REQUEST FOR LETTER OF AUTHORIZATION

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

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
µPa	micropascal(s)
μPa^2-sec	micropascal squared second
A-S	Air-to-Surface
AFAST	Atlantic Fleet Active Sonar Training
AG	Airgun
ASW	Anti-Submarine Warfare
ATCAA	Air Traffic Control Airspace
BOMBEX	Bombing Exercise
C.F.R.	Code of Federal Regulations
CG	Cruiser
CLF	Combat Logistics Force
CNMI	Commonwealth of the Northern Mariana Islands
CV	coefficient of variation
CVN	Aircraft Carrier
dB	decibel(s)
DDG	Destroyer
DoD	Department of Defense
DS	Doppler Sonar
DWADS	Mid-frequency Deep Water Active Distributed System
DZ	Danger Zone
EA	Environmental Assessment
EIS	Environmental Impact Statement
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
FA	Fathometer
FAA	Federal Aviation Administration
FDM	Farallon de Medinilla
FFG	Frigate
FR	Federal Register
ft.	feet
GIS	Geographic Information System
GUNEX	Gunnery Exercise
Helo	helicopter
HF	High-Frequency
HHS	Hand-held Sonar
hr.	hour(s)
HRC	Hawaii Range Complex
HSTT	Hawaii-Southern California Training and Testing
Hz	hertz
ICMP	Integrated Comprehensive Monitoring Program
IEER	Improved Extended Echo Ranging
IMS	Imaging Sonar
in.	inch(es)
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometers
kPa	kilopascal(s)
lb.	pound(s)
LCS	Littoral Combat Ship
LF	Low-Frequency
LMR	Living Marine Resources
LOA	Letter of Authorization
m	meter(s)
msec	millisecond(s)
M (1)	Acoustic Modem
M (2)	mass of the animals in kilograms
MAC	Multistatic Active Coherent
MCM	Mine Countermeasures
MF	Mid-Frequency
MFA	Mid-Frequency Active
mi.	mile(s)
min.	minute(s)
MINEX	Mining Exercise
MIRC	Mariana Islands Range Complex
MISSILEX	Missile Exercise
MISTCS	Mariana Islands Sea Turtle and Cetacean Survey
MITT	Mariana Islands Training and Testing
MIW	Mine Warfare
MMPA	Marine Mammal Protection Act
MPA	Maritime Patrol Aircraft
MSO	Maritime Security Operations
NAEMO	Navy Acoustic Effects Model
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
Navy	U.S. Department of the Navy
NEW	Net Explosive Weight
nm	nautical mile(s)
nm^2	square nautical miles
NMFS	National Marine Fisheries Service
NRL	Naval Research Laboratory
OEA	Overseas Environmental Assessment
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OPNAV 45	Chief of Naval Operations Energy and Environmental Readiness
OPNAVINST	Chief of Naval Operations Instruction
PCAD	Population Consequences of Acoustic Disturbance

PL	Public Law
PMRF	Pacific Missile Range Facility
psi	pounds per square inch
PTS	Permanent Threshold Shift
PVOH	polyvinyl alcohol
R (1)	Restricted Area
R (2)	Acoustic Release
R&D	Research and Development
RAC	Regional Advisory Committee
re	relative to
RIMPAC	Rim of the Pacific
rms	root mean square
ROV	Remotely Operated Vehicle
S-S	Surface-to-Surface
SAG	Scientific Advisory Group
SAR	Stock Assessment Report
SD	Swimmer Detection Sonar
SEL	Sound Exposure Level
SERDP	Strategic Environmental Research and Development Program
SINKEX	Sinking Exercise
SOCAL	Southern California
SPL	Sound Pressure Level
SSS	Side Scan Sonar
SUA	Special Use Airspace
SUS	Signal Underwater Sound
SUW	Surface Warfare
TNT	trinitrotoluene
TORP	Torpedo
TORPEX	Torpedo Exercise
TRACKEX	Tracking Exercise
TTS	Temporary Threshold Shift
UNDET	Underwater Demolition
U.S.	United States
U.S.C.	United States Code
VHF	Very High-Frequency
W	Warning Area
yd.	yard(s)

1 INTRODUCTION AND DESCRIPTION OF ACTIVITIES

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

1.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) has prepared this request for a Letter of Authorization (LOA) for the incidental taking (as defined in Chapter 5 [Take Authorization Request]) of marine mammals during the conduct of military readiness (training and testing) activities within the Mariana Islands Training and Testing (MITT) Study Area (Figure 1-1). The Navy is requesting a 5-year LOA for training and testing activities proposed to be conducted from August 2015 through August 2020 for those take numbers listed in Table 5-1. The request for the LOA is made in accordance with the requirements for this application in the Marine Mammal Protection Act (MMPA) of 1972 as amended (16 United States Code [U.S.C.] § 1371(a)(5)).

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

The Navy is preparing an Environmental Impact Statement (EIS)/Overseas EIS (OEIS) for the MITT Study Area to evaluate all components of the proposed training and testing activities. A description of the MITT Study Area (Figure 1-1) and various components is provided in Chapter 2 (Description of Proposed Action and Alternatives) of the MITT EIS/OEIS and, briefly, in Section 1.6 (Proposed Action) of this LOA application. A description of the training and testing activities for which the Navy is requesting incidental take authorizations is provided in the following sections. This request for an LOA is based on the proposed training and testing activities of the Navy's Preferred Alternative (Alternative 1 in the EIS/OEIS).

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

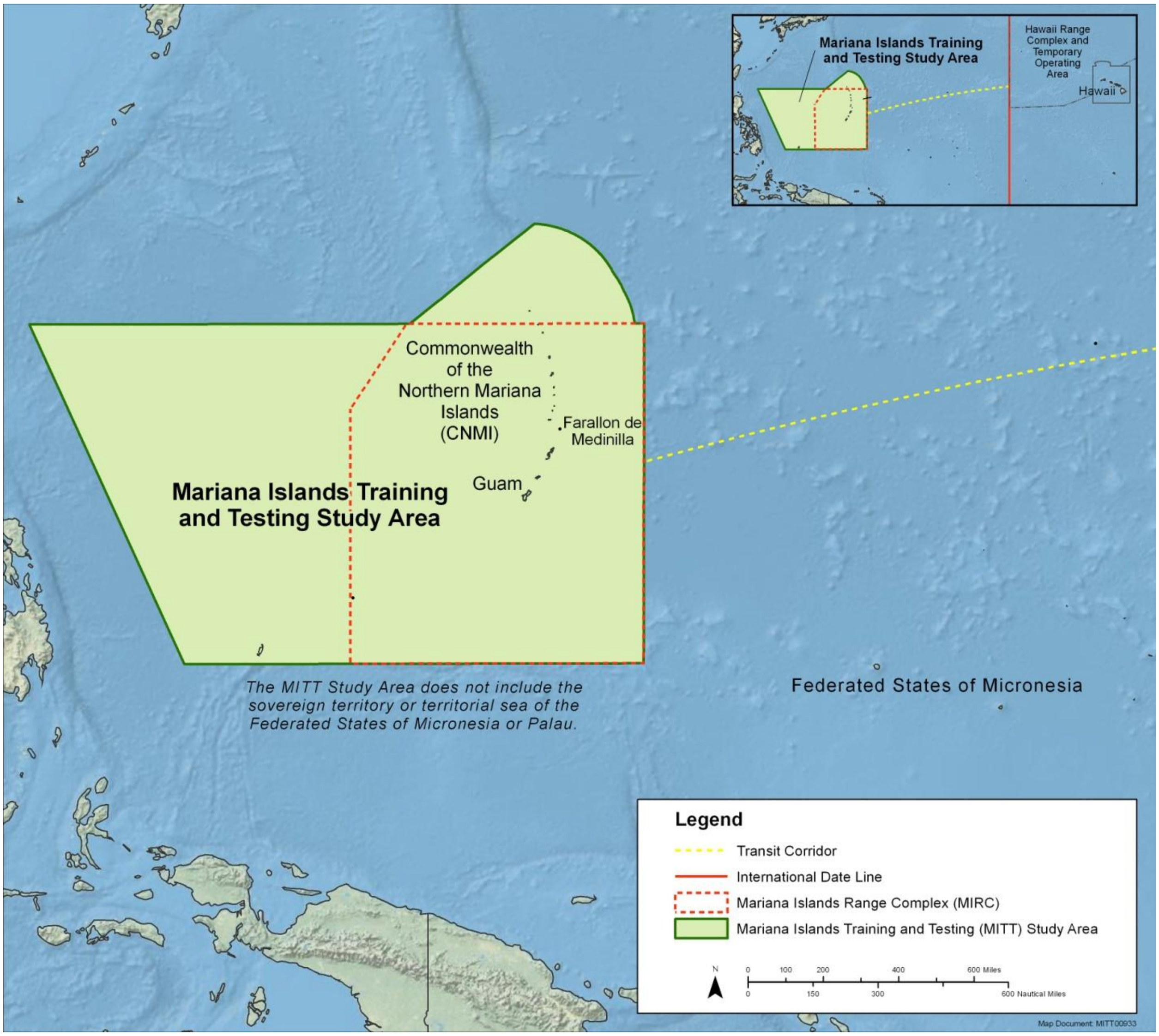

Figure 1-1: Mariana Islands Training and Testing Study Area

1.2 BACKGROUND

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

[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."

testing activities ensure naval forces are equipped with well-maintained systems that take advantage of the latest technological advances.

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

To meet training, testing, and acquisition requirements, the Navy is preparing an EIS/OEIS to assess the potential environmental impacts associated with ongoing and proposed military activities in the Study Area. The Navy is the lead agency for the MITT EIS/OEIS, and the National Marine Fisheries Service (NMFS), U.S. Coast Guard, and U.S. Air Force are cooperating agencies pursuant to 40 Code of Federal Regulations (C.F.R.) §§ 1501.6 and 1508.5. The NMFS is a cooperating agency because of its expertise and regulatory authority over marine resources. The U.S. Coast Guard is a cooperating agency because of its expertise, its federal regulator authority, and its maritime law enforcement missions in the Study Area. The U.S. Air Force is a cooperating agency as a stakeholder in the Study Area and scheduling authority over portions of the Study Area airspace.

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 or the U.S. Fish and Wildlife Service (USFWS) for those actions it has determined may affect ESA-listed species or critical habitat.

1.3 Overview of Training Activities

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

1.3.1 Description of Current Training Activities within the Study Area

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

The Navy describes and analyzes the effects of its training activities within the MITT Draft EIS/OEIS (U.S. Department of the Navy 2012a). In its assessment, the Navy concluded that, of the training activities conducted in the MITT Study Area, sonar use and explosives were the stressors most likely to result in impacts on marine mammals that could rise to the level of harassment as defined under the MMPA.

[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.

Therefore, this LOA application provides the Navy's assessment of potential effects from these stressors in terms of the various warfare mission areas in which they would be conducted. In terms of Navy warfare areas, this includes the following:

- Anti-Surface Warfare (impulse sources [explosives])
- Anti-Submarine Warfare (non-impulse sources [sonar and other active acoustic sources], impulse sources [explosives])
- Mine Warfare (non-impulse sources [sonar and other active acoustic sources], impulse sources [explosives])
- Naval Special Warfare (impulse sources [explosives])

Additionally, some activities described in the EIS/OEIS as Major Training Activities and Other Activities include impulse and non-impulse sources and are, therefore, included in this LOA application. The Navy's activities in Amphibious Warfare, Anti-Air Warfare, Strike Warfare, and Electronic Warfare do not involve non-impulse sources, explosives, or any other stressors that could result in harassment of marine mammals. The activities in these warfare areas are therefore not considered further in this application. The analysis and rationale for excluding these warfare areas from this LOA application are contained in the Navy's MITT EIS/OEIS.

1.3.1.1 Anti-Surface Warfare

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

1.3.1.2 Anti-Submarine Warfare

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

1.3.1.3 Mine Warfare

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

1.3.1.4 Naval Special Warfare

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

1.3.1.5 Major Training Activities

Major training activities involve multiple ships, aircraft, and submarines in a multi-day exercise. The Joint Expeditionary Exercise brings different branches of the U.S. military together in a joint environment that includes planning and execution efforts as well as military training activities at sea, in the air, and ashore. More than 8,000 personnel may participate and could include the combined assets of a Carrier Strike Group and Expeditionary Strike Group, Marine Expeditionary Units, Army Infantry Units, and Air Force aircraft. One example of this coordinated activity is the Joint Multi Strike Group Exercise, a 10-day exercise in which up to three carrier strike groups would conduct training exercises simultaneously. The Fleet Strike Group Exercise is a one week event focused on sustainment training for the forward deployed Carrier Strike Group and may integrate joint training activities with the U.S. Air Force and U.S. Marine Corps. The exercise focuses on integrated joint training among U.S. military forces in the maritime environment with an anti-submarine warfare threat. The Integrated Anti-Submarine Exercise involves multiple ships, aircraft, and submarines coordinating the use of their sensors, including sonobuoys, to search, detect, and track threat submarines.

1.3.1.6 Other Activities

Surface ship and submarine sonar maintenance, described under Other Activates in the MITT Draft EIS/OEIS, involve in-port and at-sea maintenance of sonar systems.

1.4 Overview of Testing Activities

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

1.4.1 Description of Current Testing Activities within the Study Area

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

Many testing activities are conducted similarly to Navy training activities and are also categorized under one of the primary mission areas described above in Section 1.3.1 (Description of Current Training Activities within the Study Area). Other testing activities are unique and are described within their specific testing categories. Because each test is conducted by a specific component of the Navy's research and acquisition community, which includes the Navy's Systems Commands and the Navy's scientific research organizations, the testing activities described in this LOA application are organized first by that particular organization as described below and in the order as presented.

The Navy describes and analyzes the effects of its testing activities within the MITT Draft EIS/OEIS (U.S. Department of the Navy 2012a). In its assessment, the Navy concluded that, of the testing activities conducted within the MITT Study Area, acoustic stressors from the use of underwater acoustic sources and explosives may result in impacts on marine mammals that rise to the level of harassment as defined under the MMPA. Therefore, this LOA application provides the Navy's assessment of potential effects from these stressors for the following testing activities organized by Systems Command:

- Naval Air Systems Command (NAVAIR) Testing
  - Anti-Surface Warfare Testing (impulse sources [explosives])
  - Anti-Submarine Warfare Testing (non-impulse sources [sonar and other active acoustic sources], impulse sources [explosives])
- Naval Sea Systems Command (NAVSEA) Testing
  - New Ship Construction (non-impulse sources [sonar and other active acoustic sources], impulse sources [explosives])
  - Life Cycle Activities (non-impulse sources [sonar and other active acoustic sources])
  - Anti-Surface Warfare/Anti-Submarine Warfare Testing (non-impulse sources [sonar and other active acoustic sources], impulse sources [underwater detonations])
  - Ship Protection Systems and Swimmer Defense Testing (non-impulse sources [sonar and other active acoustic sources], impulse sources [airguns])
- Office of Naval Research (ONR) and Naval Research Laboratory (NRL) Testing
  - ONR/NRL Research, Development, Test & Evaluation (non-impulse sources)

Other Navy testing activities that do not involve non-impulse or impulse sources include, as examples, Broad Area Maritime Surveillance and Kinetic Energy Weapons Testing and are not considered further in this application.

1.4.1.1 Naval Air Systems Command Testing

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

The majority of testing and development activities conducted by NAVAIR are similar to fleet training activities, and many platforms (e.g., Maritime Patrol Aircraft) and systems (e.g., sonobuoys) currently being tested are already being used by the fleet or will ultimately be integrated into fleet training activities. However, some testing and development may be conducted in different locations and in a different manner than the fleet and therefore, though the potential environmental effects may be the same, the analysis for those activities may differ.

Anti-Surface Warfare Testing

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

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

Anti-Submarine Warfare Testing

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

1.4.1.2 Naval Sea Systems Command Testing

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

New Ship Construction Activities

Ship construction activities include testing of ship systems, and developmental and operational test and evaluation programs for new technologies and systems. At-sea testing of systems aboard a ship may include sonar, acoustic countermeasures, radars, and radio equipment. At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, are also conducted.

Life Cycle Activities

Testing activities are conducted throughout the life of a Navy ship to verify performance and mission capabilities. Sonar system testing occurs pierside during maintenance, repair, and overhaul availabilities, and at sea immediately following most major overhaul periods. Radar cross signature testing of surface ships is conducted on new vessels and periodically throughout a ship’s life to measure how detectable the ship is to radar. Additionally, electromagnetic measurements of off-board electromagnetic signature are conducted for submarines, ships, and surface crafts periodically.

