Alaska	Annual Monitoring Report, 2011, Year 1
		Annual Exercise Report, 17 May 2011–31 Oct 2011
2012	Southern California Range Complex	Annual Range Complex Exercise Report, 2 Aug 2011–1 Aug 2012
		Marine Species Monitoring, 2012 Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 16 Feb 2011–15 Feb 2012
		Marine Species Monitoring, 2012
	Keyport Range Complex	Annual Range Complex Exercise Report, Year 2
		Annual Range Complex Monitoring Report, Year 2
	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 Dec 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 Nov 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

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

A quantitative estimate of effects to marine mammals was conducted for Navy training activities involving use of sonar and other active acoustic sources or explosives introducing sound or energy into the marine environment. To do this, information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions was needed. For the analysis presented in this request for authorization, the Navy has used thresholds and criteria as presented in Finneran and Jenkins (2012) developed in coordination with NMFS. For more general application, NMFS recently proposed *Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals* and accepted comments on those proposed thresholds and criteria up until 13 March 2014. The draft NMFS guidance generally parallels the thresholds and criteria used in the Navy's analysis (Finneran and Jenkins 2012). The Navy, with NMFS as a cooperating agency on the Gulf of Alaska Navy Training Supplemental EIS/OEIS, will monitor development of the draft guidance as it matures and as it applies to improvements in the Navy's approach that may be necessary in the future.

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 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 overestimate the number of animals that could be killed or injured.

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 and only one slight lung injury exposure (to Dall's porpoise) was predicted in the analysis of the modeling resulting from the use of explosives during training in the Study Area.

6.4.1.1 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). No gastrointestinal injuries were predicted in acoustic impact modeling for use of explosives during training in the Study Area.

6.4.1.2 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.

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).

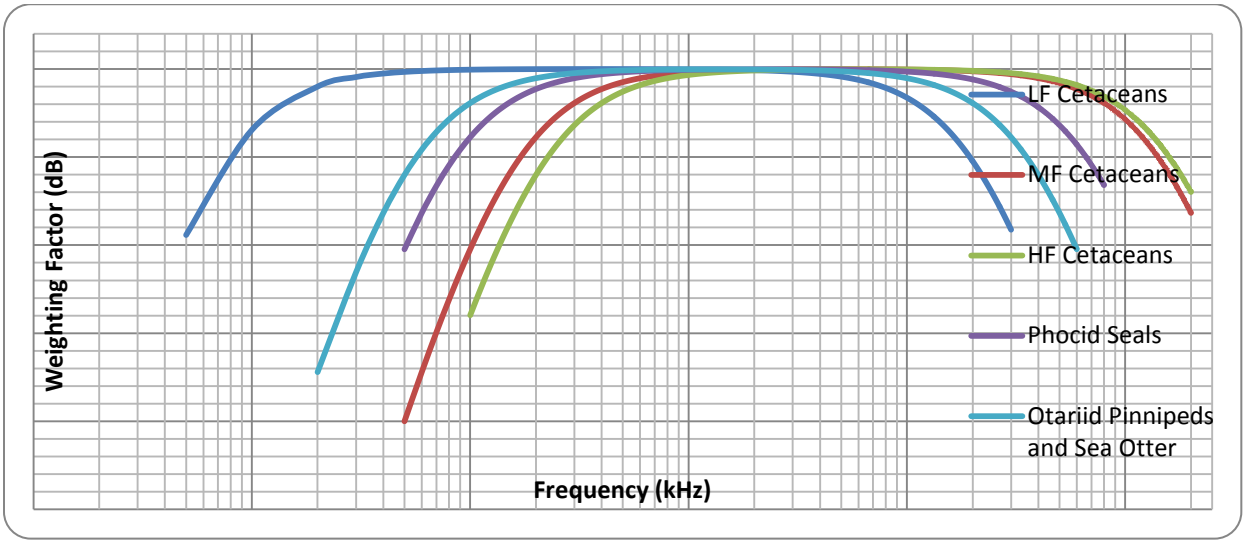


Figure 6-2: Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

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, the Southall et al. (2007) weighting functions (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.

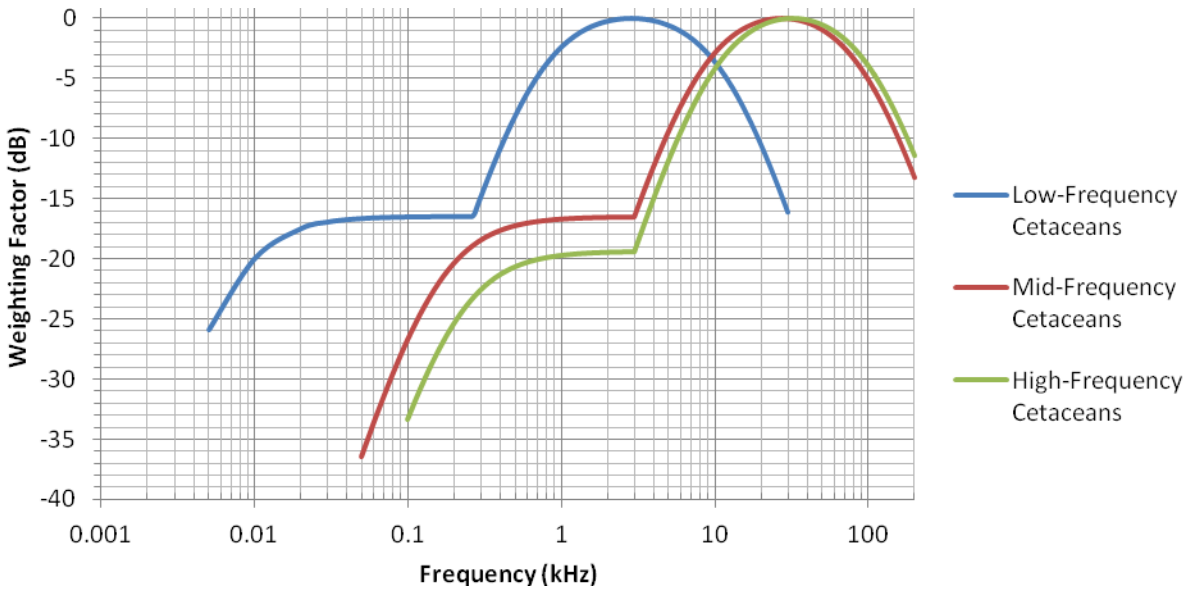


Figure 6-3: New Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans, and Pinniped

6.4.1.3 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.

6.4.1.4 Loss of Hearing Sensitivity – 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.

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

Hearing 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	Dolphins, beaked whales, and 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)	Northern elephant 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 seals	206 dB re 1 μPa^2-s SEL (Type I weighting)	220 dB re 1 μPa^2-s SEL (Type I weighting)

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)

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.

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).

6.4.1.5 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.

Table 6-3: Criteria and Thresholds for Physiological Effects to Marine Mammals Underwater for Explosives

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 μPa^2-s SEL (Type II weighting) or 224 dB re 1 μPa Peak SPL (unweighted)	187 dB re 1 μPa^2-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 μPa^2-s SEL (Type II weighting) or 224 dB re 1 μPa Peak SPL (unweighted)	187 dB re 1 μPa^2-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 μPa^2-s SEL (Type II weighting) or 195 dB re 1 μPa Peak SPL (unweighted)	161 dB re 1 μPa^2-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 μPa^2-s (Type I weighting) or 212 dB re 1 μPa Peak SPL (unweighted)	192 dB re 1 μPa^2-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 μPa^2-s (Type I weighting) or 212 dB re 1 μPa Peak SPL (unweighted)	215 dB re 1 μPa^2-s (Type I weighting) or 218 dB re 1 μPa Peak SPL (unweighted)			

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 1 micropascal, dB re 1 μPa^2-s = decibels referenced to 1 micropascal squared second

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. There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy has 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).

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

6.4.1.6 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 one-third 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).

6.4.1.7 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. As shown in Table 5-2, there are three (total annual) PTS predicted for Dall's porpoise as a result of the use of sonar and other active acoustic sources during Navy training activities.

6.4.1.8 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 6-4, to predict PTS. As shown in Table 5-2, there are two (total annual) PTS predicted for Dall's porpoise as a result of the use of explosives during Navy training activities.