Other Naval Sea Systems Command Testing Activities

Numerous test activities and technical evaluations, in support of Naval Sea Systems Command's systems development mission, often occur in conjunction with fleet activities within the MITT Study Area. Tests within this category may include, but are not limited to anti-submarine warfare and mine warfare tests using torpedoes, sonobuoys, and mine detection and neutralization systems. Pierside, swimmer detection systems will also be tested.

1.4.1.3 Office of Naval Research and Naval Research Laboratory Testing

As the Navy's Science and Technology provider, ONR and NRL provide technology solutions for Navy and Marine Corps needs. The ONR's mission, defined by law, is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, ONR manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test and evaluation. The Ocean Battlespace Sensing Department explores science and technology in the areas of oceanographic and meteorological observations, modeling, and prediction in the battlespace environment; submarine detection and classification (anti-submarine warfare); and mine warfare applications for detecting and neutralizing mines in both the ocean and littoral environment. The ONR events include: research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow water acoustic communications experiments; sediment acoustics experiments; shallow water acoustic propagation experiments; and long range acoustic propagation experiments.

An initial experiment collecting data on oceanographic conditions in the deep-water environment within the Study Area was completed in May 2011. As part of the experiment, an acoustic sensor arrays and moorings were deployed in deep waters of the northwestern Philippine Sea. The acoustic arrays have remained in place at the experiment site since that time, collecting oceanographic and acoustic data used to study the propagation of sound in deep-waters and to characterize the temperature and velocity within the water column in this oceanographically complex and highly dynamic region. Additional data will be collected during at-sea operations in May and July 2018 and during the fall of 2018. During these future events, research vessels, the acoustic sensor arrays, and other oceanographic data collection equipment will be used to collect information on the ocean environment. The resulting analyses will aid in developing a more complete understanding of deep water sound propagation and the temperature-velocity profile of the water column in this part of the world.

While this LOA request describes the anticipated ONR activities to be conducted in the Study Area, unforeseen emergent Navy requirements and scientific advances may influence actual testing activities. Activities that would be conducted by ONR have been identified and described to the extent possible within this LOA application.

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

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

1.5.1 Sonar and Other Non-Impulse 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 (anti-submarine warfare) and mines (mine warfare); safe navigation and effective communications; use of unmanned undersea vehicles; and oceanographic surveys.

1.5.2 Ordnance/Munitions

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

1.5.3 Defensive Countermeasures

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

1.5.4 Mine Warfare Systems

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

1.5.4.1 Mine Detection Systems

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

- **Towed or Hull-Mounted Mine Detection Systems.** These detection systems use acoustic, laser, and video sensors to locate and classify mines. Fixed wing and rotary wing aircraft platforms, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.
- **Unmanned/Remotely Operated Vehicles.** These vehicles use acoustic, laser, and video sensors to locate and classify mines. Unmanned/remotely operated vehicles provide unique mine warfare capabilities in nearshore littoral areas, surf zones, ports, and channels.

1.5.4.2 Mine Neutralization Systems

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

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

Explosive charges are used during Unmanned/Remotely Operated Mine Neutralization Systems Diver Emplaced Explosive Charge activities; however, only non-explosive mines or mine shapes would be used.

1.5.5 Classification of Non-Impulse and Impulse Sources Analyzed

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

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

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

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

- Frequency of the non-impulse 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-impulse 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 non-impulse source would be used:
  - The manner in which the source is deployed, such as from a moving platform.
- Other factors considered include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam, or, 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 MITT Draft EIS/OEIS (U.S. Department of the Navy 2012a), there are non-impulse sources of low source level, narrow beam width, downward directed transmission, short pulse lengths, frequencies beyond known hearing ranges of marine mammals, or some combination of these factors that are not anticipated to result in takes of protected species and therefore were not modeled. These sources generally meet the following criteria and are qualitatively analyzed in the EIS/OEIS hereafter to determine the appropriate determinations under the National Environmental Policy Act, MMPA, and ESA.

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

1.5.6 Source Classes Analyzed for Training and Testing

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

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

Source Class	Representative Munitions	Net Explosive Weight (lb.)
E1	Medium-caliber projectiles	0.1 to 0.25
E2	Medium-caliber projectiles	0.26 to 0.5
E3	Large-caliber projectiles	>0.5 to 2.5
E4	Improved Extended Echo Ranging (IEER) Sonobuoy	>2.6 to 5.0
E5	5 inch projectiles	>6 to 10
E6	15 lb. shaped charge	>11 to 20
E8	250 lb. bomb	>61 to 100
E9	500 lb. bomb	>101 to 250
E10	1,000 lb. bomb	>251 to 500
E11	650 lb. mine	>501 to 650
E12	2,000 lb. bomb	>651 to 1,000

Note: lb. = pounds

Table 1-2: Non-Impulse Training and Testing Source Classes Analyzed

Source Class Category	Source Class	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals	**LF4**	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
	LF6	Low-frequency sonar currently in development (e.g., anti-submarine warfare sonar associated with the Littoral Combat Ship [LCS])
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	**MF1**	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF2	Hull-mounted surface ship sonar (e.g., AN/SQS-56)
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF8	Active sources (greater than 200 dB) not otherwise binned
	MF9	Active sources (equal to 180 dB and up to 200 dB)
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 200 kHz) signals	**HF1**	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB)
	HF6	Active sources (equal to 180 dB and up to 200 dB)

Table 1-2: Non-Impulse Training and Testing Source Classes Analyzed (continued)

Source Class Category	Source Class	Description
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of anti-submarine warfare testing activities	**ASW1**	Mid-frequency Deep Water Active Distributed System (DWADS)
	ASW2	Mid-frequency MAC sonobuoy (e.g., AN/SSQ-125)
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	**TORP1**	Lightweight torpedo (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)
	TORP2	Heavyweight torpedo (e.g., MK-48)
Acoustic Modems (M): Systems used to transmit data acoustically through water	**M3**	Mid-frequency acoustic modems (greater than 190 dB)
Swimmer Detection Sonar (SD): Systems used to detect divers and submerged *swimmers*	**SD1**	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security.
Airguns (AG)[1]: Underwater airguns are used during swimmer defense and diver deterrent training and testing activities	**AG**	Up to 60 cubic inch airguns (e.g., Sercel Mini-G)

[1] There are no Level A or B takes from airguns.
Notes: dB = decibels, kHz = kilohertz

1.5.7 Source Classes Excluded From Quantitative Analysis for Training and Testing

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

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

Table 1-3 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 Class Category	Source Class	Justification
Doppler Sonar (DS)/ Speed Logs Navigation equipment, downward focused, narrow beam width, HF/VHF spectrum utilizing very short pulse length pulses.	**DS2, DS3, DS4**	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given the source's characteristics (e.g., narrow downward-directed beam), which is focused directly beneath the platform. Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Fathometers (FA) High-frequency sources used to determine water depth	**FA1, FA2, FA3, FA4**	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the fathometer, given its characteristics (e.g., narrow downward-directed beam). Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources. Fathometers generate a downward looking narrowly focused beam directly below the vessel (typically much less than 30 degrees), using a short pulse length (less than 10 milliseconds [msec]). Use of fathometers is required for safe operation of Navy vessels.
Hand-held Sonar (HHS) High-frequency sonar devices used by Navy divers for object location	**HHS1**	Hand-held sonar generate very high frequency sound at low power levels (150 to 178 dB relative to [re] 1 micropascal [µPa]), short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for protected species within approximately 10–15 meters (m), and they are under positive control of the diver on which direction the sonar is pointed, noise impacts are not anticipated and are not addressed further in this analysis.
Imaging Sonar (IMS) HF or VHF, very short pulse lengths, narrow bandwidths. IMS1 is a side scan sonar (HF/VHF, narrow beams, downward directed). IMS2 is a downward looking source, narrow beam, and operates above 200 kHz (basically a fathometer)	**IMS1, IMS2**	These side scan sonar operate in a very high frequency range (over 120 kHz) relative to marine mammal hearing (Richardson et al. 1995; Southall et al. 2007). The frequency range from these side scan sonar is beyond the hearing range of mysticetes (baleen whales) and pinnipeds, and, therefore, not expected to affect these species in the MITT Study Area. The frequency range from these side scan sonar falls within the upper end of odontocete (toothed whale) hearing spectrum (Richardson et al. 1995), which means that they are not perceived as loud acoustic signals with frequencies below 120 kHz by these animals. Therefore, these animals would not react to the sound in a biologically significant way. Further, in addition to spreading loss for acoustic propagation in the water column, high frequency acoustic energies are more quickly absorbed through the water column than sounds with lower frequencies (Urick 1983). Additionally, these systems are generally operated in the vicinity of the sea floor, thus reducing the sound potential of exposure even more. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the IMS given their characteristics (e.g., narrow downward-directed beam and short pulse length (generally 20 msec). Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.

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

Source Class Category	Source Class	Justification
High Frequency Acoustic Modems and Tracking Pingers	**M2, P1, P2, P3, P4,**	As determined for the Ocean Observatories Initiative for multi-beam echo sounder, sub-bottom profiler, altimeters, acoustic modems, and tracking pingers operating at frequencies between 2 and 170 kHz, fish and marine mammals would not be disturbed by any of these proposed acoustic sources given their low duty cycles (single pings in some cases), short pulse lengths (typically 20 msec), the brief period when an individual animal would potentially be within the very narrow beam of the source, and the relatively low source levels of the pingers and acoustic modems. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics. Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Acoustic Releases (R) Systems that transmit active acoustic signals to release a bottom-mounted object from its housing in order to retrieve the device at the surface	**R1, R2, R3**	Mid-frequency acoustic release (up to 190 dB) and high-frequency acoustic release (up to 225 dB). Since these are only used to retrieve bottom mounted devices they are typically only a single ping. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely minimal. Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Side Scan Sonar (SSS) Sonar that use active acoustic signals to produce high-resolution images of the seafloor	**SSS1, SSS2, SSS3**	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics such as a downward-directed beam and using short pulse lengths (less than 20 msec). Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.

Notes: dB = decibels, HF = High Frequency, kHz = kilohertz, MITT = Mariana Islands Training and Testing, VHF = Very High-Frequency

1.6 Proposed Action

The Navy and other services have been conducting military readiness activities in the Study Area for decades. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and force structure (organization of ships, weapons, and Sailors) changes. Such developments influenced the frequency, duration, intensity, and location of required training and testing activities. Training and testing activities were analyzed in the Tactical Theater Training Assessment Program Phase I documents, specifically in the environmental planning document for the Mariana Islands Range Complex (MIRC) (U.S. Department of the Navy 2010). The MITT EIS/OEIS accounts for those factors that cause training and testing fluctuations and has refined its proposed activities in two ways. First, training and testing activities have evolved to meet changes to military readiness requirements. Second, the EIS/OEIS includes additional geographic areas where training and testing activities historically occur.

1.6.1 Study Area Additions

Additions to the Study Area include an overall expansion of the Study Area to the north and west and a transit corridor extending from the MIRC Study Area to the International Date Line. This is not an expansion of where the Navy trains and tests, but is simply an expansion of the area to be analyzed and included in the incidental take authorization in support of the MITT EIS/OEIS.

The overall Study Area boundaries would be expanded to the area depicted in Figure 1-1. The EIS/OEIS contains analyses of areas where training and testing would continue as in the past, but were not considered in previous environmental analyses, including:

- **Expansion of the Northern and Western Boundary of the Study Area:** The area to the north of MIRC that is within the Exclusive Economic Zone of the Northern Mariana Islands and the areas to the west of the MIRC.
- **Transit Corridor:** Another area not previously analyzed is the open ocean associated with a transit corridor commonly used in transit to the MIRC and nearby training and testing areas from the International Date Line. Within this area, U.S. Navy ships frequently transit and, during those transits, conduct limited training and testing. The Navy will include these activities along this transit corridor in this request.

1.6.2 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, amount of non-impulse sound or impulse sound sources used in the activity, the areas where the activity is conducted, and the number of activities per year. More detailed activity descriptions can be found in the MITT EIS/OEIS. The Navy's Proposed Action is an adjustment to existing baseline training activities, as defined in the 2010 MIRC EIS/OEIS and the 2012 MIRC Airspace Environmental Assessment (EA)/Overseas EA (OEA). The Navy's Proposed Action includes changes to training requirements necessary to accommodate:

- Force structure changes including the relocation of ships, aircraft, and personnel. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change.
- Planned new aircraft platforms, new vessel classes, and new weapons systems.
- Ongoing Activities that were not addressed in previous documentation.
- The addition of Maritime Homeland Defense/Security Mine Countermeasures Exercise, as described in Table 2.4-1 of the MITT EIS/OEIS.
- The establishment of Title 33 C.F.R. Part 334 Danger Zones or Title 33 C.F.R. Part 165 Safety Zones for site-specific military ordnance training with Surface Danger Zones or hazard area extending over nearshore waters. Current site specific nearshore danger zones, surface danger zones, and exclusion zones supporting training and testing are depicted in Figure 2.7 1 of the MITT EIS/OEIS and included in the incidental take authorization in support of the MITT EIS/OEIS. Table 2.7-1 of the MITT EIS/OEIS, Nearshore Training and Testing Danger Zones and Safety Zones, lists and describes the nearshore danger zones, surface danger zones, and exclusion zones and their current establishment status as Title 33 C.F.R. Part 334 Danger Zone or 33 C.F.R. Part 165 Safety Zone.
- An increase in net explosive weight (NEW) for explosives from 10 lb. to 20 lb. at Agat Bay Mine Neutralization Site and Outer Apra Harbor Underwater Detonation Site.

In addition, the Proposed Action includes the expansion of the Study Area boundaries, as described in Section 1.6.1 (Study Area Additions), and adjustments to location, type, and tempo of training activities.

Table 1-4: Training Activities Within the Study Area

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
Anti-Surface Warfare				
Impulse	Gunnery Exercise (Surface-to-Surface) Ship – Medium caliber (GUNEX [S-S] – Ship) – Medium caliber	Surface ship crews engage surface targets with medium-caliber guns	Medium-caliber explosive rounds	100
Impulse	Gunnery Exercise (Surface-to-Surface) Ship – Large caliber (GUNEX [S-S] – Ship) – Large caliber	Surface ships engage surface targets with ship's large-caliber guns	Large-caliber explosive rounds	140
Impulse	Gunnery Exercise Surface-to-Surface (Boat) – Medium caliber (GUNEX-S-S [Boat]) – Medium caliber	Small boat crews engage surface targets with medium-caliber weapons	Medium-caliber projectiles and crew's using grenades	10
Impulse	Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against and other surface ships with missiles	Anti-surface missile, such as Harpoon	12
Impulse	Gunnery Exercise (Air-to-Surface) – Medium caliber (GUNEX [A-S] – Medium caliber)	Fixed-wing or helicopter fires small- and medium-caliber guns to engage surface targets	Medium-caliber weapons	295
Impulse	Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S] – Rocket)	Fixed-wing or helicopter fires guided and unguided rockets against surface targets	Guided and unguided rockets	3
Impulse	Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing or helicopter fires precision-guided missiles against surface targets	Anti-surface missile, such as HELLFIRE, Maverick, or TOW missiles	20
Impulse	Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircraft drop bombs against surface targets	Guided and unguided bombs	37
Non-impulse, Impulse	Sinking Exercise (SINKEX)	Aircraft, ship, and submarines use ordnance on surface target, usually deactivated ship, which is deliberately sunk using multiple weapons	A variety of weapons, which may include: Maverick missile, MK-80 series bombs, large-caliber weapons, MK-48 torpedo	2

Table 1-4: Training Activities Within the Study Area (continued)

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
Anti-Surface Warfare				
Impulse	Maritime Security Operations (MSO)	Helicopter and surface ship crews conduct a suite of Maritime Security Operations (e.g., Vessel Search, Board, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operation).	Anti-swimmer grenades	40
Anti-Submarine Warfare				
Non-impulse	Tracking Exercise (TRACKEX)/Torpedo Exercise (TORPEX) – Submarine	Submarine searches, detects, and tracks submarine(s) and surface ship(s). Exercise torpedo may be used.	Submarine sonar, such as BQQ-10 and submarine HF sonar; submarine launched torpedoes, such as MK-48 torpedo or exercise torpedo	10 TORPEX 12 TRACKEX
Non-impulse	Tracking Exercise/ Torpedo Exercise – Surface (Destroyer [DDG]/Cruiser [CG])	Surface ship searches, tracks, and detects submarine(s). Exercise torpedo may be used.	Surface ship sonar, such as SQS-53 sonar; acoustic countermeasures, such as NIXIE; surface launched torpedoes, such as MK-46/MK-54 torpedo or exercise torpedo	1 TORPEX 92 TRACKEX
Non-impulse	Tracking Exercise/ Torpedo Exercise – Surface (Frigate [FFG])	Surface ship searches, tracks, and detects submarine(s). Exercise torpedo may be used during this event.	Surface ship sonar, such as SQS-56 sonar; acoustic countermeasures, such as NIXIE; surface launched torpedoes, such as MK-46/MK-54 torpedo or exercise torpedo	1 TORPEX 30 TRACKEX
Non-impulse	Tracking Exercise/ Torpedo Exercise – Surface (LCS)	Surface ship searches, tracks, and detects submarine(s). Exercise torpedo may be used during this event.	Surface ship sonar, such as HDC-VDS, DWADS Surface launched torpedoes, such as MK-46/MK-54 exercise torpedo	1 TORPEX 10 TRACKEX
Non-impulse	Tracking Exercise/Torpedo Exercise – Helicopter	Helicopter searches, tracks, and detects submarine(s). Exercise torpedo may be used.	Dipping sonar systems, such as AQS-22, sonobuoys, such as DICASS sonobuoys; Air launched torpedoes, such as MK-46/MK-54 exercise torpedo	4 TORPEX 62 TRACKEX

Table 1-4: Training Activities Within the Study Area (continued)

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
Anti-Submarine Warfare				
Non-impulse	Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft	Maritime patrol aircraft use sonobuoys to search, detect, and track submarine(s). Exercise torpedo may be used.	Sonobuoys, such as DICASS sonobuoys; Air launched torpedoes, such as MK-46/MK-54 Exercise torpedo	4 TORPEX 34 TRACKEX
Non-impulse, Impulse	Tracking Exercise – Maritime Patrol Aircraft Extended Echo Ranging (EER) Sonobuoys	Maritime patrol aircraft search, detect, and track submarine(s) using explosive source sonobuoys or multistatic active coherent system	IEER sonobuoys MAC sonobuoys	11
Major Training Activities				
Non-impulse, Impulse	Joint Expeditionary Exercise	The Joint Expeditionary Exercise brings different branches of the U.S. military together in a joint environment that includes planning and execution efforts as well as military training activities at sea, in the air, and ashore. More than 8,000 personnel may participate and could include the combined assets of a Carrier Strike Group and Expeditionary Strike Group, Marine Expeditionary Units, Army Infantry Units, and Air Force aircraft.	Various sonar; acoustic countermeasures, such as NIXIE, various sonobuoys	1
Non-impulse, Impulse	Joint Multi-Strike Group Exercise	Multiday exercise in which up to three strike groups conduct training exercises simultaneously. Training occurs in multiple warfare areas.	Various sonar; acoustic countermeasures, such as NIXIE; various sonobuoys	1
Non-impulse, Impulse	Maritime Homeland Defense/Security Mine Countermeasures	A one-week Joint exercise focused on response to a maritime threat to homeland security. Navy, Coast Guard, and the Department of Homeland Security coordinate actions and response.	Various mine hunting sonar, explosives	1

Table 1-4: Training Activities Within the Study Area (continued)

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
Mine Warfare				
Non-impulse	Mine Countermeasure (MCM) Exercise – Towed Sonar	Surface ships, such as LCS, detect and avoid mines shapes while navigating restricted areas or channels using active sonar	Sonar systems, such as SQS-53, SQS-56,or AQS-20	4
Non-impulse	Mine Countermeasure Exercise – Surface Sonar	Surface ship (MCM, LCS) detect, locate, identify, and avoid mines while navigating restricted areas or channels using active sonar	Surface ship sonar, such as SQQ-32; (MCM) or AQS-20A (LCS)	4
Impulse	Mine Neutralization – EOD	Personnel train to disable mines using mine shaped targets as training aid. Explosive charges may be used.	1.25 lb. to 20 lb. charge	20
Impulse	Mine Neutralization – Remotely Operated Vehicle	Helicopter aircrews disable mines using remotely operated underwater vehicles	Sonar, such as ASQ-235, AQS-20, SLQ-48); Explosives	4
Non-impulse	Submarine Mine Exercise	Submarine practices detecting mines in designated area	Submarine HF sonar	16
Naval Special Warfare				
Impulse	Underwater Demolition Qualification/ Certification	Navy divers conduct training and certification in placing underwater demolition charges	20 lb. NEW charge	30
Other Training Activities				
Non-impulse	Surface Ship Sonar Maintenance	Pier side and at-sea maintenance of surface ship sonar systems. Half of all maintenance use is pierside, half at sea.	Surface ship sonar, such as SQS-53 and SQS-56	42
Non-impulse	Submarine Sonar Maintenance	Pier side and at-sea maintenance of submarine sonar systems	Submarine sonar, such as BQQ-10	48
Non-impulsive	Submarine Navigation	Submarine locates underwater objects and ships while transiting from port	BQQ-10 sonar, Sub HF sonar	8

1.6.3 Testing

The testing activities that the Navy proposes to conduct in the Study Area are described in Tables 1-5 through 1-7.

1.6.3.1 Naval Air Systems Command

Table 1-5: Naval Air Systems Command Testing Activities within the Study Area

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
Anti-Surface Warfare (ASUW)				
Impulse	Air-to-Surface Missile Test	This event is similar to the training event missile exercise (air-to-surface). Test may involve both fixed wing and rotary wing aircraft launching missiles at surface maritime targets to evaluate the weapons system or as part of another systems integration test.	Explosive missiles	8
Anti-Submarine Warfare (ASW)				
Non-impulse	Anti-Submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. The Test evaluates anti-submarine warfare systems onboard rotary wing and fixed wing aircraft and the ability to search for, detect, classify, localize, and track a submarine or similar target. Some tests from fixed-wing aircraft will involve releasing torpedoes and sonobuoys from high altitudes (approximately 25,000 feet [ft.]).	Exercise (Non-explosive) torpedoes	40
Non-impulse, Impulse	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoy)	This event is similar to the training event ASW TRACKEX-Maritime Patrol Aircraft (MPA). The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.	DICASS active sonobuoys, IEER sonobuoys (2 detonations per IEER buoy), High Duty Cycle sonobuoys, various Signal Underwater Sound (SUS) devices, MAC sonobuoys	188

1.6.3.2 Naval Sea Systems Command

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

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
New Ship Construction				
Non-impulse	ASW Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.	Ship sonar, helicopter deployed sonar, torpedo sonar	33
Impulse	ASUW Mission Package Testing	Ships and associated aircraft track and engage against surface targets with medium range missiles and guns.	Explosive missiles, explosive and non-explosive large and medium-caliber rounds	12
Impulse, Non-impulse	MCM Mission Package Testing	Ships and associated aircraft conduct mine countermeasure operations.	Towed sonar systems, mine neutralization systems	32
Life Cycle Activities				
Non-Impulse	Ship Signature Testing	Tests ship and submarine radars, electromagnetic, or acoustic signatures.	Ship sonar systems	17
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing				
Impulse, Non-impulse	Torpedo Testing	Air, surface, or submarine crews employ explosive and non-explosive torpedoes against artificial targets or deactivated ships.	Explosive torpedoes torpedo sonar	2
Non-impulse, impulse	Countermeasure Testing	Various acoustic systems (e.g., towed arrays) are employed to detect, localize, and track incoming weapons. Torpedoes are launched to localize and attack incoming weapons; can be non-explosive torpedo.	Surface ship sonar, torpedo sonar, countermeasures	2
Non-impulse	At-sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.	Submarine and ship sonar	20
Shipboard Protection Systems and Swimmer Defense Testing				
Non-impulse, impulse	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer/diver threats in harbor environments.	Swimmer defense sonar and airgun	11

1.6.3.3 Office of Naval Research

Table 1-7: Office of Naval Research Testing Activities within the Study Area

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual MITT Events
Office of Naval Research - Research, Development, Test and Evaluation				
Non-impulse	North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment (Deep Water)	The primary purpose of the North Pacific Acoustic Lab Philippine Sea Experiment is to collect acoustic and environmental data appropriate for studying the coupling of oceanography, acoustics, and underwater communications.	Mid- and high-frequency sources	1

1.6.4 Summary of Non-Impulse and Impulse Sources

1.6.4.1 Training and Testing Non-Impulse Source Classes

Table 1-8 provides a quantitative annual summary of training and testing activities by non-impulse source class analyzed in this LOA request.

Table 1-8: Annual Hours or Items of Non-Impulse Sources Used During Training and Testing Activities within the Study Area

Source Class Category	Source Class	Annual Use	Metric
Low-Frequency (LF) Sources that produce signals less than 1 kilohertz (kHz)	**LF4**	123	# of hours
	LF5	11	# of hours
	LF6	40	# of hours
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	**MF1**	1,872	# of hours
	MF2	625	# of hours
	MF3	192	# of hours
	MF4	214	# of hours
	MF5	2,588	# of items
	MF6	33	# of items
	MF8	123	# of hours
	MF9	47	# of hours
	MF10	231	# of hours
	MF11	324	# of hours
	MF12	656	# of hours
High-Frequency (HF) and Very High-Frequency (VHF) Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 200 kHz	**HF1**	113	# of hours
	HF4	1,060	# of hours
	HF5	336	# of hours
	HF6	1,173	# of hours

Table 1-8: Annual Hours or Items of Non-Impulse Sources Used During Training and Testing Activities within the Study Area (continued)

Source Class Category	Source Class	Annual Use	Metric
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	**ASW1**	144	# of hours
	ASW2	660	# of items
	ASW3	3,935	# of hours
	ASW4	32	# of items
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	**TORP1**	115	# of items
	TORP2	62	# of items
Acoustic Modems (M) Transmit data acoustically through the water	**M3**	112	# of hours
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	**SD1**	2,341	# of hours
Airgun (AG)[1]	**AG**	308	# of items

[1] There are no Level A or B takes from airguns.

1.6.4.2 Training and Testing Impulse Source Classes

Table 1-9 provides a quantitative annual summary of training and testing impulse source classes analyzed in this LOA request.

Table 1-9: Annual Number of Impulse Source Detonations During Training and Testing Activities within the Study Area

Explosive Class	Net Explosive Weight	Annual In-Water Detonations
E1	(0.1 lb. to 0.25 lb.)	10,140
E2	(0.26 lb. to 0.5 lb.)	106
E3	(0.6 lb. to 2.5 lb.)	932
E4	(>2.5 lb to 5 lb.)	420
E5	(>5 lb. to 10 lb.)	684
E6	(>10 lb. to 20 lb.)	76
E8	(>60 lb. to 100 lb.)	16
E9	(>100 lb. to 250 lb.)	4
E10	(>250 lb. to 500 lb.)	12
E11	(>500 lb. to 650 lb.)	6
E12	(>650 lb. to 2,000 lb.)	184

Note: lb. = pounds

1.6.5 Other Stressors – Vessel Strikes

Vessels strikes may occur from surface operations and sub-surface operations (excluding bottom crawling, unmanned underwater vehicles). Vessels used as part of the proposed action include ships, submarines and boats ranging in size from small, 16 feet (ft.) (5 meters [m]) Rigid Hull Inflatable Boat to aircraft carriers (CVNs) with lengths up to 1,092 ft. (333 m). Representative Navy vessel types, lengths, and speeds used in both training and testing activities are shown in Table 1-10.

Table 1-10: Typical Navy Boat and Vessel Types with Length Greater than 18 Meters Used within the Study Area

Vessel Type (>18 m)	**Example(s)** (specifications in meters (m) for length, metric tons (mt) for mass, and knots for speed)	**Typical Operating Speed** (knots)
Aircraft Carrier	**Aircraft Carrier (CVN)** length: 333 m beam: 41 m draft: 12 m displacement: 81,284 mt max. speed: 30+ knots	10–15
Surface Combatants	**Cruiser (CG)** length: 173 m beam: 17 m draft: 10 m displacement: 9,754 mt max. speed: 30+ knots **Destroyer (DDG)** length: 155 m beam: 18 m draft: 9 m displacement: 9,648 mt max. speed: 30+ knots **Frigate (FFG)** length: 136 m beam: 14 m draft: 7 m displacement: 4,166 mt max. speed: 30+ knots **Littoral Combat Ship (LCS)** length: 115 m beam: 18 m draft: 4 m displacement: 3,000 mt max. speed: 40+ knots	10–15
Amphibious Warfare Ships	**Amphibious Assault Ship (LHA, LHD)** length: 253 m beam: 32 m draft: 8 m displacement: 42,442 mt max. speed: 20+knots **Amphibious Transport Dock (LPD)** length: 208 m beam: 32 m draft: 7 m displacement: 25,997 mt max. speed: 20+knots **Dock Landing Ship (LSD)** length: 186 m beam: 26 m draft: 6 m displacement: 16,976 mt max. speed: 20+knots	10–15
Mine Warship Ship	**Mine Countermeasures Ship (MCM)** length: 68 m beam: 12 m draft: 4 m displacement: 1,333 max. speed: 14 knots	5–8
Submarines	**Attack Submarine (SSN)** length: 115 m beam: 12 m draft: 9 m displacement: 12,353 mt max. speed: 20+knots **Guided Missile Submarine (SSGN)** length: 171 m beam: 13 m draft: 12 m displacement: 19,000 mt max. speed: 20+knots	8–13

Table 1-10: Typical Navy Boat and Vessel Types with Length Greater than 18 Meters Used within the Study Area (continued)

Vessel Type (>18 m)	**Example(s)** (specifications in meters (m) for length, metric tons (mt) for mass, and knots for speed)	**Typical Operating Speed** (knots)
Combat Logistics Force (CLF) Ships[1]	**Fast Combat Support Ship (T-AOE)** length: 230 m beam: 33 m draft: 12 m displacement: 49,583 mt max. speed: 25 knots **Dry Cargo/Ammunition Ship (T-AKE)** length: 210 m beam: 32 m draft: 9 m displacement: 41,658 mt max speed: 20 knots **Fleet Replenishment Oilers (T-AO)** length: 206 m beam: 30 m draft: 11 displacement: 42,674 mt max. speed: 20 knots **Fleet Ocean Tugs (T-ATF)** length: 69 m beam: 13 m draft: 5 m displacement: 2,297 mt max. speed: 14 knots **Joint High Speed Vessel (JHSV)**[2] length: 103 m beam: 28.5 m draft: 4.57 m displacement: 2,362 mt max speed: 40 knots	8–12
Support Craft/Other	**Landing Craft, Utility (LCU)** length: 41m beam: 9 m draft: 2 m displacement: 381 mt max. speed: 11 knots **Landing Craft, Mechanized (LCM)** length: 23 m beam: 6 m draft: 1 m displacement: 107 mt max. speed: 11 knots	3–5
Support Craft/Other Specialized High Speed	**MK V and VI Special Operations Craft** length: 25 m beam: 5 m displacement: 52 mt max. speed: 50 knots	Variable

[1] CLF vessels are not normally permanently homeported in Pearl Harbor or San Diego, but are frequently used for various fleet support and training support events in the MITT.
[2] Typical operating speed of the Joint High Speed Vessel is 25–32 knots.

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

The number of Navy vessels in the Study Area varies based on training and testing schedules. Most activities include either one or two vessels, with an average of one vessel per activity, and last from a few hours up to two weeks. Multiple ships, however, can be involved with major training events, although ships can often operate for extended periods beyond the horizon and out of visual sight from each other.

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

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2 DURATION AND LOCATION OF ACTIVITIES

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

Training and testing activities would be conducted in the Study Area throughout the year from July 2015 through July 2020.

The MITT Study Area is comprised of the established ranges, operating areas, and special use airspace in the region of the Mariana Islands that are part of the MIRC, its surrounding seas, and includes a representative transit corridor. The representative transit corridor is outside the geographic boundaries of the MIRC and is a direct route across the high seas for Navy assets in transit[3] between the Mariana Islands and the Hawaii Range Complex starting at the International Date Line. The MITT Study Area also includes Navy pierside activity locations where sonar maintenance or testing may occur. The MITT Study Area is depicted in Figure 2-1.

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

- **Operating Area.** An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. Operating areas may include the following:
    - **Danger Zones.** A danger zone is a defined water area used for target practice, bombing, rocket firing, or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the Army Corps of Engineers. Danger zones may be closed to the public on a full-time or intermittent basis (33 Code of Federal Regulations [C.F.R.] 334).
    - **Restricted Areas.** A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and/or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 C.F.R. 334).
    - **Safety Zones.** A Safety Zone is a water area, shore area, or water and shore area to which, for safety or environmental purposes, access is limited to authorized persons, vehicles, or vessels. It may be stationary and described by fixed limits or it may be described as a zone around a vessel in motion. Safety zones are established pursuant to statutory authority of the U.S. Coast Guard. Safety zones may be closed to the public on a full-time or temporary basis (33 C.F.R. 165).

[3] Vessel transit corridors are routes typically used by Navy assets to traverse from one area to another. The route depicted in Figure 2-1 is a representational direct route between the Mariana Islands and the Hawaii Range Complex starting at the International Date Line, making it a quick and fuel-efficient transit. The depicted transit corridor is notional and may not represent actual routes used. Actual routes navigated are based on a number of factors including, but not limited to, weather, training, and operational requirements.