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 be modeled as having a behavioral reaction multiple times over the course of the multi-day Carrier Strike Group exercise.

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; 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).

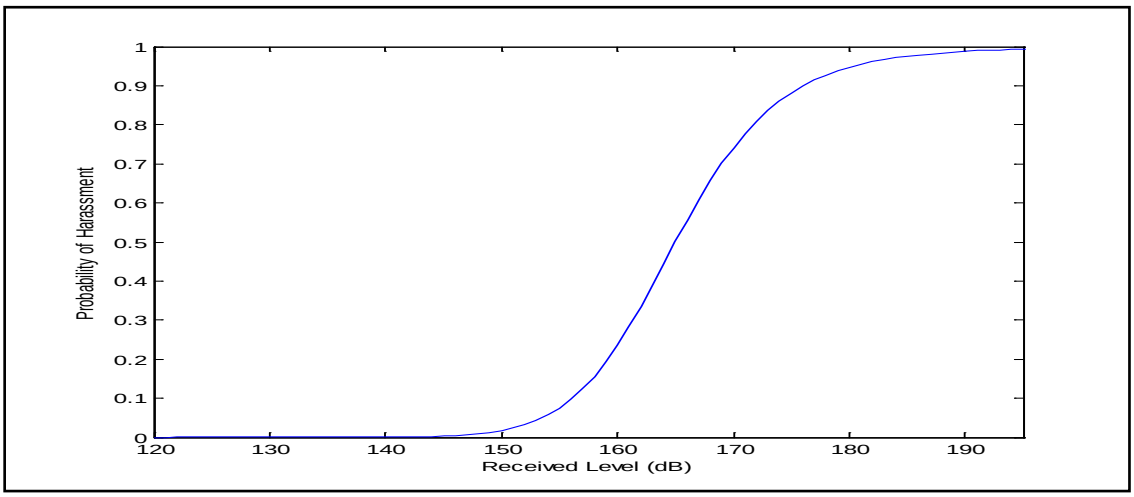


Figure 6-4: Behavioral Response Function Applied to Odontocetes and Pinnipeds

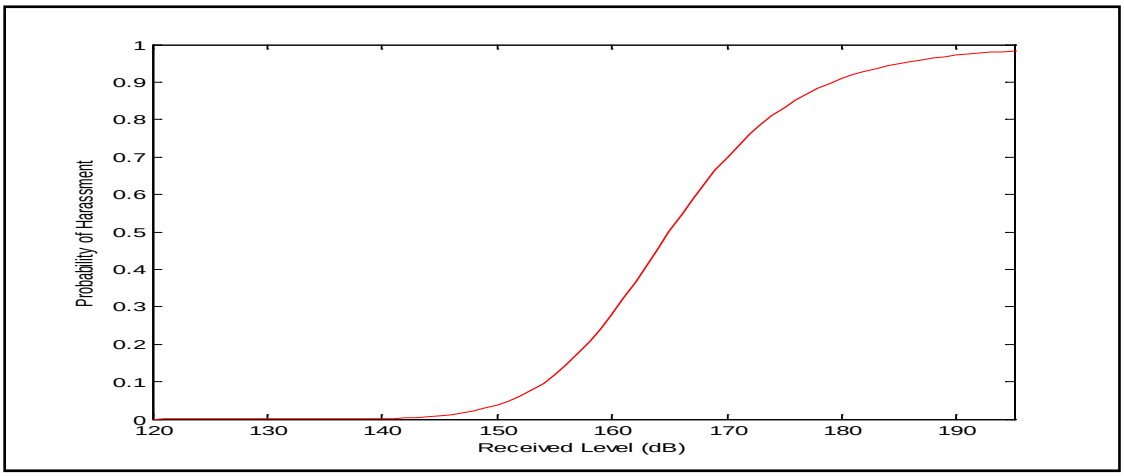


Figure 6-5: Behavioral Response Function Applied to Mysticetes

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 MFA 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 AUTEC 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, De Ruiter 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 MFA sonar at distances of 3.4–9.5 km. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise (approximately 118 km away). Received levels from the MFA 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 AUTEC that analyzed beaked whale responses to actual naval exercises using MFA 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. 2005b) 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 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 (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 (underwater)	172 dB SEL (P_{WI})	177 dB SEL (P_{WI}) or 212 dB Peak SPL
Otariidae (underwater)	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 in water (see Finneran and Jenkins 2012). (2) SEL = re 1 µPa^2-s, SPL = re 1 µPa, SEL = Sound Exposure Level, dB = decibels, 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 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 and 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.

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 received sound 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 at the three science centers (Alaska Fisheries Science Center, Southwest Fisheries Science Center, and Pacific Islands Fisheries Science Center) having species ranges overlapping the TMAA, 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 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 Alaska Region Stock Assessment Report (Allen and Angliss 2014) and Pacific Region Stock Assessment Report (Carretta et al. 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 haul-out sites. For example, for species such as Steller sea lion, population estimates are based on counts of pups at the breeding sites (Allen and Angliss 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 (Allen and Angliss 2014). Population estimates for pinniped species that occur in the TMAA are provided in the Alaska Region Stock Assessment Report (Allen and Angliss 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), and for species such as harbor seal, time of day and tide level. Species-specific foraging ranges from tracking data were also used when available (see Benoit-Bird et al. 2013; Boveng et al. 2008; Robinson et al. 2012; Womble and Gende 2013). These parameters identified from the literature were then 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 the time period of the Proposed Action.

6.5.1.1 Ribbon Seals

There is insufficient information available for the accurate derivation of a density or abundance representing the likely presence of ribbon seals in the Study Area. As presented in Section 4.21 (Ribbon Seal [*Histriophoca fasciata*]), satellite telemetry data presented by Boveng et al. (2008) suggests ribbon seals could be present in the Gulf of Alaska in summer although they would likely be very small in number. Given this, any derived density for the Study Area 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., harbor seal), the Navy has determined possible effects to ribbon seals from Navy training in the Study Area are discountable and a density for the ribbon seal is therefore not required for the impact analyses which follow.

Modeling Effects Prorated by Stock

There are a number of species of marine mammals having more than one overlapping stock in the Study Area (Table 6-5). For species having overlapping stocks in the Study Area, modeling for acoustic effects at the species level was therefore prorated to each stock based on the relative abundance of each stock as shown in Table 6-5.

Table 6-5: Ratios Used to Prorate Modeling Results on Species to Individual Stocks of Marine Mammals in the Study Area

Species Common Name	Stock	Number of Animals in Stock	Total for Species	Ratio of Total Modeled Effects for Species	Rounded Ratio for Prorating Modeled Effects
Humpback whale	Central North Pacific	10,103	11,041	0.915	0.92
	Western North Pacific	938		0.085	0.08
Blue whale	Eastern North Pacific	2,497	2497	Estimate	0.99
	Central North Pacific	Not available		Estimate	0.01
Gray whale	Eastern North Pacific	19,126	19,281	0.992	0.99
	Western North Pacific	155		0.008	0.01
Killer whale	Alaska Resident	2,084	2,854	0.730	0.73
	Offshore	211		0.073	0.08
	AT1 Transient	7		0.002	0.00
	Gulf of Alaska, Aleutian Island, and Bering Sea Transient	552		0.193	0.19
Harbor porpoise	Gulf of Alaska	31,046	42,192	0.736	0.74
	Southeast Alaska	11,146		0.264	0.26
Steller sea lion	Eastern U.S.	52,847	98,763	0.535	0.54
	Western U.S.	45,916		0.465	0.46
Harbor seal	N. Kodiak	4,509	75,145	0.060	0.06
	S. Kodiak	11,117		0.148	0.15
	Prince William Sound	31,503		0.419	0.42
	Glacier Bay/Icy Strait	5,042		0.067	0.07
	Sitka/Chatham	8,586		0.114	0.11
	Dixon/Cape Decision	14,388		0.191	0.19

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 demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 6-6 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 6-6: 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
Phocid seals (underwater)	50	80,000
Otariid pinniped (underwater)	50	60,000

Note: Hz = Hertz

6.5.3 NAVY ACOUSTIC EFFECTS MODEL

For this analysis of training activities at sea, the Navy developed a set of software tools and compiled data for the quantification of predicted acoustic impacts to marine mammals. These databases and tools 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 2014).