  - **Surface Danger Zones.** A Surface Danger Zone is the surface and airspace designated within the range complex for vertical and lateral containment of projectiles, fragments, debris, and components resulting from the firing, launching, or detonation of weapon systems to include explosives and demolitions. The Surface Danger Zone is a depiction of the mathematically predicted area a projectile will return to earth either by direct fire or ricochet. Surface Danger Zones are calculated by the range operator to contain the hazard area for each unique live fire training event and location, hence they are not permanently charted.
  - **Exclusion Zones.** The purpose of the Exclusion Zone is the protection of unauthorized personnel from blast overpressure and fragmentation hazards from ordnance disposal and explosive charges. It is the minimum separation distance between the exploding device or ordnance and unauthorized personnel. The range operator will exclude unauthorized personnel from the Exclusion Zone and delay conduct of a live fire event until the Exclusion Zone has been cleared.

- **Special Use Airspace.** Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8 2013). Types of special use airspace most commonly found in range complexes include the following:

  - **Restricted Areas.** Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD), and some are shared with non-military agencies.
  - **Military Operations Areas.** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.
  - **Warning Area.** Areas of defined dimensions, extending from 3 nautical miles (nm) outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.
  - **Air Traffic Control Assigned Airspace.** Airspace that is Federal Aviation Administration defined and is not over an existing training and testing area. It is used to contain specified activities, such as military flight training, that are segregated from other instrument flight rules air traffic.

The MITT Study Area includes the representative transit corridor, the MIRC land training areas, and at-sea operating areas that were previously addressed in the MIRC EIS/OEIS (May 2010) with modifications to the special use air space that were addressed in the MIRC Airspace EA/OEA (U.S. Department of the Navy 2013), the seaward extensions to the northern and western edges of the MIRC, and MIRC pierside locations in Apra Harbor and Inner Apra Harbor.

2.1 MARIANA ISLANDS RANGE COMPLEX

The MIRC includes land training areas, ocean surface areas, and subsurface areas. These areas extend from the waters south of Guam to north of Pagan (Commonwealth of the Northern Mariana Islands [CNMI]), and from the Pacific Ocean east of the Mariana Islands to the Philippine Sea to the west, encompassing 501,873 square nautical miles (nm^2) of open ocean.

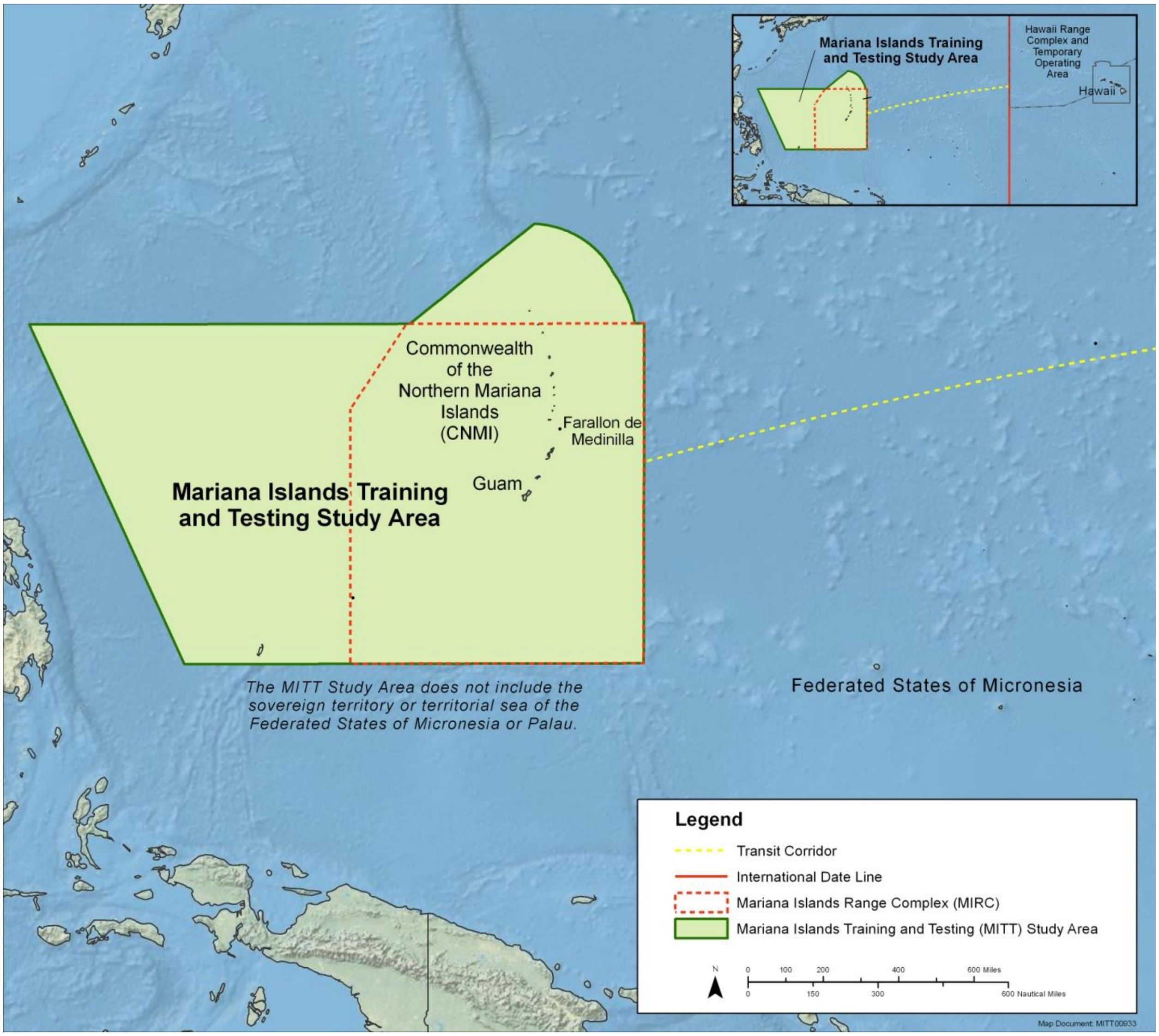

Figure 2-1: Mariana Islands Training and Testing Study Area

2.1.1 SPECIAL USE AIRSPACE

In a separate EA/OEA that tiers off from the MIRC EIS/OEIS, the Navy analyzed the potential impacts of expanding the airspace and seaspace of training areas in the Study Area and replacing the Air Traffic Control Airspace (ATCAA) with Warning Areas. In that EA/OEA, no new training or testing events were proposed and the EA/OEA found no significant impacts to the environment from the airspace expansion. The FAA has rule-making authority for the expansion of the airspace surrounding FDM, and the MIRC Airspace EA/OEA supported the FAA in its rule-making process to establish the SUA. No FAA rule-making is required for the additional airspace expansion resulting in the creation of new warning areas. Once rule-making is complete, the MITT Study Area will include approximately 77,000 nm^2 of SUA. As depicted in Figure 2-2, this airspace is almost entirely over the ocean (except ATCAA 6) and includes warning areas, ATCAA, and restricted areas.

- Warning Area (W)-517 (Figure 2-3) and W-12 include approximately 11,769 nm^2 of SUA. W-11 (A/B) is approximately 10,467 nm^2 of SUA, and W-13 (A/B/C) is approximately 12,769 nm^2 of SUA.
- The ATCAA of the MIRC account for more than 28,750 nm^2 of airspace and includes ATCAA 5 and ATCAA 6 (Figure 2-2).
- The restricted area airspace over or near land areas within the MIRC makes up 450 nm^2 of SUA and includes restricted areas (R)-7201 and R-7201A, which extends in a 12-nm radius from the center of FDM (Figure 2-2).

2.1.2 DANGER ZONES

The MIRC EA/OEA also analyzed the expansion of the DZ around FDM Restricted Area 7201 from 10 nm to 12 nm. The Army Corps of Engineers has rule-making authority for the DZ expansion, and the MIRC Airspace EA/OEA supported the Army Corp of Engineers in its rule-making process to establish DZs under 33 C.F.R. 334. Once rule-making is complete, the DZ around FDM will include approximately 450 nm^2 based on a radius of 12 nm extending from the center of FDM.

The Proposed Action for the MITT Study Area includes the establishment of DZs for site specific military ordnance training conducted at Orote Point Known Distance Range, Small Boat Small Arms Range, Agat Bay Floating Mine Neutralization Site, Piti Point Floating Mine Neutralization Site, Apra Harbor Underwater Detonation Site, Finegayan Small Arms Range, Pati Point Combined Arms Training and Maintenance Range, and Pati Point EOD Range (Figure 2-4).

2.1.3 SEA AND UNDERSEA SPACE

The MITT EIS/OEIS Study Area includes the undersea space to the ocean floor. The MIRC is a component of the MITT EIS/OEIS Study Area. The MIRC EIS/OEIS designated sea and undersea space training sites within the Study Area to include designated drop zones, underwater demolition and floating mine neutralization sites, a danger zone associated with FDM (0 to 10 nm) and Orote Point Known Distance Range, and training areas associated with nearshore military controlled beaches, harbors, and littoral areas. Portions of the Marianas Trench National Monument, established in January 2009 by Presidential Proclamation under the authority of the Antiquities Act (16 U.S.C. §§ 431-433), lie within the Study Area. The prohibitions required by the Proclamation do not apply to activities and exercises of the Armed Forces (including those carried out by the U.S. Coast Guard). Underwater detonation sites in the MITT Study Area are located off the western side of Guam in or in the vicinity of Apra Harbor (Figure 2-5). Training or testing activities that would take place at these sites include:

- Maritime Homeland Defense/Security Mine Countermeasures Exercise – A one-week Joint exercise focused on response to a maritime threat to homeland security. Navy, Coast Guard, and the Department of Homeland Security coordinate actions and response.
- Maritime Security Operations – Helicopter and surface ship crews conduct a suite of Maritime Security Operations (e.g., Vessel Search, Board, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operation).
- Mine Neutralization – Explosive Ordnance Disposal (EOD) – Personnel disable threat mines. Explosive charges may be used.
- Underwater Demolition Qualification/Certification – Navy divers conduct training and certification in placing underwater demolition charges.
- Mine Countermeasures (MCM) Mission Package Testing – Ships conduct mine countermeasure operations.