The NAEMO improves upon previous modeling efforts (e.g., U.S. Department of the Navy 2008; 2011a) in several ways. First, unlike earlier methods 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, animats (virtual animals) are distributed nonuniformly based on higher resolution species-specific density, depth distribution, 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 worst 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 2014). 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 of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive SPLs greater than or equal to 120 dB re 1 µPa are distributed within the modeling predicted sound energy footprint. 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 2014). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the 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 on nonuniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method, they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the 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 nonuniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were carried out during development of the NAEMO. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures was 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 in use during the Carrier Strike Group exercise. This is done 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 in a manner consistent with the modeled activity. 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.

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 (Au and Moore 1984, Kastelein et al. 2005c; 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, of the 2011 GOA Final EIS/OEIS). 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 6.5.7.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources), 6.5.5 (Marine Mammal Avoidance of Sound Exposures), and Section 6.5.6 (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 6.3 (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 porpoises and beaked whales have been observed to be especially sensitive

to human activity, which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonars and other active acoustic sources. Both finless porpoises (Li et al. 2008) and harbor porpoises (Barlow 1988; Evans et al. 1994; Palka and Hammond 2001; Polacheck and Thorpe 1990) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise, appears to avoid large vessels at about 2,995 ft. (913 m) (Jaramillo-Legorreta et al. 1999). The assumption is that the harbor porpoise would respond similarly to large Navy vessels. Beaked whales have 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 (Section 6.3, Analysis Background and Framework).

Therefore, for certain naval activities preceded 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 a sonar or other active sources and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 6.5.5 (Marine Mammal Avoidance of Sound Exposures).

6.5.6 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone. The NAEMO estimates acoustic effects without taking into account any shutdown or delay of the activity when marine mammals are detected; therefore, the model overestimates impacts to marine mammals within mitigation zones. The post-model analysis considers the potential for 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 Gulf of Alaska Training* (U.S. Department of the Navy 2014b).

Two factors are considered when quantifying the effectiveness of mitigation: (1) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics, and (2) 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. The mitigation zones proposed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the 2011 GOA Final EIS/OEIS encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the acoustic effects analysis when the mitigation zone can be fully or mostly observed up to and during a sound-producing activity. Mitigation for each activity is considered in its entirety, taking into account the different scenarios that may take place as part of that activity (some

scenarios involve different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) was estimated for each training 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 Lookouts to detect marine mammals in or approaching the mitigation zone is the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data was 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.

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 were simply missed by the observer. 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 generally occurs more often 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 that are currently available. The Navy used g(0) values with both perception and availability bias components if that data was 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 represent 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 California or the east coast), 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.[7] 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 (see Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflects the fact that marine mammal surveys are often conducted in less than ideal conditions (see Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., 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 0–2 (Barlow 2003).

Navy training 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 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 such as Navy Carrier Strike Group training in the Gulf of Alaska, events 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., sinking exercise). 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.
- 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 activities involve area-focused events (e.g., ASW tracking exercise), where participants are likely to remain in the same general area during an event. In other cases, Navy training activities are stationary (e.g., use of dipping sonar), which allow Lookouts to focus on the same area

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

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 activity to facilitate implementation of mitigation. The distinctions require careful consideration when comparing the Navy Lookouts to marine mammal surveys.[8]

- 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 are responsible for observing the water for safety of ships and aircraft, during specific training 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 or on watch onboard vessels at the surface 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.

Although there are distinct differences between marine mammal surveys and Navy training, 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 activities.

[8] 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. Additionally, in the TMAA during the proposed mid-summer training, there should be 18–19 hours of daylight. 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 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).

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 (note this will occur less often in the TMAA during the mid-summer training when there should be 18–19 hours of daylight).
- 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 support personnel aboard a boat towing a target or onboard support aircraft), even though information about marine mammal sightings are shared among units participating in the training or activity. In other words, the Navy only quantitatively adjusted the model-predicted effects based on the required number of Lookouts as specified in established mitigation measures.
- The Navy only quantitatively adjusted model-predicted effects within the range to mortality (explosives only) and injury (all sound-producing activities) (see Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures, 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 or other predicted behavioral 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. This sightability factor is then used in post-modeling adjustments to account for the reduced potential for mortality and injury to occur as a result of implemented mitigation. 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 (Table 6-7).

Table 6-7: 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
California Sea Lion, Northern Fur Seal, Steller Sea Lion	Zalophus, Callorhinus, Eumetopias	0.299	0.299
Cuvier's Beaked Whale	Ziphidae	0.23	0.074
Dall's Porpoise	Phocoenidae	0.822	0.221
Gray Whale	Eschrichtiidae	0.921	0.482
Harbor Porpoise	Phocoenidae	0.769	0.292
Harbor Seal, Ribbon Seal	Phoca, Histriophoca	0.281	0.281
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.921	0.95
Minke Whale	Balaenopteridae	0.856	0.386
North Pacific Right Whale	Eubalaena	0.645	0.41
Northern Elephant Seal	Mirounga	0.105	0.105
Pacific White-Sided Dolphin	Delphinidae	0.856	0.67
Sperm Whale	Physeteridae	0.87	0.32
Stejneger's Beaked Whale	Mesoplodon	0.23	0.074

Notes: When there was no value available 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 g(0) for Cuvier's beaked whale was used for Stejneger's beaked whale given there is no data available for Stejneger's. The published California Sea Lion aircraft g(0) is used for Steller Sea Lion and Northern Fur Seal since all are in the otariidae family and there is no g(0) data for these other species. The published Harbor Seal aircraft g(0) is used for Ribbon Seal since they are in the phocid family and there is no g(0) data for ribbon seal. North Atlantic right whale data (Palka 2005) has been used for North Pacific right whale. Sources: Barlow 2006; Barlow 2006; Barlow and Forney 2007; Carretta et al. 2000; Forney and Barlow 1998; Laake et al. 1997; Palka 2005

The post-model acoustic effect analysis quantification process is summarized in Table 6-8 and presented in detail in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Gulf of Alaska Training* (U.S. Department of the Navy 2014b). 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 6-8.

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.

Table 6-8: 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 porpoise and beaked whales) are assumed to avoid the activity area, as the participants arrive and prepare for the event and before sonar activities and the use of explosives commence, 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 Carrier Strike Group exercise is modeled as having multiple vessel movements and hovering helicopters as part of the exercise events.	Species sensitive to human activity (i.e., harbor porpoise 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). For this analysis, the Sinking Exercise (SINKEX) is the only activity using explosives modeled as being preceded by multiple vessel movements and hovering helicopters.
S-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 11) up to and during the sound-producing activity?	***E-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 11) up to and during the sound-producing activity?***
If Lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated PTS are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the 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 6-7. The Mitigation Effectiveness during the Carrier Strike Group exercise is given a factor of 1, since the activities are modeled as involving multiple vessels and aircraft operating in a coordinated manner and is provided in Table 6-15. 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).	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 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 6-7. 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 Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS to high-frequency cetaceans, low frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-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. Given that the Carrier Strike Group exercise involves multiple vessels and aircraft operating in a coordinated manner during the anti-submarine warfare events.	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Table 6-16.

6.5.7 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 (Introduction and Description of Activities).

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 6.3.1 (Direct Injury). Direct injury (other than potential PTS) from sonar and other active acoustic sources 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 associated with the Proposed Action. These sounds are likely within the audible range of most cetaceans but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each, but most are shorter than 1 second. The duty cycle is low, with most tactical ASW sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed, and most events are limited to a few hours. Tactical sonar has a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant auditory masking in marine mammals.

Some sound sources (i.e., submarine navigation sonar) have a high duty cycle producing up to a few pings per second. Such sonar typically employs high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. These higher-frequency systems are typically outside the hearing and vocalization ranges of mysticetes (see Finneran and Jenkins 2012); therefore, mysticetes are unlikely to be able to detect the higher frequency systems, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many higher frequency systems overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of these systems is narrow, limiting the likelihood of auditory masking. With any of the activities using these systems, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other non-impulse sources are PTS, TTS, and behavioral reactions (Section 6.4.2.1, Non-Impulsive Sound from Sonar and Other Active Acoustic Sources). 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.