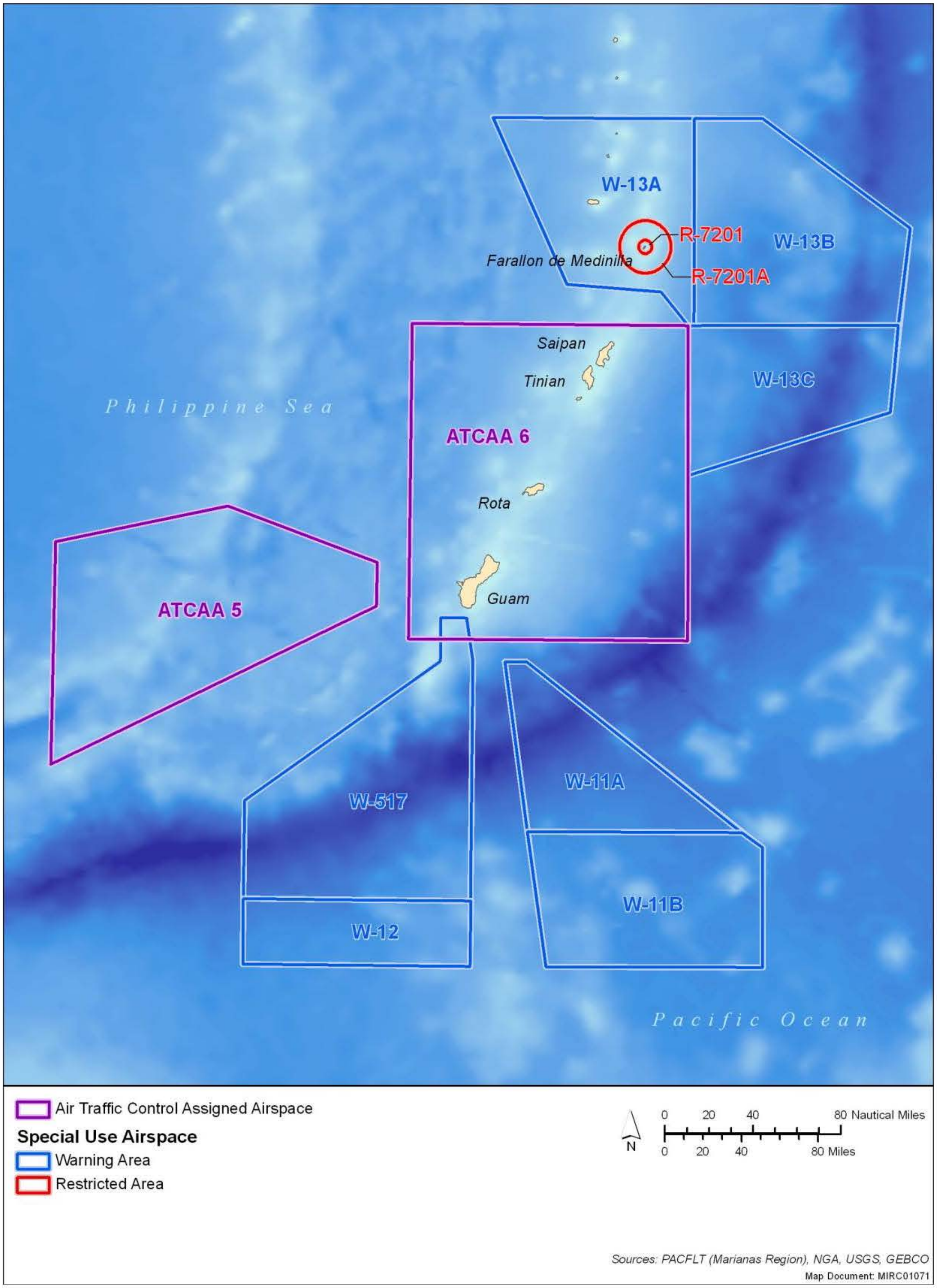

Figure 2-2: Mariana Islands Range Complex Airspace

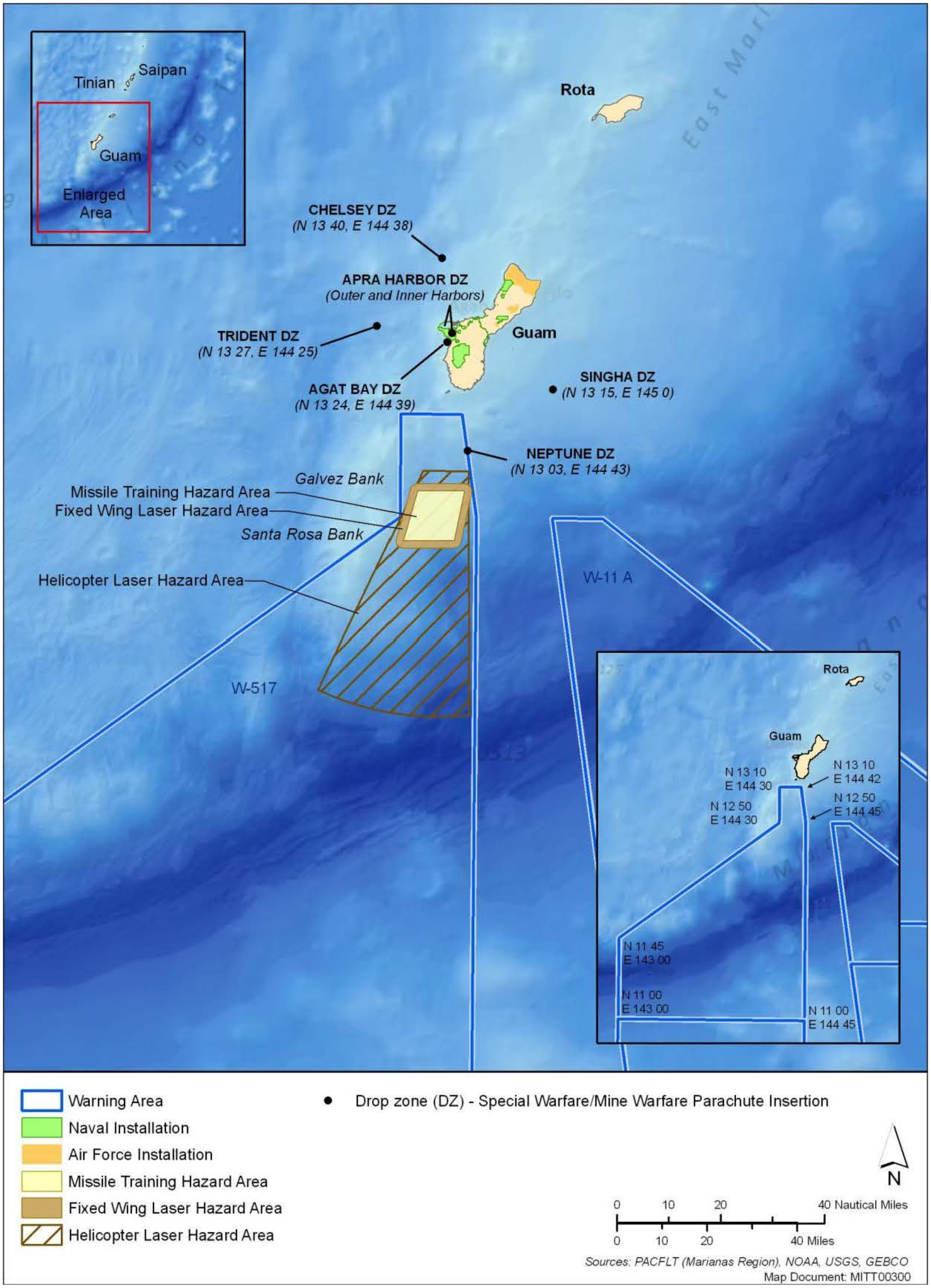

Figure 2-3: Warning Area 517 and Proposed Warning Area 12

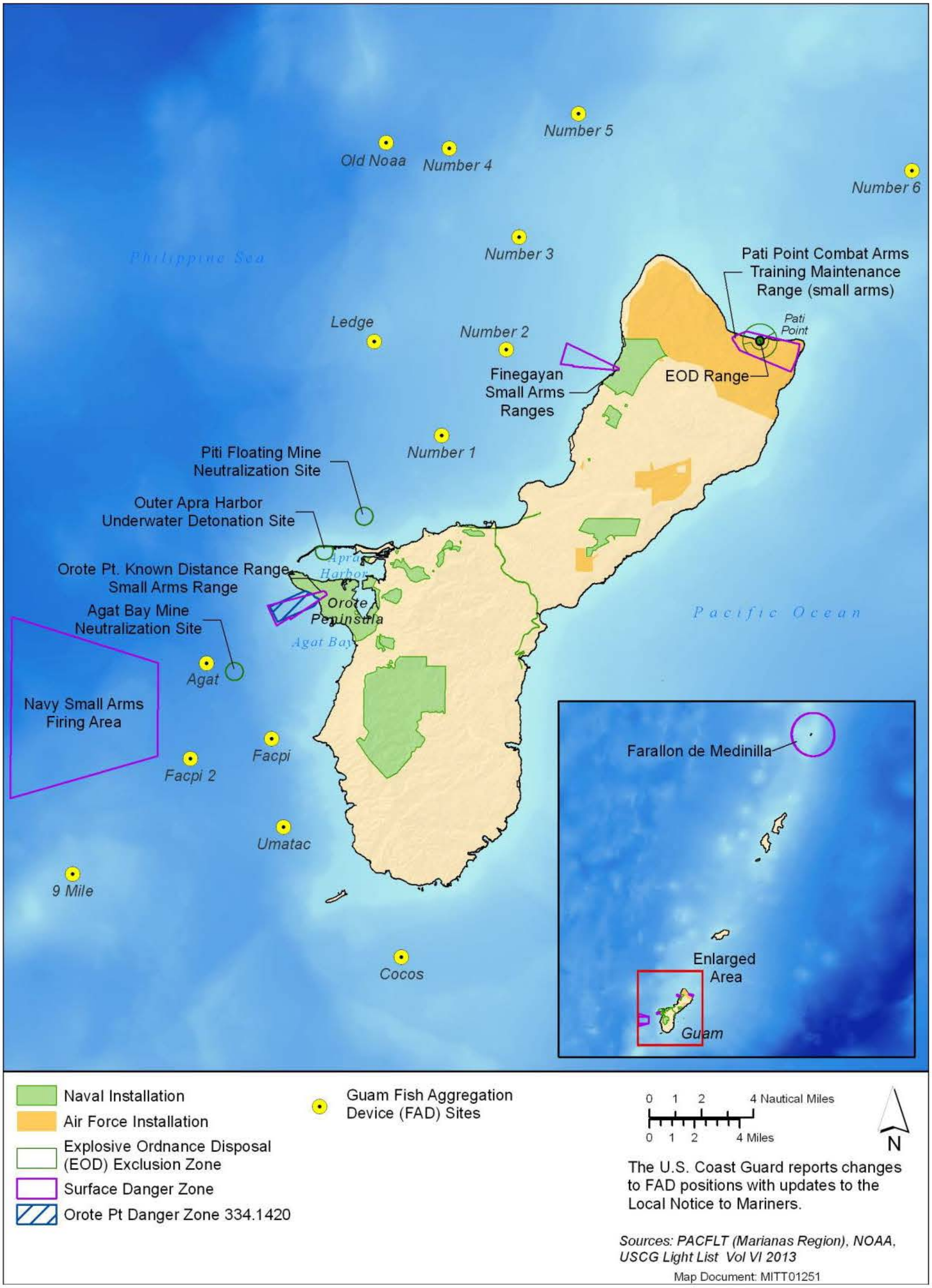

Figure 2-4: Nearshore Training and Testing Danger Zones, Surface Danger Zones, and Exclusion Zones

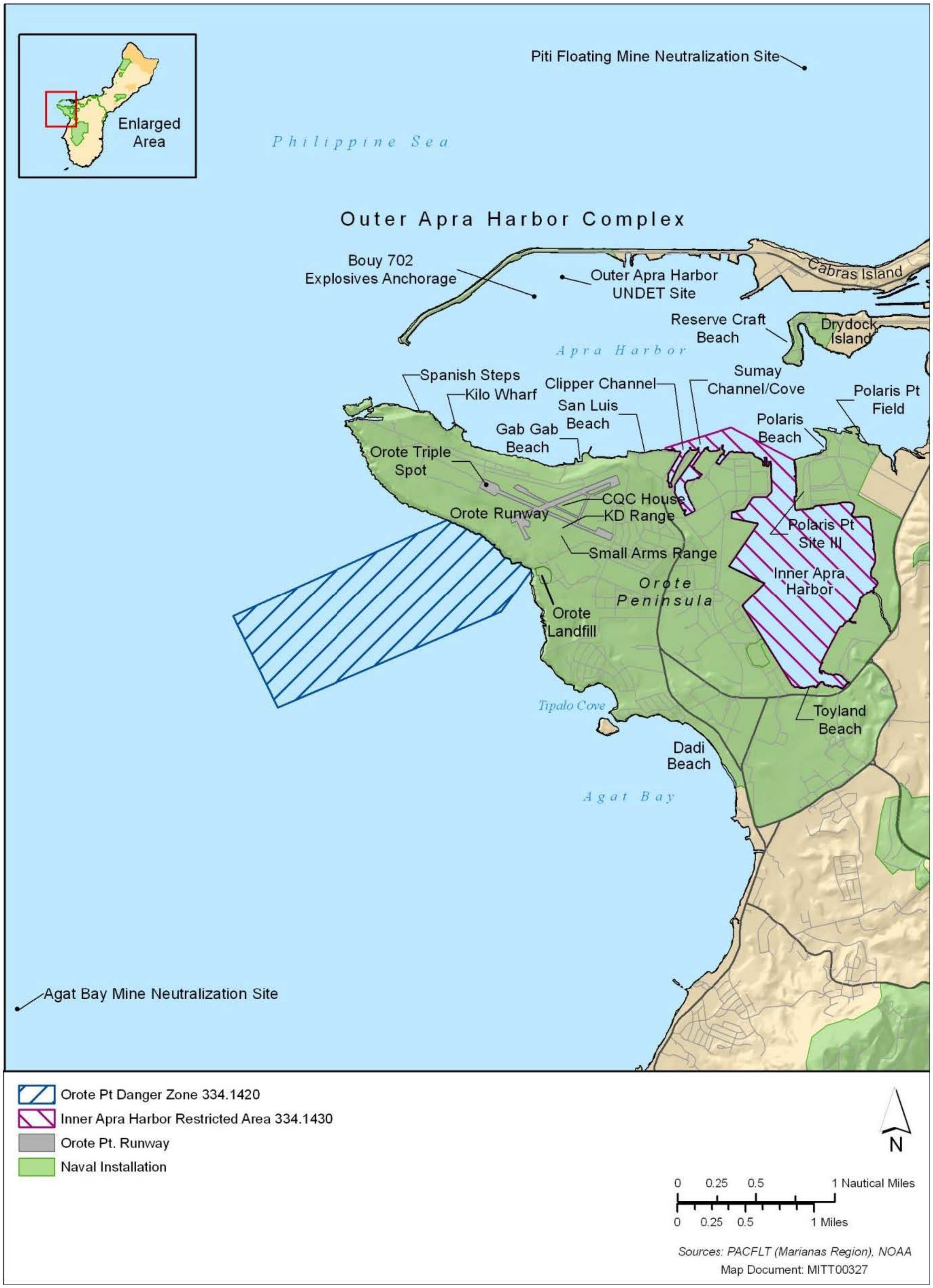

Figure 2-5: Underwater Detonations Sites Located in or in the Vicinity of Apra Harbor

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3 MARINE MAMMAL SPECIES AND NUMBERS

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

3.1 MARINE MAMMAL SPECIES

Twenty-six marine mammal species may occur in the MITT Study Area, including 7 mysticetes (baleen whales) and 19 odontocetes (dolphins and toothed whales). These species are presented in Table 3-1 and relevant information on their status, distribution, and seasonal distribution (when applicable) is presented in Chapter 4 (Affected Species Status and Distribution). Extralimital species (i.e., a species that does not usually occur in the area but for which there is at least one recorded occurrence) and species that may have once inhabited or transited the MITT Study Area but have not been sighted in recent years, include the North Pacific right whale (*Eubalaena japonica*), western subpopulation of gray whale (*Eschrichtius robustus*), short-beaked common dolphin (*Delphinus delphis*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), Hawaiian monk seal (*Monachus schauinslandi*), northern elephant seal (*Mirounga angustirostris*), and dugong (*Dugong dugon*). These species are not expected to be exposed to or affected by any project activities and, therefore, are not discussed further.

There are five ESA-listed species known to occur in the region (Table 3-1); however, no critical habitat for marine mammals protected under the ESA has been designated within the MITT Study Area. Further, due to the paucity of systematic survey data in the Study Area, little is known about the stock structure of the majority of marine mammal species in the region. Therefore, there is no specific Study Area information on the stocks recognized and managed by the NMFS.

Prior to 2007 there was little information available on the occurrence of marine mammals in the Study Area, and much of what was known came from whaling records, stranding records, and anecdotal sighting reports. Eldredge (1991) compiled the first list of published and unpublished records for the greater Micronesia area, reporting 19 marine mammal species, later refining the list to 13 cetacean species thought to occur around Guam (Eldredge 2003). Wiles (2005) provided a list of birds and mammals recorded in the Micronesia area through March 2005, including all records of marine mammals. Some sighting data are available from scientific surveys conducted in the western and central Pacific, although most of these efforts focused on waters off Japan, Taiwan, the Philippines, and lower latitude regions (Darling and Mori 1993; Yang et al. 1999; Wang et al. 2001; Ohizumi et al. 2002; Dolar et al. 2006), and provide limited to no data specific to the Study Area.

The Navy conducted the first comprehensive marine mammal survey of waters off the Mariana Islands from 13 January to 13 April 2007 (Fulling et al. 2011). The survey was conducted using systematic line transect survey protocol consistent with that used by NMFS, Southwest Fisheries Science Center (Barlow 2003; 2006). Both visual and acoustic detection methods were used during the survey (Fulling et al. 2011). The Navy also conducted a 5-day aerial survey in August 2007, providing additional sighting data specific to the Study Area (Mobley 2007).

Table 3-1: Marine Mammals with Possible or Confirmed Presence within the Mariana Islands Training and Testing Study Area

Species Name and Regulatory Status				Occurrence in Study Area[4]	
Common Name	Scientific Name[1]	ESA Status[2]	MMPA Status[3]	Summer (June–Nov)	Winter (Dec–May)
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Humpback whale	*Megaptera novaeangliae*	Endangered	Depleted	Rare	Regular
Blue whale	*Balaenoptera musculus*	Endangered	Depleted	Rare	Rare
Fin whale	*Balaenoptera physalus*	Endangered	Depleted	Rare	Rare
Sei whale	*Balaenoptera borealis*	Endangered	Depleted	Rare	Regular
Bryde's whale	*Balaenoptera brydei/edeni*	Not Listed	-	Regular	Regular
Minke whale	*Balaenoptera acutorostrata*	Not Listed	-	Rare	Regular
Omura's whale	*Balaenoptera omurai*	Not Listed	-	Rare	Rare
Suborder Odontoceti (toothed whales)					
Sperm whale	*Physeter macrocephalus*	Endangered	Depleted	Regular	Regular
Pygmy sperm whale	*Kogia breviceps*	Not Listed	-	Regular	Regular
Dwarf sperm whale	*Kogia sima*	Not Listed	-	Regular	Regular
Killer whale	*Orcinus orca*	Not Listed	-	Regular	Regular
False killer whale	*Pseudorca crassidens*	Not Listed	-	Regular	Regular
Pygmy killer whale	*Feresa attenuata*	Not Listed	-	Regular	Regular
Short-finned pilot whale	*Globicephala macrorhynchus*	Not Listed	-	Regular	Regular
Melon-headed whale	*Peponocephala electra*	Not Listed	-	Regular	Regular
Common bottlenose dolphin	*Tursiops truncatus*	Not Listed	-	Regular	Regular
Pantropical spotted dolphin	*Stenella attenuata*	Not Listed	-	Regular	Regular
Striped dolphin	*Stenella coeruleoalba*	Not Listed	-	Regular	Regular

Table 3-1: Marine Mammals with Possible or Confirmed Presence within the Mariana Islands Training and Testing Study Area (continued)

Species Name and Regulatory Status				Occurrence in Study Area[4]	
Common Name	**Scientific Name[1]**	**ESA Status[2]**	**MMPA Status[3]**	**Summer (June–Nov)**	**Winter (Dec–May)**
Spinner dolphin	*Stenella longirostris*	Not Listed	-	Regular	Regular
Rough-toothed dolphin	*Steno bredanensis*	Not Listed	-	Regular	Regular
Fraser's dolphin	*Lagenodelphis hosei*	Not Listed	-	Regular	Regular
Risso's dolphin	*Grampus griseus*	Not Listed	-	Regular	Regular
Cuvier's beaked whale	*Ziphius cavirostris*	Not Listed	-	Regular	Regular
Blainville's beaked whale	*Mesoplodon densirostris*	Not Listed	-	Regular	Regular
Longman's beaked whale	*Indopacetus pacificus*	Not Listed	-	Regular	Regular
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	Not Listed	-	Rare	Rare

[1] Taxonomy follows Perrin et al. (2009).
[2] ESA listing status from Carretta et al. (2011).
[3] All marine mammals are protected under the MMPA. Populations or stocks that have fallen below the optimum sustainable population level are depleted. Due to the paucity of survey data, little is known about the stock structure of species in the region.
[4] Regular = a species that occurs as a regular or usual part of the fauna of the area, regardless of how abundant or common it is; Rare = a species that occurs in the area only sporadically. Occurrence designations from the Navy's Mariana Islands Marine Resource Assessment (MRA; U.S. Department of the Navy 2005), updated with new information as described in U.S. Department of the Navy (2012a). The MRA compiles species occurrence information based on peer-reviewed papers, unpublished technical reports, and other information sources.
Notes: ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act

Subsequent to the 2007 surveys, both the Navy and NMFS, Pacific Islands Fisheries Science Center have conducted dedicated small boat surveys around Guam and the CNMI, including: (1) surveys off Guam and Saipan from 9 February to 3 March 2010 (Oleson and Hill 2010; Ligon et al. 2011), (2) surveys off Guam from 17 February to 3 March 2011 (HDR 2011), (3) surveys off Guam and other islands in the CNMI from 26 August to 29 September 2011 (Hill et al. 2011), (4) surveys off Guam and Saipan from 15 to 29 March 2012 (HDR EOC 2012), and (5) surveys off Guam and other islands in the CNMI at various times between May and July 2012 (Hill et al. 2013). In addition, NMFS Pacific Islands Fisheries Science Center conducted a large vessel cetacean and oceanographic survey between Honolulu and Guam and within the Exclusive Economic Zones of Guam and CNMI from 20 January to 3 May 2010 (Oleson and Hill 2010). Information on the cetaceans sighted during the Navy and Pacific Islands Fisheries Science Center surveys are summarized within the species-specific subsections included in Chapter 4 (Affected Species Status and Distribution).