Included in this discussion is the subject of repeated and chronic noise exposures to marine mammals and their observed reactions. As was previously mentioned, none of the Carrier Strike Group exercises (Naval activities) will add chronic or long-term noise sources to the environment. The activities will occur a maximum of twice during the summer, use of sonar and other active acoustic sources will only occur

during a fraction of the exercise (less than approximately 17 percent of the total hours), and the participants will be constantly moving.

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 6-9 (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 activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

Table 6-9: 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	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 6-9 relative to the marine mammal's functional hearing group (Navy's high frequency sources have a lower source level and more energy loss over distance than these mid-frequency examples and therefore have a shorter range to effects). For a SQS-53C sonar transmitting for one second at 3 kHz and a source level of 235 dB re 1 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 approximately 100 m (109 yd.). Since any surface vessel using hull mounted ASW sonar, such as the SQS-53, engaged in ASW training would be moving at between 10 and 15 knots (5.1 and 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 280 yd. (257 m) during the time between those pings (note: 10 knots is the speed used in the NAEMO). As a result of the vessel moving forward, 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 in such close proximity to each other while using their active sonar.

For all other functional hearing groups (low-frequency cetaceans and mid-frequency cetaceans, and pinniped) single-ping PTS zones are within 110 yd. (100 m) of the sound source. A scenario could be imagined where an animal does not leave the vicinity of a ship or travels a course parallel to the ship within the PTS zone, however, as indicated in Table 6-9, the sustained proximity to the ship required make it unlikely there would be exposures resulting in PTS from any subsequent pings. 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 result in a PTS exposure. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are well within 55 yd. (50 m), even for multiple pings (up to five pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

TTS: Table 6-10 illustrates the ranges to the onset of TTS (i.e., the maximum distances to which TTS would be expected) for one, five, and ten pings from four representative source bins and sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer; this can also be thought of as a larger volume acoustic footprint for TTS effects. Because the effects threshold is total summed sound energy and because of the longer distances, successive pings can add together, further increasing the range to onset-TTS.

Behavioral Response: Table 6-11 and Table 6-12 show the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete[9] behavioral response functions, at various SPLs (in 6 dB received level increments), from three representative sonar sources. See Section 6.4.2.1 (Non-Impulsive Sound from Sonar and Other Active Acoustic Sources) 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.

Range to 120 dB re 1 µPa varies by system, output setting, and environmental conditions, but under ideal conditions can reach approximately 100 nm for the most powerful hull mounted sonar; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 130 dB re 1 µPa, 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 out to approximately 42 nm in reaction to received level of 140 dB re 1 µPa or greater. For context, measurements of the ambient sound level in Puget Sound, Washington 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 has the potential to make perception of and reaction to the sound from the sonar at that distance less likely.

[9] The Odontocete Behavioral Risk Function is used for mid-frequency and high-frequency cetaceans and pinnipeds (see Finneran and Jenkins [2012] for a discussion of this approach).

Table 6-10: 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 Range to Onset TTS (meters)								
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)			Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-frequency cetaceans	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
Phocid seals	70–1,720	200–3,570	350–4,850	< 50	100	150	< 50	< 50	< 50
Otariid seals & sea lion	230–570	1,240–1,300	1,760–1,780	< 50	< 50	< 50	< 50	< 50	< 50

Note: ASW = Anti-Submarine Warfare, TTS = Temporary Threshold Shift

Table 6-11: 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 in 6 dB Increments for Low-Frequency Cetaceans	Source Bin MF1 (e.g., SQS-53; Anti-Submarine Warfare Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; Anti-Submarine Warfare Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; Anti-Submarine Warfare Sonobuoy)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL <126	185,400–160,325	0%	91,363–70,650	0%	20,463–12,725	0%
126 <= SPL <132	160,325–138,400	0%	70,650–49,125	0%	12,725–7,575	0%
132 <= SPL <138	138,400–118,100	0%	49,125–28,950	4%	7,575–3,813	5%
138 <= SPL <144	118,100–85,400	2%	28,950–10,800	29%	3,813–2,200	15%
144 <= SPL <150	85,400–61,288	7%	10,800–4,250	29%	2,200–638	51%
150 <= SPL <156	61,288–42,750	19%	4,250–2,013	19%	638–250	18%
156 <= SPL <162	42,750–20,813	43%	2,013–638	16%	250–100	9%
162 <= SPL <168	20,813–4,375	26%	638–200	3%	100–< 50	3%
168 <= SPL <174	4,375–1,825	1%	200–100	0%	< 50	0%
174 <= SPL <180	1,825–750	0%	100–< 50	0%	< 50	0%
180 <= SPL <186	750–375	0%	< 50	0%	< 50	0%
186 <= SPL <192	375–200	0%	< 50	0%	< 50	0%
192 <= SPL <198	200–100	0%	< 50	0%	< 50	0%

Table 6-12: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments under the Odontocete* Behavioral Response Function for Three Representative Sonar Systems (Average Values for the Study Area)

Received Level in 6 dB Increments for Odontocetes and Pinnipeds	Source Bin MF1 (e.g., SQS-53; Anti-Submarine Warfare Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; Anti-Submarine Warfare Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; Anti-Submarine Warfare Sonobuoy)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL <126	185,450–160,475	0%	93,075–71,275	0%	21,288–14,200	0%
126 <= SPL <132	160,475–138,750	0%	71,275–50938	0%	14,200–8,238	0%
132 <= SPL <138	138,750–123,113	0%	50,938–29,075	1%	8,238–4,350	1%
138 <= SPL <144	123,113–85,450	1%	29,075–11,050	14%	4,350–2,425	6%
144 <= SPL <150	85,450–61,363	4%	11,050–4,250	25%	2,425–1,213	24%
150 <= SPL <156	61,363–42,763	14%	4,250–2,013	24%	1,213–250	54%
156 <= SPL <162	42,763–21,025	44%	2,013–638	28%	250–150	7%
162 <= SPL <168	21,025–4,475	35%	638–200	7%	150–< 50	9%
168 <= SPL <174	4,475–1,850	2%	200–100	1%	< 50	0%
174 <= SPL <180	1,850–763	0%	100–< 50	0%	< 50	0%
180 <= SPL <186	763–400	0%	< 50	0%	< 50	0%
186 <= SPL <192	400–200	0%	< 50	0%	< 50	0%
192 <= SPL <198	200–100	0%	< 50	0%	< 50	0%

* Note the Odontocete Behavioral Risk Function is used for mid-frequency and high-frequency cetaceans and pinnipeds; see Finneran and Jenkins (2012) for discussion of this approach.
Notes: dB = decibels, m = meters, SPL = Sound Pressure Level

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 animals representing individual marine mammals) do not move horizontally or react in any way to avoid sound or any other disturbance. In reality, various researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Palka and Hammond 2001; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998; Tyack 2009). See Section 6.4.2 (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 intense activity associated with a sound source (such as a low hovering helicopter) or a sound source or both is assumed in 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) of the 2011 GOA Final EIS/OEIS, 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 (Implementing Mitigation to Reduce Sound Exposures).

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 6.5.5.1 (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 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. The Carrier Strike Group exercise events are undertaken in a coordinated manner and therefore involve multiple vessels, aircraft, and hovering helicopters operating together while conducting ASW training. Harbor porpoise and 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 before the Carrier Strike Group exercise begins use of sonar and other active acoustic sources.

As previously discussed, 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), post model processing is used to account for the effect of mitigation measures. As already stated, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed by Lookouts. Since the range to PTS for most species and for all systems is much less than 50 m (55 yd.) and a maximum of approximately 100 m (110 yd.) for high-frequency cetaceans, the entire zone to PTS will be under observation at all times. As a result, the mitigation adjustment factor used to account for implemented mitigation is 1 for use of sonar and other active acoustic sources during the Carrier Strike Group exercise.

For the adjustment procedure, 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 this factor 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).

Many of the marine species in consideration here are often encountered in groups. Consequently they have a higher potential for being visually detected since there are more sighting opportunities and thus making it more likely mitigation will be implemented. Additionally, detection of any one animal in a group can result in implementation of mitigation for the entire group including animals that individually may not have been otherwise detected. Data from the GOALS II survey (Rone et al. 2014) provided observed group sizes for the species encountered in and around the Study Area as presented in Table 6-13.