3.2 Marine Mammal Numbers

In order to conduct a quantitative analysis of the potential impacts on marine mammals, data on the abundance and distribution of the species occurring in the MITT Study Area were needed. To develop a database of marine species density estimates, the Navy, in consultation with NMFS experts at the two science centers (Southwest Fisheries Science Center and Pacific Islands Fisheries Science Center), adopted a protocol to select the best data sources based on available species information. As shown in Table 3-2, the resulting Geographic Information System database includes a density estimate for every marine mammal species present within the MITT Study Area (U.S. Department of the Navy 2012b).

Table 3-2: Marine Mammal Density Estimates Used for the MITT Study Area Effects Analysis

Species	Density Estimate (animals/km^2)	Source (see text for additional information)
Order Cetacea		
Suborder Mysticeti (baleen whales)		
Humpback whale	0.00089 (CV = NA)	LGL Limited 2008
Blue whale	0.00001 (CV = 1.00)	Ferguson and Barlow 2003
Fin whale	0.00001 (CV = 1.00)	Ferguson and Barlow 2003
Sei whale	0.00029 (CV = 0.49)	Fulling et al. 2011
Bryde's whale	0.00041 (CV = 0.45)	Fulling et al. 2011
Minke whale	0.00059 (CV = 0.25)	Norris et al. 2012
Omura’s whale	0.00004 (CV = NA)	10% of Fulling et al. 2011 Bryde’s whale estimate based on approach taken by LGL (2008)
Suborder Odontoceti (toothed whales)		
Sperm whale	0.00123 (CV = 0.60)	Fulling et al. 2011
Blainville’s beaked whale	0.00117 (CV = 1.25)	Barlow 2006
Bottlenose dolphin	0.00131 (CV = 0.59)	Barlow 2006
Cuvier's beaked whale	0.00621 (CV = 1.43)	Barlow 2006
Dwarf sperm whale	0.00714 (CV = 0.74)	Barlow 2006
False killer whale	0.00111 (CV = 0.74)	Fulling et al. 2011
Fraser’s dolphin	0.00417 (CV = 1.16)	Barlow 2006
Ginkgo-toothed beaked whale	0.00093 (CV = 0.41) (*Mesoplodon* spp.)	Ferguson and Barlow 2003
Killer whale	0.00014 (CV = 0.98)	Barlow 2006
Longman’s beaked whale	0.0004 (CV = 1.26)	Barlow 2006
Melon-headed whale	0.00428 (CV = 0.70)	Fulling et al. 2011
Pantropical spotted dolphin	0.0226 (CV = 0.70)	Fulling et al. 2011
Pygmy killer whale	0.00014 (CV = 0.88)	Fulling et al. 2011
Pygmy sperm whale	0.00291 (CV = 1.12)	Barlow 2006
Risso's dolphin	0.00097 (CV = 0.65)	Barlow 2006
Rough-toothed dolphin	0.00355 (CV = 0.45)	Barlow 2006

Table 3-2: Marine Mammal Density Estimates Used for the MITT Study Area Effects Analysis (continued)

Species	Density Estimate (animals/km^2)	Source (see text for additional information)
Suborder Odontoceti (toothed whales)		
Short-finned pilot whale	0.00362 (CV = 0.38)	Barlow 2006
Spinner dolphin	Inshore (w/in 10nm): 0.00699 Offshore (> 10nm): 0.00083 (Overall CV = 0.74)	Barlow 2006
Striped dolphin	0.00616 (CV = 0.54)	Fulling et al. 2011

Notes: CV = Coefficient of Variation, km^2 = square kilometers, nm = nautical miles

The primary data source for the MITT Study Area is the Navy-funded 2007 line-transect survey, which provides the only published density estimates based upon systematic sighting data collected specifically in this region (Fulling et al. 2011). Norris et al. (2012) used modified line-transect methods to estimate minke whale density based on passive acoustic detections from the 2007 survey. Given the similar habitat and species diversity with the MITT Study Area, density estimates derived from survey data in waters around the Hawaiian Islands (Barlow 2006) were also used for species with insufficient sightings to estimate densities during the 2007 survey. For spinner dolphin, density estimates were defined for both an island-associated and pelagic population, consistent with data from Barlow (2006).

Densities from surveys in the Eastern Tropical Pacific (Ferguson and Barlow 2003) were used for blue whale, fin whale, and ginkgo-toothed beaked whale. For blue and ginkgo-toothed beaked whales, densities and associated coefficients of variation were re-calculated from the Ferguson and Barlow (2003) strata having oceanic conditions similar to the Mariana Islands region, including Strata 122 to 131 (extending west of 105 degrees [°] W between 5 to 10°N) and 141 to 151 (extending west of 95°W between 10 and 15°N). The ginkgo-toothed beaked whale estimate represents the density for unidentified species belonging to the genus *Mesoplodon* (Ferguson and Barlow 2003). There are few sightings of fin whales south of 30° N and they are considered rare in the tropics (Reilly et al. 2008c). Therefore, the blue whale estimate was used to represent a conservative estimate of fin whale density.

There was one off-effort humpback whale sighting during the 2007 survey of the Study Area and this species was detected acoustically; however, these data did not allow for a density estimate. In the absence of any other density data, an estimate from an assessment of potential impacts on cetaceans from a seismic survey in southeast Asia was used (LGL Limited 2008). The LGL Limited (2008) density estimate is considered a reasonable approximation given their habitat assumptions (i.e., a mix of bathymetry but primarily deep water habitat) and use of regional sighting data. The distribution of Omura’s whale extends into the Study Area (Reilly et al. 2008a), but no density estimates are available for this species. Therefore, 10 percent of the Bryde’s whale density estimate was used for this species, consistent with the approach taken by LGL Limited (2008).

To reduce redundancy, additional information about the species and numbers of marine mammals likely to be found within the Study Area is included in Chapter 4 (Affected Species Status and Distribution).

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4 AFFECTED SPECIES STATUS AND DISTRIBUTION

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

The marine mammal species discussed in this section are those for which general regulations governing potential incidental takes of marine mammals are sought. Relevant information on their status, distribution, and seasonal distribution (when applicable) is presented below, as well as additional information about the numbers of marine mammals likely to be found within the activity areas. Information on the general biology and ecology of marine mammals is beyond the scope of this application and is included in the Mariana Islands Marine Resource Assessment (U.S. Department of the Navy 2005). The Navy is currently updating the Mariana Islands Marine Resource Assessment and it should be available in spring of 2013. Additional information on the general biology and ecology of marine mammals are included in Rice (1998), Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009).

Humpback Whale (*Megaptera novaeangliae*)

Status – Humpback whales are listed as depleted under the MMPA and endangered under the ESA. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or down listing from the U.S. Endangered Species List (National Marine Fisheries Service 2009a).

In the Pacific, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2010). NMFS has designated four stocks: (1) the Central North Pacific stock, with feeding areas from Southeast Alaska to the Alaska Peninsula; (2) the Western North Pacific stock, with feeding areas from the Aleutian Islands, Bering Sea, and Russia; (3) the California, Oregon, Washington, and Mexico stock, with feeding areas off the U.S. west coast; and (4) the American Samoa Stock, with feeding areas as far south as the Antarctic Peninsula (Allen and Angliss 2010). Humpback whales in the MITT Study Area are most likely part of the Western North Pacific stock.

Distribution and Seasonal Distribution – Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs (Herman et al. 2010). In the north Pacific, humpback whales feed primarily along the Pacific Rim from California to Russia (Barlow et al. 2011). Wintering (breeding) areas for North Pacific humpback whales include the coasts of Central America and Mexico, offshore islands of Mexico, Hawaii, and the western Pacific (Calambokidis et al. 2001). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 degrees Fahrenheit [°F] to 82°F) (24 degrees Celsius [°C] to 28°C) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Smultea 1994; Clapham 2000; Craig and Herman 2000). There is known to be some interchange of whales among different wintering grounds, for example, some of these interchanges have been noted between Hawaii and Japan and between Hawaii and Mexico (Darling et al. 1996; Calambokidis et al. 2001). Although interchange does occur among all the breeding stocks in the wintering grounds, it is not common (Calambokidis et al. 1997; Calambokidis et al. 2001). Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Clapham and Mattila 1990; Calambokidis et al. 2001).

Humpback whales have been sighted during the Navy's routine aerial surveys of FDM on several occasions, including two sightings in 2006 (January and March), both close to the island, and another sighting in February 2007, 18 miles (mi.) (29 kilometers [km]) north of Saipan (Vogt 2008). During a ship survey in the Study Area (January to April 2007), humpback whales were observed in both deep (2,625 to 3,940 ft. [800 to 1,200 m]) and shallow (1,234 ft. [374 m]) waters northeast of Saipan (Fulling et al. 2011). Acoustic detections of humpback song were also made during these sightings as well as on other occasions (Fulling et al. 2011). These observations suggest that there could be a small wintering population of humpback whales in the MITT Study Area, although additional research is needed for confirmation (Fulling et al. 2011; Ligon et al. 2011).

Population and Abundance – The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation [CV] = 0.04; this is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean, with a lower number representing less variation), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011). Data indicates the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year so approximately doubling every 10 years (Calambokidis et al. 2008). Of the different stocks of humpback whales recognized in the Pacific Ocean, the Western North Pacific stock is the one most likely to be encountered within the MITT Study Area. The current population estimate for this stock is 938 to 1,107 animals (Allen and Angliss 2011).

Blue Whale (*Balaenoptera musculus*)

Status – The blue whale is listed as endangered under the ESA and as depleted under the MMPA. The NMFS considers blue whales found in the MITT Study Area as part of the Central North Pacific stock (Carretta et al. 2011) due to differences in call types with the Eastern North Pacific stock (Stafford et al. 2001; Stafford 2003).

Distribution and Seasonal Distribution – The blue whale inhabits all oceans and typically occurs in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Mate et al. 1999). 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). Blue whales belonging to the Central Pacific stock feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and less frequently to the central Pacific (Watkins et al. 2000; Stafford et al. 2004). There are no recent sighting records for the blue whale in the MITT Study Area, although this area is in the distribution range for this species (Reilly et al. 2008b). The Pacific Islands Fisheries Science Center has deployed several High-Frequency Acoustic Recording Packages (HARPs) to monitor marine mammals and ambient noise levels in U.S. Exclusive Economic Zone waters off the Mariana Islands. Recordings from these instruments are currently being analyzed, but it has been confirmed that blue whales have been acoustically detected (Oleson 2013); however, since blue whale calls can travel up to 621 mi. (1,000 km), it is unknown whether the animals were actually within the study area. Blue whales would be most likely to occur in the MITT Study Area during the winter.

Population and 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 Širović et al. 2004; (Branch et al. 2007). The best available abundance estimate for the Eastern North Pacific stock of blue whales is 2,497 (Carretta et al. 2011) and 1,400 animals for the Eastern Tropical Pacific (Wade and

Gerrodette 1993). With the exception of sightings by observers on fishing vessels (Carretta et al. 2011), there have been no sightings of blue whales during systematic surveys off Hawaii (Mobley et al. 2000; Barlow 2006), and no blue whales were detected during a 2007 winter survey of the Study Area (Fulling et al. 2011); therefore, no population estimates exist for the Central North Pacific blue whale stock.

Fin Whale (*Balaenoptera physalus*)

Status – The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known, and NMFS has designated three stocks of fin whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2011). The International Whaling Commission recognizes two management stocks in the North Pacific: a single widespread stock in the North Pacific and a smaller stock in the East China Sea (Donovan 1991). Little is known about the stock structure of fin whales in the MITT Study Area.

Distribution and Seasonal Distribution – Fin whales are found in all the world's oceans, typically between approximately 20° to 75° N and S latitudes (Calambokidis et al. 2008). In the northern hemisphere, most fin whales migrate seasonally from high latitude feeding areas in summer to low latitude breeding and calving areas in winter (Kjeld et al. 2006; MacLeod et al. 2006). The fin whale is typically found in continental shelf and oceanic waters (Gregr and Trites 2001; Reeves et al. 2002). Globally, it tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Payne et al. 1986; Payne et al. 1990; Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003;). Fin whales in the north Pacific spend the summer feeding along the cold eastern boundary currents (Perry et al. 1999).

Fin whales are typically not expected south of 20°N during summer, and less likely to occur near Guam (Miyashita et al. 1996; National Marine Fisheries Service 2006). Miyashita et al. (1996) presented a compilation of at-sea sighting results by species, from commercial fisheries vessels in the Pacific Ocean from 1964 to 1990. For fin whales in August, Miyashita et al. reported no sightings south of 20°N, and significantly more sightings north of 40°N. However, they also showed limited search effort south of 20°N. There were no fin whale sightings during the winter 2007 survey of the Study Area (Fulling et al. 2011). The Pacific Islands Fisheries Science Center has deployed several High-Frequency Acoustic Recording Packages (HARPs) to monitor marine mammals and ambient noise levels in U.S. Exclusive Economic Zone waters off the Mariana Islands. Recordings from these instruments are currently being analyzed, but it has been confirmed that fin whales have been acoustically detected (Oleson 2013).

Population and Abundance – In the north Pacific, the total pre-exploitation population size of fin whales is estimated at 42,000 to 45,000 whales (Ohsumi and Wada 1974). In 1973, fin whale abundance in the entire North Pacific basin was estimated between 13,620 and 18,680 whales (Ohsumi and Wada 1974). The lack of sighting data precludes an estimate of fin whale abundance specific to the MITT Study Area.

Sei Whale (*Balaenoptera borealis*)

Status – The sei whale is listed as endangered under the ESA and as depleted under the MMPA. The International Whaling Commission groups all of sei whales in the entire north Pacific Ocean into one stock (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research, indicate that more than one stock exists; one between 175°W and 155°W longitude, and another east of 155°W longitude (Masaki 1976, 1977). NMFS has designated three stocks of sei whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2011). Little is known about the stock structure of sei whales in the MITT Study Area.

Distribution and Seasonal Distribution – Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. On feeding grounds, their distribution is largely associated with oceanic frontal systems (Horwood 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified. 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).

Various scientists have described the seasonal distribution of sei whales as occurring from 20°N to 23°N during the winter and from 35°N to 50°N during the summer (Masaki 1976, 1977; Horwood 2009; Smultea et al. 2010). However, sei whales were sighted during the 2007 survey of the Study Area, thus providing evidence that this species occurs south of 20°N in the winter (Fulling et al. 2011). They are considered absent or at very low densities in most equatorial areas.

Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Kenney and Winn 1987; Schilling et al. 1992; Gregr and Trites 2001; Best and Lockyer 2002). These reports are consistent with observations during the 2007 survey of the Study Area, as sightings most often occurred in deep water 10,381 to 30,583 ft. (3,164 to 9,322 m). Most sei whale sightings were also associated with steep bathymetric relief (*e.g.*, steeply sloping areas), including sightings adjacent to the Chamorro Seamounts east of the CNMI) (Fulling et al. 2011). All confirmed sightings of sei whales were south of Saipan (approximately 15°N) with concentrations in the southeastern corner of the Study Area (Fulling et al. 2011). Sightings also often occurred in mixed groups with Bryde's whales. It is often difficult to distinguish sei whales from Bryde's whales at sea, and if a positive species identification cannot be made, sightings are typically categorized as sei/Bryde's whale.

Population and Abundance – In the north Pacific, the pre-exploitation sei whale population was estimated at 42,000 whales (Tillman 1977). The most current population estimate for sei whales in the entire north Pacific is 9,110 (Calambokidis et al. 2008). Sei whales were considered to be extralimital in the Study Area but during the 2007 systematic survey, sei whales were sighted on 16 occasions with a resulting abundance estimate of 166 individuals (CV = 0.49) (Fulling et al. 2011).

Bryde's Whale (*Balaenoptera edeni*)

Status – The Bryde's whale is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: (1) western north Pacific, (2) eastern north Pacific, and (3) east China Sea (Donovan 1991), although the biological basis for defining separate stocks of Bryde's whales in the central north Pacific is not clear (Carretta et al. 2010). In the most recent Stock Assessment Report, NMFS has designated two areas for Bryde's whale in the north Pacific: (1) waters in the eastern Pacific (east of 150° W and including the Gulf of California and waters off California), and (2) waters around Hawaii (Carretta et al. 2011). Little is known about the stock structure of Bryde's whales in the MITT Study Area.

Distribution and Seasonal Distribution – Bryde's whales are found year-round in tropical and subtropical waters, generally not moving poleward of 40° in either hemisphere (Jefferson et al. 1993; Kato 2002). Limited shifts in distribution toward and away from the equator, in winter and summer, respectively, have been observed (Cummings 1985; Best 1996). Data suggest that winter and summer grounds partially overlap in the central north Pacific, from 5°S to 40°N (Kishiro 1996; Ohizumi et al. 2002). They have been reported to occur in both deep and shallow waters globally. Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Best et al. 1984; Baker and Madon 2007). Bryde's whales are the most common baleen whales likely to occur in the Study Area (Eldredge 1991; Kishiro 1996; Miyashita et al. 1996; Okamura and Shimada 1999; Eldredge 2003). Occurrence patterns are expected to be the same throughout the year.