Table 6-13: Marine Mammals Sightings from the Gulf of Alaska Line-Transect Survey II Survey (Rone et al. 2014)

Species	Total Sightings	Total Individuals	Average Group Size	Group Size	
				Min	Max
Baird's beaked whale	7	58	8.3	2	16
Blue whale	5	7	1.4	1	2
Cuvier's beaked whale	1	1	1.0	1	1
Dall's porpoise	337	907	2.7	1	25
Elephant seal	16	16	1.0	1	1
Fin whale	200	392	2.0	1	13
Fin/Sei whale	1	1	1.0	1	1
Gray whale	1	25	25.0	25	25
Harbor porpoise	8	11	1.4	1	2
Humpback whale	106	331	3.1	1	15
Killer whale	21	138	6.6	1	45
Minke whale	3	6	2.0	1	3
Northern fur seal	78	83	1.1	1	2
Sperm whale	19	22	1.2	1	2
Unidentified beaked whale	5	8	1.6	1	2
Unidentified dolphin	3	4	1.3	1	2
Unidentified large whale	122	160	1.3	1	5
Unidentified small whale	4	4	1.0	1	1
Unidentified pinniped	6	6	1.0	1	1
Unidentified porpoise	22	87	4.0	1	10
Total	**965**	**2,267**			

Note: Numbers presented in the table above were derived from data presented in Rone et al. (2014).

The group size data from the Study Area and adjacent waters as derived from Rone et al. (2014) have been considered in the analysis of predicted exposures as presented subsequently in Section 3.8.3.3.2 (Model Predicted Exposures from Use of Sonar and Other Active Acoustic Sources) and Section 3.8.3.3.4 (Model Predicted Exposures from Use of Explosives) of the Supplemental EIS/OEIS. Note that the new group size data in Table 6-13 were not used as input to the NAEMO since they only represent data from one survey as opposed to the more rigorous dataset presented in Watwood and Buonantony (2012). The group size numbers presented in Table 6-13 above are, however, within the range of values[10] used in the NAEMO distribution of species within the Study Area (Navy Marine Species Modeling Team 2014).

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 (Table 6-9) 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).

[10] The Navy's acoustic effects modeling used group size estimates provided in Watwood and Buonantony (2012) to distribute animats within an acoustic impact modeling location. Groups of animats were distributed using the mean group size and standard deviations into species-typical groups for modeling purposes (see Navy Marine Species Modeling Team 2013). Each species-specific group size presented in Table 6-13 (derived from Rone et al. 2014), is well within one standard deviation of the mean presented in Watwood and Buonantony (2012) and as used in the acoustic modeling's prediction of exposures.

Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (Table 6-9) do not exceed approximately 77 and 110 yd. (70 m 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. 2005b). 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.

As noted previously, the NAEMO does not account for several factors (Section 6.3.2, Primary Blast Injury and Barotrauma) 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 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), and provide additional protections that are not considered in the numerical results presented in Chapter 5 (Take Authorization Requested).

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) Sources

Use of explosives during the proposed training activities could occur throughout the Study Area but generally will not occur inshore of the shelf-break or slope. These activities include strike warfare, ASUW, and ASW that will take place during and in association with the Carrier Strike Group exercise. Activities that involve explosions are described in Chapter 1 (Introduction and Description of Activities; see Table 1-4, Table 1-5, and Table 1-6). The NAEMO, in conjunction with the explosive thresholds and criteria (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 impulsive 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 (a loss of hearing sensitivity over a limited part of an animal's hearing range) may impact an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Partial hearing impairment could conceivably decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal's hearing abilities, but the individual would recover with what may be little or no consequences or 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 training activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing substantial auditory masking in marine mammals.

6.5.7.3.1 Range to Impulsive Effects for Explosives

Table 6-14 shows the minimum and maximum ranges to the potential effect based on the thresholds described in Section 6.4 (Thresholds and Criteria for Predicting Non-Impulsive and Impulsive Acoustic Impacts on Marine Mammals). Table 6-14 also shows the ranges to onset mortality for mid-frequency and high frequency cetaceans for a representative range of explosive sizes (NEW). 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 6-14: 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 (>0.5–2.6 lb. NEW)	Bin E5 (>5–10 lb. NEW)	Bin E7 (>20–60 lb. NEW)	Bin E9 (>100–250 lb. NEW)	Bin E10 (>250–500 lb. NEW)	Bin E12 (>650–1,000 lb. NEW)
Low-Frequency Cetaceans						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655

Table 6-14: 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) (continued)

Hearing Group Criteria/Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins					
	Bin E3 (>0.5–2.6 lb. NEW)	Bin E5 (>5–10 lb. NEW)	Bin E7 (>20–60 lb. NEW)	Bin E9 (>100–250 lb. NEW)	Bin E10 (>250–500 lb. NEW)	Bin E12 (>650–1,000 lb. NEW)
Mid-Frequency Cetaceans						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-Frequency Cetaceans						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705
Phocinea						
Onset Mortality	30	50	240	150	185	225
Onset Slight Lung Injury	60	100	445	265	320	385
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	95	180	410	340	445	680
TTS	235	500	1,215	665	815	1,350
Behavioral Response	345	600	1,575	815	950	1,685
Otariidae						
Onset Mortality	35	65	285	175	215	260
Onset Slight Lung Injury	70	115	530	307	370	450
Onset Slight GI Tract Injury	40	8	150	145	180	250
PTS	30	50	30	50	85	150
TTS	40	85	210	220	260	400
Behavioral Response	60	145	305	300	350	530

Notes: GI = gastrointestinal, lb. = pound(s), NEW = Net Explosive Weight, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift

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, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig 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 (Section 6.5.6, Implementing Mitigation to Reduce Sound Exposures).

If explosive activities are preceded by multiple vessels or hovering aircraft, harbor porpoise and beaked whales are assumed to move beyond the range to onset mortality before detonations occur. For the Carrier Strike Group exercise events, this is only applicable and assessed to occur during the Sinking Exercise. Table 6-14 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/pup. Because the Navy NAEMO does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Therefore, harbor porpoise and beaked whales that were model-estimated to be within range of a mortality criteria exposure are assumed to avoid the vicinity of a sinking exercise and are analyzed as being in the range of potential injury prior to the start of the explosive activity for that event.

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) (Table 6-7).

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, 2]	Factor for Adjustment of Preliminary Modeling Estimates		Mitigation Platform Used for Assessment
	Injury Zone	Mortality Zone	
Bombing Exercise (Air-to-Surface)	0.5	1	Aircraft
Sinking Exercise	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 (e.g., Anti-Submarine Tracking Exercise – Extended Echo Ranging Sonobuoys; Gunnery Exercises).
[2] 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. For activities in which only mitigation in the mortality zone is considered in the analysis, no value is provided for the injury zone.

During an activity with a series of explosions (not concurrent multiple explosions; Table 6-16), 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 6-14. 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 during the Carrier Strike Group Exercise with Multiple Non-Concurrent Explosions

Activity
Bombing Exercise (Air-to-Surface)
Gunnery Exercise (Surface-to-Surface) – Large-Caliber, Ship
Sinking Exercise

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 Non-Impulsive and Impulsive Source Effects

Table 5-1 represents the Navy's final estimated impulsive and non-impulsive source effects to marine mammals by MMPA category for the Study Area. Table 5-2 shows the details of estimated non-impulsive (sonar and other active acoustic sources) and impulsive (explosives) source effects by species and stock within the Study Area.

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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 5-1 and Table 5-2).
- Marine mammal densities inputted into the model are also overly conservative, particularly when considering species where data is limited in the Study Area.
- Additionally, the mitigation measures described in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) 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 Navywide 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 Navywide 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 using an impulsive source (underwater explosion).

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. 2009; Southall et al. 2012; 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 Washington's 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 GOA Study Area, there are no new areas being considered for training and the same historically used area is 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 events are not expected to result in serious injuries or mortality to any marine mammals.

Conclusion – The Navy concludes that training activities proposed in the GOA Study Area would result in Level B and Level A takes, and would not result in mortality, as summarized in Table 5-1 and Table 5-2. Based on best available science the Navy concludes that exposures to marine mammal species and stocks due to GOA 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 Table 5-1 and Table 5-2 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 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) are designed to reduce 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 (Number and Species Taken) for each species or species group. The species-specific analyses, in combination with the mitigation measures provided in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), support the conclusion that proposed GOA 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.