Historical records show a consistent presence of Bryde's whales in the Mariana Islands. Miyashita *et al.* (1996) sighted Bryde's whales in the Mariana Islands during a 1994 survey, commenting that in the western Pacific these whales are typically only seen when surface water temperature was greater than 68°F (20°C) although Yoshida and Kato (1999) reported a preference for water temperatures between approximately 59° and 68°F (15° and 20°C). A single Bryde's whale washed ashore on Masalok Beach on Tinian in February, 2005 (Trianni and Tenorio 2012). There is also one reported stranding for this area that occurred in August 1978 (Eldredge 1991, 2003). During marine mammal monitoring activities for Valiant Shield 07, a single Bryde's whale was observed about 87 nm east of Guam at the edge of the Mariana Trench (Mobley 2007).

Bryde's whales were identified 18 times during the 2007 survey of the Study Area (Fulling et al. 2011). They were observed in groups of one to three, with several sightings including calves. Bryde's whales were sighted in deep waters, ranging from 8,363 to 24,190 ft. (2,534 to 7,330 m). Most sightings were associated with steep bathymetric relief (e.g., steeply sloping areas and seamounts), including sightings adjacent to the Chamorro Seamounts east of CNMI and over the West Mariana Ridge. There were several sightings in waters over and near the Mariana Trench, as well as in the southeast corner of the Study Area. Multi-species aggregations with sei whales were observed on several occasions (Fulling et al. 2011). As noted previously, Bryde's whales are often difficult to distinguish from sei whales at sea; if a positive species identification cannot be made, sightings are typically categorized as sei/Bryde's whale.

Population and Abundance – Little is known of population status and trends for most Bryde's whale populations. Based on Japanese and Soviet fishing records, the stock size of Bryde's whale in the north Pacific was estimated to decline from approximately 22,500 animals in 1971 to 17,800 animals in 1977 (Tillman 1978). Based on line-transect estimates from the 2007 survey, an estimated 233 (CV = 0.45) Bryde's whales were present in the Study Area (Fulling et al. 2011).

Minke Whale (*Balaenoptera acutorostrata*)

Until recently, all minke whales were classified as the same species. Three subspecies of the common minke whale are now recognized: *Balaenoptera acutorostrata davidsoni* in the north Atlantic, *Balaenoptera acutorostrata scammoni* in the north Pacific (including the Study Area), and a third—formally unnamed but generally called the dwarf minke whale—that mainly occurs in the southern hemisphere (Arnold et al. 1987).

Status – The minke whale is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three stocks of minke whales in the north Pacific: (1) the Sea of Japan, (2) the rest of the western Pacific west of 180°N, and (3) one in the "remainder of the Pacific" (Donovan 1991). These broad designations basically reflect a lack of knowledge about the population structure of minke whales in the north Pacific (Carretta et al. 2011). NMFS has designated three stocks of minke whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2011). Little is known about the stock structure of minke whales in the MITT Study Area.

Distribution and Seasonal Distribution – Minke whales are present in the north Pacific from near the equator to the Arctic (Horwood 1990; Jefferson et al. 1993). In the winter, minke whales are found south to within 2° of the equator (Perrin and Brownell 2002). There is no obvious migration from low-latitude, winter breeding grounds to high-latitude, summer feeding locations in the western North Pacific, as there is in the North Atlantic (Horwood 1990); however, there are some monthly changes in densities in both high and low latitudes (Okamura et al. 2001). Some coastal minke whales restrict their summer activities to exclusive home ranges (Dorsey 1983) and exhibit site fidelity to these areas between years (Borggaard et al. 1999).

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 (Slijper et al. 1964; Horwood 1990; Mitchell 1991; Mellinger et al. 2000; Roden and Mullin 2000).

Due to the cryptic behavior of this species it is not unusual to have acoustic sightings with no visual confirmation (Rankin et al. 2007). Minke whale vocalizations in the Pacific Islands have been reported during the winter months, and in November during a 2002 survey of the U.S. Exclusive Economic Zone waters around Hawaii, a minke whale was sighted while "off effort" after the animal was detected acoustically (Rankin and Barlow 2005; Barlow 2006). Minke whales were the most frequently acoustically detected species of baleen whale during the 2007 survey of the Study Area and were mostly found in the southwestern area near the Mariana Trench (Fulling et al. 2011).

Population and Abundance – There are no population estimates for minke whales in the entire north Pacific, and abundance estimates have not been made for the Hawaiian stock of minke whales (Carretta et al. 2010). Recent line-transect analyses of acoustic detections of minke whales during the 2007 survey of the Study Area resulted in an estimate of approximately 183 to 227 animals (Norris et al. 2011); however, methods for estimating density from acoustic detections are currently being developed and numerous assumptions are associated with the calculations. These estimates should thus be considered preliminary.

Omura's Whale (*Balaenoptera omurai*)

Status – Omura's whale is protected under the MMPA and is not listed under the ESA. Until recently, all medium-sized baleen whales were considered members of one of two species, *Balaenoptera edeni* (Bryde's whale) or *Balaenoptera borealis* (sei whale). However, at least three genetically-distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Rice 1998; Kato and Perrin 2008). In 2003, a new species, Omura's whale, was first described from records from the Philippines, eastern Indian Ocean, Indonesia, Sea of Japan, and the Solomon Islands (Wada et al. 2003). Whales in the Solomon Islands were found to be distinct from Bryde's whales found in the offshore waters of the western north Pacific and the East China Sea (Wada and Numachi 1991; Yoshida and Kato 1999). Later it became evident that the term "pygmy Bryde's whale" had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al. 2004). Given the general paucity of data on this species, nothing is known of the stock structure of Omura's whale.

Distribution and Seasonal Distribution – Little is known of the geographic range of Omura's whale since few sightings of this species have been confirmed. Omura's whale is known to occur in the tropical and subtropical waters of the western Pacific and eastern Indian Oceans (Jefferson et al. 2008). It generally occurs alone or in pairs, and has been sighted primarily over the continental shelf in nearshore waters (Jefferson et al. 2008). It is possible that this species may occur in the Study Area.

Population and Abundance – There are currently no global estimates of the population size of Omura's whale. Ohsumi (1980) used sighting data to estimate an abundance of 1,800 animals for the Solomon Islands "Bryde's whale" stock; given the previous mistaken identity of the species, this estimate may relate to Omura's whale. Given the likelihood that some of the animals may have actually been Bryde's whales, and that the estimate was based on a small sample size, it is not considered reliable. There are no abundance estimates specific to the Study Area.

Sperm Whale (*Physeter macrocephalus*)

Status – The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009b), and is depleted under the MMPA. The International Whaling Commission divided the north Pacific into two management regions to define a western and eastern stock of sperm whales; the boundary consists of a zigzag pattern that starts at 150°W at the equator, is at 160°W between 40 to 50°N, and ends up at 180°W north of 50°N (Donovan 1991). NMFS has designated three stocks of sperm whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2011). Little is known about the stock structure of sperm whales in the MITT Study Area.

Distribution and Seasonal Distribution – Sperm whales are found throughout the North Pacific, and are distributed broadly from equatorial to polar waters (Whitehead et al. 2008). Mature female and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45˚N throughout the year; these groups are rarely found at latitudes higher than 50˚N and 50˚S (Reeves and Whitehead 1997). In some tropical areas, sperm whales appear to be largely resident, with pods of females with calves remaining on the breeding grounds throughout the year (Rice 1989; Whitehead 2003; Whitehead et al. 2008). Sexually mature males join these groups throughout the winter. During the summer, mature male sperm whales are thought to move north into the Aleutian Islands, Gulf of Alaska, and the Bering Sea. In the northern hemisphere, "bachelor" groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007).

Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters. Although this species shows a preference for deep waters, in some areas adult males are reported to consistently frequent waters with bottom depths less than 330 ft. (100 m) and as shallow as 130 ft. (40 m) (Romero et al. 2001; Jefferson et al. 2008). Typically, sperm whale concentrations correlate with areas of high productivity. These areas are generally near drop offs and areas with strong currents and steep topography (Gannier and Praca 2007; Jefferson et al. 2008).

Sightings collected by Kasuya and Miyashita (1988) suggest that that there are two stocks of sperm whales in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands and winter off Hokkaido and Sanriku, and the southwestern North Pacific stock with females that summer in the Kuroshio Current System and winter around the Bonin Islands. The males of these two stocks are found north of the range of the corresponding females—in the Kuril Islands/Sanriku/Hokkaido and in the Kuroshio Current System, respectively, during the winter.

Whaling records demonstrate sightings year-round in the Study Area (Townsend 1935). There are also two stranding records for this area (Kami and Lujan 1976; Eldredge 1991, 2003). During the Navy-funded survey in 2007, there were multiple sightings that included young calves and large bulls (Fulling et al. 2011). These findings are consistent with an earlier sighting of a group of sperm whales that included a newborn calf off the west coast of Guam (Eldredge 2003). During the 2007 survey, sperm whales were observed in waters 2,670 to 32,584 ft. (809 to 9,874 m) deep (Fulling et al. 2011). During a small boat survey around Guam and Saipan in February and early March 2010, there were two sperm whale sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 ft. (500 m) isobath, and (2) a group of six animals northwest of Saipan in waters greater than 3,281 ft. (1,000 m) deep (Ligon et al. 2011). A group of 10 sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 ft. deep (1,200 m) on 19 March 2012 (HDR EOC 2012).

Population and Abundance – It is estimated that there are between 200,000 and 1,500,000 sperm whales worldwide (National Marine Fisheries Service 2010). A ship survey conducted in the eastern temperate North Pacific in spring 1997 resulted in estimates of 26,300 (CV = 0.81) to 32,100 (CV = 0.36) animals based on visual sightings or acoustic detections, respectively (Barlow and Taylor 2005).

The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 survey with acoustic detections almost three times higher (61)than visual detections in the field (Norris et al. 2012). Post processing of the acoustic data resulted in 91 distinct localizations of individual sperm whales. Based on a preliminary analysis, the distribution of sperm whales appeared to be clustered in three main regions of the Study Area, the northeast, central, and southwest portions, with a few others in the trench and offshore regions (Norris et al. 2012). Line-transect abundance estimates derived from these survey data yielded an estimate of 705 (CV = 0.60) sperm whales in the Study Area (Fulling et al. 2011).

Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia* that could occur in the Study Area: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*) (discussed below). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008).

Status – The pygmy sperm whale is protected under the MMPA and is not listed under the ESA. NMFS recognizes two discrete non-contiguous stocks of pygmy sperm whales in the U.S. Exclusive Economic Zone: (1) California, Oregon, and Washington and (2) Hawaiian (Carretta et al. 2011). Little is known about the stock structure of pygmy sperm whales in the MITT Study Area.

Distribution and Seasonal Distribution – Pygmy sperm whales have a worldwide distribution in tropical and temperate waters (Jefferson et al. 1993). The pygmy sperm whale appears to frequent more temperate habitats than the other *Kogia* species, which is more of a tropical species. For example, during boat surveys between 2000 and 2003 in the main Hawaiian Islands, the pygmy sperm was observed, but less commonly than the dwarf sperm whale (Baird et al. 2003; Barlow et al. 2004; Baird 2005). They are most often observed in waters along the continental shelf break and over the continental slope (e.g., Baumgartner et al. 2001; Baird 2005; McAlpine 2009). Little is known about possible migrations of this species. Pygmy sperm whales are difficult to photograph or tag and thus additional data are needed to be able to define migration routes or seasonality (Baird et al. 2011).There were no *Kogia* species sighted during the 2007 survey of the Study Area (Fulling et al. 2011). However, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort sea states greater than 4). On December 4, 1997, a pygmy sperm whale was found stranded at Sugar Dock, Saipan (Trianni and Tenorio 2012). During marine mammal monitoring for Valiant Shield 07, a group of three *Kogia* (dwarf or pygmy sperm whales) was observed about 8 nm east of Guam (Mobley 2007).

Population and Abundance – Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for pygmy sperm whales in the Western Pacific. There are no available population estimates for pygmy sperm whales in the Study Area.

Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the pygmy sperm whale (discussed above) and the dwarf sperm whale, which until recently had been considered to be the same species. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al. 2008). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Chivers et al. 2005; Jefferson et al. 2008).

Status – The dwarf sperm whale is protected under the MMPA and is not listed under the ESA. NMFS recognizes two discrete non-contiguous stocks of dwarf sperm whales in the U.S. Exclusive Economic Zone: (1) California, Oregon, and Washington and (2) Hawaiian (Carretta et al. 2011). Little is known about the stock structure of dwarf sperm whales in the MITT Study Area.

Distribution and Seasonal Distribution – Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters (MacLeod et al. 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of this species are not well understood. Records of this species have been documented from the western Pacific (Taiwan) and the eastern Pacific (California) (Scott et al. 1987; Sylvestre 1988; Wang et al. 2001; Wang and Yang 2006; Jefferson et al. 2008; Carretta et al. 2010).

There were no species of *Kogia* sighted during the 2007 survey of the Study Area (Fulling et al. 2011). However, similar to the pygmy sperm whale, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort sea states greater than 4). On August 24, 1993, a dwarf sperm whale was found stranded at San Jose Beach, Saipan (Trianni and Tenorio 2012). During marine mammal monitoring for Valiant Shield 07, a group of three *Kogia* (dwarf or pygmy sperm whales) was observed about 8 nm east of Guam (Mobley 2007). There was one sighting of a single dwarf sperm whale in the Marpi Reef area, northeast of Saipan, during small boat surveys conducted in August and early September 2011 (Hill et al. 2011).

Population and Abundance – Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for dwarf sperm whales in the Western Pacific. There are no available population estimates for dwarf sperm whales in the Study Area.

Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called “ecotypes” (Ford 2008; 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).

Status – The killer whale is protected under the MMPA, and the overall species is not listed under the ESA (although the southern resident population found in the Northeast Pacific is listed as endangered under the ESA and as depleted under the MMPA). Little is known of stock structure of killer whales in the North Pacific, with the exception of the northeastern Pacific where resident, transient, and offshore “ecotypes” have been described for coastal waters of Alaska, British Columbia, and Washington to California (Carretta et al. 2004). These ecotypes are defined specifically for these northeastern Pacific coastal waters, where regularly occurring populations have been studied for decades (Hoelzel and Dover 1991; Hoelzel et al. 1998). For stock assessment purposes, NMFS currently recognizes eight stocks of killer whale in the Pacific: (1) the Eastern North Pacific Alaska Resident stock, (2) the Eastern North Pacific Northern Resident stock, (3) the Eastern North Pacific Southern Resident stock, (4) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock, (5) the AT1 Transient stock, (6) the West Coast Transient stock, (7) the Eastern North Pacific offshore stock, and (8) the Hawaiian stock (Carretta et al. 2011). Little is known about killer whales in other tropical regions of the Pacific (Guinet and Bouvier 1995; Pitman and Ensor 2003; Forney and Wade 2006; Andrews et al. 2008). Given the lack of information, NMFS currently does not define a stock specific to the MITT Study Area.

Distribution and Seasonal Distribution – Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999; 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 (Dahlheim 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 (Morin et al. 2010). Data from satellite telemetry showed that killer whales made seasonal, fast, and direct round-trip movements to subtropical waters when foraging near the Antarctic Peninsula (Durban and Pitman 2012).There are accounts of killer whales off the coast of Japan (Kasuya 1971). Japanese whaling and whaling sighting vessels indicate that concentrations of killer whales occurred north of the Northern Mariana Islands (Miyashita et al. 1995). Rock (1993) reported that killer whales have been reported in the tropical waters around Guam, Yap, and Palau. There are a few sightings of killer whales off Guam (Eldredge 1991), including a sighting 14.6 nm west of Tinian during January, 1997 reported to the NMFS Platforms of Opportunity Program. There was also a badly decomposed killer whale found stranded on Guam in August 1981 (Kami and Hosmer 1982). On 25 May 2010, a group of approximately five killer whales, including one calf, were sighted about 20 mi. (32 km) south of FDM, apparently having just killed an unidentified large whale (Wenninger 2010).

Population and Abundance – There are no abundance estimates available for the killer whale in the Study Area, and there were no sightings of this species during the 2007 systematic line-transect survey (Fulling et al. 2011).