The effects of the proposed action were considered and based on the detailed review presented in Section 6.3.7 (Long-Term Consequences for the Individual and the Population). The Navy does not expect its activities to result in impacts to marine mammal populations; therefore, 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 in the Study Area. 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. Underwater detonations activities such as bombing exercises, gunnery exercises, and use of explosive echo ranging sonobuoys do not constitute a long-term physical alteration of the water column or bottom topography, as these activities occur or near the surface, 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 the Study Area.

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 2011 GOA Final EIS/OEIS. Based on the detailed review within the 2011 GOA Final 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 activities 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 (Impacts on the Marine Mammal Habitat and the Likelihood of Restoration), 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 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 activities involving underwater explosions could potentially result in minor long-term changes to benthic habitat as the items settle to the ocean floor. Expended materials could be colonized overtime by benthic organisms that prefer hard substrate and they could attract some species of fish.

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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 in aircraft, or on 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 and some Navy ships, Lookouts for these platforms may be supplemented by personnel on other aircraft or crew aboard other vessels. 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 in the remainder of this section primarily consist of having Lookouts during specific training 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 GOA Supplemental EIS/OEIS (U.S. Department of the Navy 2014c).

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

11.1.1 ACOUSTIC STRESSORS – NON-IMPULSIVE SOUND

11.1.1.1 Hull Mounted Mid-Frequency Active Sonar

The Navy's current Lookout mitigation measures during training activities involving hull-mounted MFA 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 MFA sonar. Ships using hull-mounted MFA sonar sources associated with ASW 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. 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.

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

The Navy currently conducts activities using high-frequency and non-hull-mounted MFA sonar in the Study Area. Non-hull-mounted MFA sonar training activities include the use of aircraft deployed sonobuoys, helicopter dipping sonar, and submarine 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 MFA sonar activities.

11.1.2 ACOUSTIC STRESSORS – EXPLOSIVES AND IMPULSIVE SOUND

11.1.2.1 Improved Extended Echo Ranging Sonobuoys

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

11.1.2.2 Gunnery Exercises – Large-Caliber Using a Surface Target

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.

11.1.2.3 Bombing Exercises (Explosive)

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.

11.1.2.4 Weapons Firing Noise During Gunnery Exercises

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 gunnery exercises. This may be the same Lookout described in Section 11.1.2.2 (Gunnery Exercises – Large-Caliber Using a Surface Target) when that activity is conducted from a ship against a surface target.

11.1.2.5 Sinking Exercises

The Navy is proposing to continue using the number of Lookouts currently implemented for this activity. The Navy will have two Lookouts (one positioned in an aircraft and one on a vessel) during sinking exercises.

11.1.3 Physical Disturbance and Strike

11.1.3.1 Vessels

Currently, the Navy employs the following Lookout procedures to avoid physical disturbance and strike of marine mammals during at-sea training:

- 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.

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 practice munitions—small-, medium-, and large-caliber gunnery exercises—as described above in Section 11.1.2.2 (Gunnery Exercises – Large-Caliber Using a Surface Target).

The Navy is proposing to continue using the number of Lookouts currently implemented for these activities. The Navy will have one Lookout during activities involving non-explosive practice munitions (e.g., small-, medium-, and large-caliber gunnery exercises) against a surface target.

11.1.4.2 Bombing Exercises

Currently, the Navy employs the same mitigation measures for non-explosive bombing exercises as described above in Section 11.1.2.3 (Bombing Exercises [Explosive]).

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.

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 GOA Supplemental EIS/OEIS (U.S. Department of the Navy 2014c).

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 species from training activities. Mitigation zones are measured as the radius from a source. Unique to each activity category, each radius represents a distance that the Navy will visually observe to help reduce injury to marine species. Visual detections of applicable marine species will be communicated immediately to the appropriate watch station for information dissemination and appropriate action. If the presence of marine mammals is detected acoustically, Lookouts posted in aircraft and on surface vessels will increase the vigilance of their visual surveillance. As a reference, aerial surveys are typically made by flying at 1,500 ft. (457 m) altitude or lower at the slowest safe speed.

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 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 GOA Supplemental 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 for the Gulf of Alaska Training Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* technical report (Marine Species Modeling Team 2014).

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 GOA 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 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 includes 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. 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 (kelp paddies), which are indicators of potential marine mammal presence within the mitigation zone. Those specified activities will not commence if floating vegetation (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 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 (Longest) Average Range to TTS	Predicted (Longest) Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Non-Impulse Sound					
Hull-Mounted Mid-Frequency Active Sonar	SQS-53 ASW hull-mounted sonar (MF1)	3,821 yd. (3.5 km) for one ping	100 yd. (91 m) for one ping	Not Applicable	6 dB power down at 1,000 yd. (914 m); 4 dB power down at 500 yd. (457 m); and shutdown at 200 yd. (183 m)
High-Frequency and Non-Hull Mounted Mid-Frequency Active Sonar	AQS-22 ASW dipping sonar (MF4)	230 yd. (210 m) for one ping	20 yd. (18 m) for one ping	Not applicable	200 yd. (183 m)
Explosive and Impulse Sound					
Gunnery Exercises – Large-Caliber (Surface Target)	5 in. projectiles (E5)	453 yd. (414 m)	186 yd. (170 m)	526 yd. (481 m)	600 yd. (549 m)
Bombing Exercises	MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2,500 yd. (2.3 km)[2]
Sinking Exercises	Various up to MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2.5 nm[(2)]

[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] Recommended mitigation zones are larger than the modeled injury zones to account for multiple types of sources or charges being used.
Notes: in = inches, km = kilometers, lb. = pounds, m = meters, nm = nautical miles, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift, yd. = yards

11.2.1 ACOUSTIC STRESSORS – NON-IMPULSIVE SOUND

11.2.1.1 Hull Mounted Mid-Frequency Active Sonar

The Navy is proposing to (1) continue implementing the current measures for MFA sonar and (2) to clarify the conditions needed to recommence an activity after a marine mammal has been detected.

Activities that involve the use of hull-mounted MFA sonar 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. (914 m) of the sonar dome, and by an additional 4 dB when sighted within 500 yd. (457 m) from the source, for a total reduction of 10 dB. Active transmissions will cease if a marine mammal is sighted within 200 yd. (183 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.

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

Non-hull-mounted MFA 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. (183 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).

11.2.2 Acoustic Stressors – Explosives and Impulsive Sound

11.2.2.1 Explosive Signal Underwater Sound Buoys Using >0.5–2.5 Pound Net Explosive Weight

Mitigation measures do not currently exist for activities using signal underwater sound (SUS) buoys.

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.

11.2.2.2 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. (183 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. (366 m) away from the location of the last sighting.

11.2.2.3 Gunnery Exercises – Large-Caliber Explosive Rounds Using a Surface Target

The Navy is proposing to (1) continue using the currently implemented mitigation zone measures for this activity, (2) clarify the conditions needed to recommence an activity after a sighting, and (3) implement a requirement to visually observe for kelp paddies. The recommended measures are provided below.

Mitigation will include visual observation from a ship immediately before and during the exercise within a mitigation zone of 600 yd. (549 m) around the intended impact location. Ships will observe the mitigation zone from the firing position. 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 30 minutes.

11.2.2.4 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 missiles have a wide range of warhead strength, the Navy recommends two mitigation zones; one for missiles with warheads 250 lb. NEW and less, and a larger mitigation zone for missiles with larger warheads. The Navy is proposing to (1) modify the mitigation measures currently implemented for missile exercises involving missiles with 250 lb. NEW and smaller warheads by reducing the mitigation zone from 1,800 yd. (1.6 km) to 900 yd. (823 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.

When aircraft are firing, mitigation will include visual observation by the aircrew or supporting aircraft prior to commencement of the activity within a mitigation zone of 900 yd. (823 m) around the deployed

target. 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).

11.2.2.5 Missile Exercises >250–500 Pound Net Explosive Weight (Surface Target)

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 to 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).

11.2.2.6 Bombing Exercises

Currently, the Navy employs the following mitigation zone procedures during bombing exercises:

- Ordnance shall not be targeted to impact within 1,000 yd. (914 m) of known or observed floating kelp or marine mammals.
- A 1,000 yd. (914 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.

11.2.2.7 Sinking Exercises

The Navy is proposing to (1) modify the mitigation measures currently implemented for this activity by increasing the mitigation zone from 2.0 nm to 2.5 nm, (2) clarify the conditions needed to recommence

an activity after a sighting, (3) add a requirement to visually observe for kelp paddies, and (4) adopt the marine mammal and sea turtle mitigation zone size for aggregations of jellyfish for ease of implementation. The recommended measures are provided below.

Mitigation will include visual observation within a mitigation zone of 2.5 nm around the target ship hulk. Sinking exercises will include aerial observation beginning 90 minutes before the first firing, visual observations from vessels throughout the duration of the exercise, and both aerial and vessel observation immediately after any planned or unplanned breaks in weapons firing of longer than 2 hours. Prior to conducting the exercise, the Navy will review remotely sensed sea surface temperature and sea surface height maps to aid in deciding where to release the target ship hulk.

The Navy will also monitor using passive acoustics during the exercise. Passive acoustic monitoring would be conducted with Navy assets, such as passive ships sonar systems or sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft and on vessels in order to increase vigilance of their visual surveillance. Lookouts will also increase observation vigilance before the use of torpedoes or unguided ordnance with a NEW of 500 lb. or greater, or if the Beaufort sea state is a 4 or above.

The exercise will cease if a marine mammal, sea turtle, or aggregation of jellyfish is sighted within the mitigation zone. The exercise 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 a determination of its course and speed and the relative motion between the animal and the source, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 minutes Upon sinking the vessel, the Navy will conduct post-exercise visual surveillance of the mitigation zone for 2 hours (or until sunset, whichever comes first).

11.2.2.8 Weapons Firing Noise During Gunnery Exercises – Large-Caliber

The Navy currently has no mitigation zone procedures for this activity in the Study Area.

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.

11.2.3 PHYSICAL DISTURBANCE AND STRIKE – VESSELS AND IN-WATER DEVICES

11.2.3.1 Vessels

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. (457 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. (457 m) mitigation zone currently established for whales, and to implement a 200 yd. (183 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. (457 m) around observed whales and 200 yd. (183 m) around all other marine mammals (except bow-riding dolphins), providing it is safe to do so.

11.2.3.2 Towed In-Water Devices

The Navy currently has no mitigation zone procedures for this activity in the Study Area.

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. (229 m) around any observed marine mammal, providing it is safe to do so.

11.2.4 NON-EXPLOSIVE PRACTICE MUNITIONS

11.2.4.1 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 11.2.2.3 (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. (183 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. (366 m) away from the location of the last sighting.

11.2.4.2 Bombing Exercises

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. (914 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.

11.2.4.3 Missile Exercises (Including Rockets) Using a Surface Target

The Navy is proposing to (1) modify the mitigation measures currently implemented for this activity by reducing the mitigation zone from 1,800 yd. (1.6 km) to 900 yd. (823 m), (2) clarify the conditions needed to recommence an activity after a sighting, (3) adopt the marine mammal and sea turtle mitigation zone size for floating vegetation for ease of implementation, and (4) modify the platform of observation to eliminate the requirement to observe when ships are firing. The recommended measures are provided below.

When aircraft are firing, mitigation will include visual observation by the aircrew or supporting aircraft prior to commencement of the activity within a mitigation zone of 900 yd. (823 m) around the deployed target. 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 a determination of its course and speed and the relative motion between the animal and the source, 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).

12 SUBSISTENCE EFFECTS AND PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

Subsistence use is the traditional exploitation of marine mammals by native peoples (i.e., for their own consumption). In terms of the GOA LOA application, none of the proposed training activities in the Study Area occur where traditional Arctic subsistence hunting exists. Based on the Navy discussions and conclusions in Chapters 7 and 8 (Impacts on Marine Mammal Species or Stocks and Impacts on Subsistence Use), there are no anticipated effects on any species or stocks residing in or migrating through the Study Area that might impact their availabiiity 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 or training area based on a set of initial field metrics. The Navy's related, but separate, marine mammal research and development (R&D) program is described in Chapter 14 (Research).

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 and training area based on a 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 Gulf of Alaska 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 and/or ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and/or density of species);
2. An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals and/or ESA-listed species to any of the potential stressor(s) associated with the action (e.g., tonal and impulsive sound), through better understanding of one or more of the following: (1) the action and the environment in which it occurs (e.g., sound source characterization, propagation, and ambient noise levels); (2) the affected species (e.g., life history or dive patterns); (3) the likely co-occurrence of marine mammals and/or ESA-listed marine species with the action (in whole or part) associated with specific adverse effects, and/or; (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and/or ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving or feeding areas);
3. An increase in our understanding of how individual marine mammals or ESA-listed marine species respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or received level);
4. An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either: (1) the long-term fitness and survival of an individual; or (2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival);
5. An increase in our understanding of the effectiveness of mitigation and monitoring measures;
6. A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement;
7. An increase in the probability of detecting marine mammals (through improved technology or methods), both specifically within the safety zone (thus allowing for more effective implementation of the mitigation) and in general, to better achieve the above goals; and
8. A reduction in the adverse impact of activities to the least practicable level, as defined in the MMPA.

13.3.1 GULF OF ALASKA STUDY AREA MONITORING, 2011–2014

During the LOA development process for the 2011 GOA Final EIS/OEIS, the Navy and NMFS agreed that monitoring in the Gulf of Alaska should focus on augmenting existing baseline data, since regional data on species occurrence and density are extremely limited. There have been four reports to date covering work in the Gulf of Alaska (U.S. Department of the Navy 2011c, 2011d, 2012, 2013f). Collecting baseline data was deemed a priority prior to focusing on exercise monitoring and behavioral response as is now being done in other Navy OPAREAs and ranges. There have been no previous dedicated monitoring efforts during Navy training activities in the TMAA with the exception of deployed HARPs.

In July 2011, the Navy funded deployment of two long-term bottom-mounted passive acoustic monitoring buoys by Scripps Institute of Oceanography. These HARPs were deployed southeast of Kenai Peninsula in the TMAA with one on the shelf approximately 50 nm from land (in 111 fathoms [203 m] depth) and on the shelf-break slope approximately 100 nm from land (in 492 fathoms [900 m] depth). Intended to be collected annually, results from the first deployment (July 2011–May 2012) included over 5,756 hours of passive acoustic data (Baumann-Pickering et al. 2012b). Identification of marine mammal sounds included four baleen whale species (blue whales, fin whales, gray whales, and humpback whales) and at least six species of odontocetes (killer whale, sperm whale, Stejneger's beaked whale, Baird's beaked whale, Cuvier's beaked whale, and an unidentified porpoise presumed to be Dall's porpoise; Baumann-Pickering et al. 2012b). Researchers also noted the detection of anthropogenic sound from commercial shipping. There were no Navy activities or vessels in the area at any time during the recording period.

Analysis of the passive acoustic detections made from May 2012 to June 2013 were presented in Baumann-Pickering et al. (2013), Debich et al. (2013), Debich et al. (2014) and the Navy's 2012, 2013, and 2014 GOA annual monitoring report submitted to NMFS (U.S. Department of the Navy 2012, 2013f, 2014d). Three baleen whale species were detected: blue whales, fin whales, and humpback whales. No North Pacific right whale calls were detected at either site during this monitoring period. At least seven species of odontocetes were detected: Risso's dolphins, killer whales, sperm whales, Baird's beaked whales, Cuvier's beaked whales, Stejneger's beaked whales, and unidentified porpoises (likely Dall's porpoise). Focused analysis of beaked whale echolocation recordings were presented in Baumann-Pickering et al. (2013).

As also presented in Debich et al. (2013) and U.S. Department of the Navy (2013f), broadband ship noise was found to be more common at the slope and Pratt Seamount monitoring sites within the TMAA than at the nearshore (on shelf) site. Sonar (a variety of frequencies, most likely fathometers and fish-finders), were more common on the shelf and slope sites. Very few explosions were recorded at any of the three sites throughout the monitoring period. Origin of the few explosions detected are unknown, but there was no Navy explosive use in the GOA TMAA during this period, so these explosive-like events may be related to fisheries activity, lightning strikes, or some other unidentified source. There were no detections of Navy mid-frequency sonar use in the recordings (Debich et al. 2013, 2014; U.S. Department of the Navy 2013f, 2014d). In September 2012, an additional HARP buoy was deployed at Pratt Seamount (near the east end of the TMAA) and in June 2013 two additional buoys were deployed in the TMAA: one at the shelf-break near the southwest corner of the TMAA and one at Quinn Seamount (the approximate middle of the TMAA's southeast boundary). This constitutes a total of five Navy-funded concurrent long-term passive acoustic monitoring packages present in the TMAA through fall of 2014. Debich et al. reported the first detection of a North Pacific right whale at the Quinn Seamount site. Over two days between June and August 2013, the Quinn seamount HARP detected three hours of North Pacific right whale calls (Debich et al. 2014, Širović et al. in press). Given the

recording device location near the southwest border of the TMAA, inability of the device as configured to determine call directionality, and likely signal propagation of several 10s of miles, it remains uncertain if the detected calls orginated within or outside of the TMAA. Previous related Navy funded monitoring at multiple sites within the Study Area reported no North Pacific right whale detections (Baumann-Pickering et al. 2012b, Debich et al. 2013).

Remaining monitoring through spring of 2015 will include the deployment of two HARPs. Future monitoring will include varying numbers of HARPs or other passive acoustic technologies based on annual Adaptive Management discussions with NMFS (see U.S. Department of the Navy [2014d] for details in that regard).

In the Gulf of Alaska, the Navy has also funded two previous marine mammal surveys to gather occurrence and density data. Although there was no regulatory requirement for the Navy to undertake either survey, the Navy funded the data collection to first support analysis of potential effects for the 2011 GOA Final EIS/OEIS and again recently to support the current Supplemental EIS/OEIS. The first Navy-funded survey (GOALS) was conducted by NMFS in April 2009 (see Rone et al. 2009). Line-transect survey visual data was gathered to support distance sampling statistics and acoustic data were collected over a 10-day period both within and outside the TMAA. This survey resulted in sightings of several species and allowed for the derivation of densities for fin and humpback whale that supplemented multiple previous survey efforts in the vicinity (Rone et al. 2009). In summer 2013, the Navy funded an additional visual line-transect survey in the offshore waters of the Gulf of Alaska (Rone et al. 2014). The GOALS II survey was a 30-day visual line-transect survey supplemented by use of passive acoustics and was a follow-on effort to the previously Navy-funded GOALS survey in 2009. The primary objectives for the GOALS II survey were to acquire baseline data to increase understanding of the likely occurrence (i.e., presence, abundance, distribution and/or density of species) of beaked whales and ESA-listed marine mammals in the Gulf of Alaska. Specific research objectives were:

- Assess the abundance, spatial distribution and/or density of marine mammals, with a focus on beaked whales and ESA-listed cetacean species through visual line-transect surveys and passive acoustics using a towed hydrophone array and sonobuoys
- Increase knowledge of species' vocal repertoire by linking visual sightings to vocally active cetaceans, in order to improve the effectiveness of passive acoustic monitoring
- Attempt to photo-identify and biopsy sample individual whales opportunistically for analysis of population structure, genetics and habitat use
- Attempt to locate whales for opportunistic satellite tagging using visual and passive acoustic methodology in order to provide information on both large- and fine-scale movements and habitat use of cetaceans

The Navy-funded GOALS II survey also sampled four distinct habitat areas (shelf, slope, offshore, and seamounts) which were partitioned into four strata. The survey design was intended to provide uniform coverage within the Gulf of Alaska. However, given the overall limited knowledge of beaked whales within the Gulf of Alaska, the survey was also designed to provide coverage of potential beaked whale habitat and resulted in 13 encounters with beaked whales numbering 67 individual animals (Rone et al. 2014). The following additional details are summarized from the presentation in Rone et al. (2014). The visual survey consisted of 4,504 km (2,431 nm) of 'full-effort' and included 349 km (188 nm) of 'transit-effort.' There was an additional 375 km (202 nm) of 'fog-effort' (transect and transit). Based on total effort, there were 802 sightings (1,998 individuals) identified to species, with an additional 162 sightings (228 individuals) of unidentified cetaceans and pinnipeds. Acoustic surveying was

conducted round-the-clock with a towed-hydrophone array for 6,304 km (3,997 nm) of line-transect effort totaling 426 hours of 'standard' monitoring, with an additional 374 km (202 nm) of ~30 hours of 'non-standard' and 'chase' effort. There were 379 acoustic detections and 267 localizations of 6 identified cetacean species. Additionally, 186 acoustic sonobuoys were deployed with 7 identified cetacean species detected. Two satellite transmitter tags were deployed; a tag on a blue whale (B. musculus) transmitted for 9 days and a tag on a Baird's beaked whale (Berardius bairdii) transmitted for 15 days. Based on photo-identification matches, the tagged blue whale had been previously identified off Baja California, Mexico, in 2005. Photographs of five cetacean species were collected for photo-identification purposes: fin, humpback, blue, killer (Orcinus orca) and Baird's beaked whales. The estimates of abundance and density for five species were obtained for the first time for the central Gulf of Alaska. Overall, the Navy funded GOALS II survey provided one of the most comprehensive datasets on marine mammal occurrence, abundance, and distribution within that rarely surveyed area (Rone et al. 2014).

The NMFS has acknowledged that the Navy's GOA TMAA monitoring will enhance understanding of marine mammal vocalizations and distributions within the offshore waters of the Gulf of Alaska. Additionally, NMFS pointed out that information gained from the investigations associated with the Navy's monitoring may be used in the adaptive management of monitoring measures in subsequent NMFS authorizations, if appropriate and in consultation with NMFS. The Navy is committed to structuring the Navy-sponsored research and monitoring program to address both NMFS' regulatory requirements as part of any MMPA authorizations while at the same time making significant contributions to the greater body of marine mammal science (see U.S. Department of the Navy 2013f).

13.3.2 Pacific Northwest Cetacean Tagging

A Navy-funded effort in the Pacific Northwest is ongoing and involves attaching long-term satellite tracking tags to migrating gray whales off the coast of Oregon and northern California (U.S. Department of the Navy 2013e). This study is being conducted by the University of Oregon and has also included tagging of other large whale species such as humpback whales, fin whales, and killer whales when encountered. This effort is not programmed, affiliated, or managed as part of the GOA TMAA monitoring, and is a separate regional project, but has provided information on marine mammals and their movements that has application to the Gulf of Alaska.

In one effort between May 2010 and May 2013, satellite tracking tags were placed on three gray whales, 11 fin whales, five humpback whales, and two 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 nearshore margins of the TMAA in the Gulf of Alaska where it would be considered part of the Offshore stock (for stock designations, see Allen and Angliss 2014). In a second effort between 2012 and 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 Northwest Training and Testing Range contains the details of the findings from both research efforts described above (U.S. Department of the Navy 2013e).

13.3.3 MONITORING AND RESEARCH AT OTHER PACIFIC NAVY RANGE COMPLEXES

Based on NMFS-Navy meetings in June and October 2011, future Navy compliance monitoring, including ongoing 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 TMAA Study Area, the Navy's monitoring for TMAA 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 TMAA Monitoring Project Table in consultation with NMFS.

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 on 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 R&D efforts related to marine mammals are conducted in an open, transparent manner with validated study needs and requirements. The goal of the Navy's R&D program is to enable collection and publication of scientifically valid research as well as development of techniques and tools for Navy, academic, and commercial use. Historically, R&D programs are funded and developed by the Navy's Chief of Naval Operations Energy and Environmental Readiness (OPNAV N45) and ONR, Code 322 Marine Mammals and Biological Oceanography Program. The 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 GOA Study Area. Some data and results, when available from these R&D 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 R&D 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 GOA annual monitoring reports.

Other National Department of Defense Funded Initiative – Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) are the Department of Defense's environmental research programs, harnessing the latest science and technology to improve environmental performance, reduce costs, and enhance and sustain mission capabilities. The programs respond to environmental technology requirements that are common to all of the military Services, complementing the Services' research programs. SERDP and ESTCP promote partnerships and collaboration among academia, industry, the military Services, and other Federal agencies. They are independent programs managed from a joint office to coordinate the full spectrum of efforts, from basic and applied research to field demonstration and validation.

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