False Killer Whale (*Pseudorca crassidens*)

Status – The false killer whale is protected under the MMPA, and is not listed under the ESA. Effective in December 2012, the Main Hawaiian Islands insular stock was listed as endangered under the ESA (National Marine Fisheries Service 2012), but this stock is considered a resident to the Hawaiian Islands and is not likely to be present in the Study Area. Not much is known about most false killer whale populations globally. While the species is not considered rare, few areas of high density are known. For stock assessment purposes, NMFS currently recognizes five stocks of false killer whale in the Pacific: (1) the main Hawaiian Islands insular stock includes the animals that occur in waters within 100 mi. (140 km) of the main Hawaiian Islands; (2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within 58 mi. (93 km) of the Northwestern Hawaiian Islands and Kauai; (3) the Hawaii pelagic stock includes animals that inhabit waters greater than 25 mi. (40 km) from the main Hawaiian Islands; (4) the Palmyra Atoll stock includes whales found within the U.S. Exclusive Economic Zone of Palmyra Atoll; and (5) the American Samoa stock, which includes false killer whales found within the U.S. Exclusive Economic Zone of American Samoa (Carretta et al. 2012). Little is known about the stock structure of false killer whales in other regions of the world; and given the lack of information; NMFS currently does not define a stock specific to the MITT Study Area (Chivers et al. 2007).

Distribution and Seasonal Distribution – The false killer whale is an oceanic species, occurring in deep waters of the Pacific (Miyashita et al. 1996; Wang et al. 2001; Carretta et al. 2010), and is known to occur close to shore near oceanic islands (Baird et al. 2012). They are found in tropical and temperate waters, generally between 50°S and 50°N latitude with a few records north of 50°N in the Pacific and the Atlantic (Odell and McClune 1999). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune 1999). Satellite-tracked individuals around the Hawaiian islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 mi. (96.6 km) offshore (Baird 2009).

During the 2007 survey of the Study Area, there were 10 false killer whales sightings in waters with bottom depths ranging from 10,095 to 26,591 ft. (3,059 to 8,058 m) and group sizes ranging from 2 to 26 individuals, with several including calves (Fulling et al. 2011). Several sightings were made over the Mariana Trench and the southeast corner of the Study Area, in waters with a bottom depth greater than 16,404 ft. (5,000 m). There was also a sighting in deep water west of the West Mariana Ridge (Fulling et al. 2011). There is one reported false killer whale stranding which occurred in the Saipan Lagoon in 2000 (Trianni and Tenorio 2012).

Population and Abundance – There are estimated to be about 6,000 false killer whales in the area surrounding the Mariana Islands (Miyashita 1993). Based on sighting data from the 2007 survey, there were an estimated 637 (CV = 0.74) false killer whales in the Study Area (Fulling et al. 2011).

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance to this species.

Status – The pygmy killer whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands and adjacent international waters

(Carretta et al. 2010). Little is known about the stock structure of pygmy killer whales in the MITT Study Area.

Distribution and Seasonal Distribution – The pygmy killer whale has a worldwide distribution in deep tropical and subtropical oceans (Davis et al. 2000; Wursig et al. 2000). Pygmy killer whales generally do not range north of 40°N or south of 35°S (Jefferson et al. 1993), and their distribution is continuous across the Pacific (Donahue and Perryman 2008; Jefferson et al. 2008). Reported sightings suggest that this species primarily occurs in equatorial waters, at least in the eastern tropical Pacific (Perryman et al. 1994). This species has been sighted in the western Pacific (Wang and Yang 2006; Brownell et al. 2009). Most of the records outside the tropics are associated with strong, warm western boundary currents that effectively extend tropical conditions into higher latitudes (Ross and Leatherwood 1994; Baird et al. 2011; Jeyabaskaran et al. 2011).

There was only one pygmy killer whale sighting of a group of six animals during the 2007 survey of the Study Area (Fulling et al. 2011). The sighting was made near the Mariana Trench, south of Guam, where the bottom depth was 14,564 ft. (4,413 m). This is consistent with the known habitat preference of this species for deep, oceanic waters. During small boat surveys of Guam and CNMI waters in August and early September 2011, there was a single pygmy killer whale sighting of six animals in the Marpi Reef area, northeast of Saipan, in waters with a bottom depth of 1,847 ft. (563 m) (Hill et al. 2011).

Population and Abundance – Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the Pacific management stock of pygmy killer whale is 956 individuals (CV = 0.83) (Carretta et al. 2010). Based on the single sighting during the 2007 Study Area survey, the best estimate of abundance was 78 individuals (CV = 0.88) (Fulling et al. 2011).

<u>Short-Finned Pilot Whale (*Globicephala macrorhynchus*)</u>

Status – The short-finned pilot whale is protected under the MMPA and is not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: (1) waters off California, Oregon and Washington, and (2) Hawaiian waters (Carretta et al. 2010). In Japanese waters, two stocks (northern and southern) have been identified based on pigmentation patterns and head shape differences of adult males (Kasuya et al. 1988). The southern stock of short-finned pilot whales is probably the stock associated with the Mariana Islands area (Kasuya et al. 1988).

Distribution and Seasonal Distribution – The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Hui 1985; Payne and Heinemann 1993; Bernard and Reilly 1999). The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson 2009; Sakai et al. 2011). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in waters off the northeastern United States (Payne and Heinemann 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Mignucci-Giannoni 1998; Gannier 2000).

Miyashita et al. (1996) reported sightings in the vicinity of the Northern Mariana Islands during February through March 1994, but did not provide the actual sighting coordinates. A group of more than 30 individuals was sighted in late April 1977 near Urunao Point, off the northwest coast of Guam (Birkeland 1977). A stranding occurred on Guam in July 1980 (Kami and Hosmer 1982; Donaldson 1983).

During the 2007 survey of the Study Area, there were a total of five sightings of short-finned pilot whales in waters with bottom depth ranging from 3,041 to 14,731 ft. (922 to 4,464 m), and group size ranging from 5 to 43 individuals (Fulling et al. 2011). Three sightings were over the West Mariana Ridge (an area of seamounts), and another sighting was 7 nm off the northeast corner of Guam, just inshore of the 9,900 ft. (3,000 m) isobath. There was also an off-effort sighting of a group of 6 to 10 pilot whales near the mouth of Apra Harbor (Fulling et al. 2011). No calves were seen, although there was a mixed-species aggregation involving bottlenose dolphins and rough-toothed dolphins. On 30 March 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there was a single short-finned pilot whale sighting of an estimated 23 individuals, at approximately 17 °N, more than 60 nm north of FDM (Oleson and Hill 2010). A mixed-species group of short-finned pilot whales and bottlenose dolphins were sighted during small boat surveys around Guam in February 2011 (HDR 2011). A group of 14 short-finned pilot whales were seen off Guam in August 2011 (Hill et al. 2011). During small boat surveys in waters of the CNMI in August and September 2011, there were a total of four short-finned pilot whale sightings: (1) off the west coast of Guam north of Tumon Bay; (2) north of Saipan; (3) west of Tinian; and (4) off the northwest coast of Rota (Hill et al. 2011). The sighting off Rota was just inshore from the 656 ft. (200 m) isobath, while the other three sightings were in waters with bottom depths ranging from 1,640 to 3,281 ft. (500 to 1,000 m) (Hill et al. 2011). During small boat surveys in March 2012, a group of 23 short-finned pilot whales was sighted off the western coast of Guam (HDR EOC 2012), and several groups of 20-30 were sighted in the summer of 2012 off Guam and CNMI (Hill et al. 2013).

Population and Abundance – The Japanese southern stock of short-finned pilot whales has been estimated to number about 18,700 whales in the waters south of 30º N (Miyashita 1993). There were an estimated 909 (CV = 0.68) short-finned pilot whales in the Study Area based on the 2007 survey (Fulling et al. 2011). Between 22 February 2011 and 10 June 2012, as part of an ongoing photo-identification project, a total of 5,636 photos were analyzed from 10 sightings of short-finned pilot whales in the Study Area (Hill et al. 2013). Across all locations and years, 129 individual pilot whales were identified (Hill et al. 2013).

Melon-Headed Whale (*Peponocephala electra*)

Status – The melon-headed whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2010). Little is known about the stock structure of melon-headed whales in the MITT Study Area.

Distribution and Seasonal Distribution – Melon-headed whales are found worldwide in tropical and subtropical oceanic waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range, because records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day, and feed in deeper waters at night (Gannier 2002; Woodworth et al. 2011). The melon-headed whale is not known to migrate.

There was a live stranding of a melon-headed whale on the beach at Inarajan Bay, Guam in April 1980 (Kami and Hosmer 1982; Donaldson 1983), and there have been some sightings at Rota and Guam (Jefferson et al. 2006; Fulling et al. 2011). Based on sighting records, melon-headed whales are expected to occur from the shelf break (660 ft. [200 m] isobath) to seaward of the Mariana Islands area and vicinity. There is also a low or unknown occurrence from the coastline to the shelf break, since deep water is very close to shore at these islands. On 4 July 2004, there was a sighting of an estimated 500 to 700 melon-headed whales and an undetermined smaller number of rough-toothed dolphins at Sasanhayan Bay (Rota) (Jefferson et al. 2006). There were two sightings of melon-headed whales during the 2007 survey of the Study Area, with group sizes of 80 to 109 individuals (Fulling et al. 2011). Melon-headed whales were sighted in waters with a bottom depth, ranging from 10,577 to 12,910 ft. (3,205 to 3,912 m). One of the two sightings was in the vicinity of the West Mariana Ridge. There was one sighting of approximately 53 animals on 5 February 2010, southeast of Guam during the large vessel Pacific Islands Fisheries Science Center survey (Oleson and Hill 2010). During small boat surveys in March 2012, a group of 100 melon-headed whales was sighted off the western coast of Guam in waters approximately 8,530 ft. (2,600 m) deep (HDR EOC 2012).

Population and Abundance – Based on sighting data from the 2007 survey, there were an estimated 2,455 (CV = 0.70) melon-headed whales in the Study Area (Fulling et al. 2011). This estimate is very similar to the abundance estimate for the Hawaiian stock of melon-headed whale, derived from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Pacific Exclusive Economic Zone, of 2,950 animals (CV = 1.17) (Barlow 2006). Based on photo-identification data, Baird et al. (2010) determined that the population of melon-headed whales around the main Hawaiian Islands exhibited stable population structure and long-term site fidelity spanning up to 22.6 years.

Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question; while two species are generally recognized, the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998), the specific affinities of these animals remains controversial. Recent morphological analyses suggest a new species be recognized, *Tursiops australis* (Charlton-Robb et al. 2011).

Status – The common bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, bottlenose dolphins within the Pacific U.S. Exclusive Economic Zone are divided into seven stocks: (1) California coastal, (2) California, Oregon and Washington Offshore, (3) Kauai and Niihau, (4) Oahu, (5) the 4-Islands Region, (6) Hawaii Island, and (7) the Hawaii Pelagic, including animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2010). Little is known about the stock structure of bottlenose dolphins in the MITT Study Area.

Distribution and Seasonal Distribution – Common bottlenose dolphins are generally found in coastal and continental shelf waters of tropical and temperate regions of the world. They are known to occur in most enclosed or semi-enclosed seas. The species is known to inhabit shallow, murky, estuarine waters as well as deep, clear offshore waters in oceanic regions (Wells et al. 2009; Martien et al. 2012). Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin 2004).

Miyashita (1993) reported multiple sightings of bottlenose dolphins in the western Pacific. However, there are no stranding records available for this species in the Mariana Islands area and vicinity, and only a mention by Trianni and Kessler (2002) that bottlenose dolphins are seen in coastal waters of Guam. It is possible that bottlenose dolphins do not occur in great numbers in this island chain, but they are frequently seen. In the main Hawaiian Islands, data suggest that bottlenose dolphins exhibit site fidelity (Baird et al. 2009; Martien et al. 2012). Gannier (2002) noted that large densities of bottlenose dolphins do not occur at the Marquesas Islands and attributed this to the area's lack of a significant shelf component. A similar situation could be occurring in the Study Area and vicinity.

There were three on-effort sightings of bottlenose dolphins during the 2007 survey of the Study Area. Two of the sightings were in the vicinity of Challenger Deep, while the other sighting was east of Saipan near the Mariana Trench in deep waters ranging from 13,995 to 16,536 ft. (4,241 to 5,011 m) (Fulling et al. 2011). The Challenger Deep sighting was a mixed-species aggregation that included sperm whales (with calves) logging at the surface. Another mixed-species aggregation involved short-finned pilot whales and rough-toothed dolphins. A mixed-species group of bottlenose dolphins and short-finned pilot whales were also sighted during small boat surveys around Guam in February 2011 (HDR 2011). During small boat surveys in waters of Guam and the CNMI in August and September 2011, there were a total of three bottlenose dolphin sightings: (1) off Rota Bank north of Guam (14 animals including 2 calves); (2) in inshore waters off the southeast coast of Saipan (10 animals); and (3) in inshore waters off the northwest tip of Tinian (10 animals) (Hill et al. 2011). During small boat surveys in March 2012, a group of 11 bottlenose dolphins was sighted off the northwestern coast of Saipan in waters approximately 328 ft. (100 m) deep (HDR EOC 2012), and several groups observed in the summer of 2012 (Hill et al. 2013).

Population and Abundance – As mentioned above, little is known of the stock structure of bottlenose dolphins around the Mariana Islands. A bottlenose dolphin abundance estimate of 31,700 animals was made for the area north of the Marianas (Miyashita 1993), which may possibly represent a stock of offshore bottlenose dolphins that occurs around the Mariana Islands. In some regions "inshore" and "offshore" species differ genetically and morphologically (Tezanos-Pinto et al. 2009). Between 22 February 2011 and 29 June 2012, as part of an ongoing photo-identification project, a total of 1,793 photos were analyzed from nine sightings of bottlenose dolphins in the Study Area (Hill et al. 2013). Across all locations and years, 34 individual bottlenose dolphins were identified (Hill et al. 2013).

Pantropical Spotted Dolphin (*Stenella attenuata*)

Status – The species is protected under the MMPA and is not listed under the ESA. Pantropical spotted dolphins may have several stocks in the western Pacific (Miyashita 1993), although this is not confirmed at present. For the MMPA stock assessment reports, pantropical spotted dolphins are considered under a single management stock which includes animals found in the Hawaiian Islands and in adjacent international waters. In the eastern tropical Pacific, DNA analyses suggest genetic isolation between inshore and offshore populations of spotted dolphins (Escorza-Treviño et al. 2005). Little is known about the stock structure of pantropical spotted dolphins in the MITT Study Area.

Distribution and Seasonal Distribution – The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40° N and 40° S (Baldwin et al. 1999; Perrin 2008a), although this species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Perrin 2001; Jefferson et al. 2008). Pantropical spotted dolphins are extremely gregarious, forming groups of hundreds or even thousands of individuals. Their range in the central Pacific is from the Hawaiian Islands in the north to at least the Marquesas Islands in the south (Perrin and Hohn 1994). Based on the known habitat preferences of the pantropical spotted dolphin, this species is expected to occur seaward of the shelf break (660 ft. [200 m] isobath). Low or unknown occurrence of the pantropical spotted dolphin from the coastline to the shelf break (except in harbors and lagoons) is based on sightings of pantropical spotted dolphins being reported in coastal waters of Guam (Trianni and Kessler 2002). Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (Scott and Chivers 2009). Mixed-species groups of pantropical spotted dolphins and spinner dolphins have been observed off the Waianae (western) coast of Oahu (Psarakos et al. 2003).

Pantropical spotted dolphins were sighted throughout the Study Area during the 2007 ship survey in waters with a variable bottom depth, ranging from 374 to 18,609 ft. (113 to 5,639 m) (Fulling et al. 2011). The vast majority of the sightings (65 percent; 11 of 17 sightings) were in deep waters greater than 10,000 ft. (3,030 m); these findings match the known preference of this species for oceanic waters. There was only one shallow-water sighting 1.4 nm north of Tinian, in waters with a bottom depth of 374 ft. (113 m). Pantropical spotted dolphin group size ranged from 1 to 115 individuals. There were multiple sightings that included young calves, one mixed species aggregation with melon-headed whales, and another with an unidentified *Balaenoptera* species. These pantropical spotted dolphins were identified as the offshore morphotype.

During marine mammal monitoring for Valiant Shield 07, a group of 30 pantropical spotted dolphins was observed about 140 nm southeast of Guam (Mobley 2007). A group of 17 pantropical spotted dolphins was sighted during small boat surveys around Guam in February and early March 2010 (Ligon et al. 2011). This species was also sighted during small boat surveys in August and September 2011, with two sightings off the northwest coast of Guam and one sighting off the northwest coast of Saipan (Hill et al. 2011). All three of these sightings were in waters with bottom depth ranging from 1,640 to 3,281 ft. (500 to 1,000 m). There were two sightings of pantropical spotted dolphins during small boat surveys in March 2012, both on 19 March off the western coast of Guam (HDR EOC 2012). The first was a group of 6 animals in waters approximately 3,940 ft. (1,200 m) deep and the second was a group of 30 animals in waters approximately 4,593 ft. (1,400 m) deep (HDR EOC 2012). Several groups of pantropical spotted dolphins were observed off Guam and the CNMI in the summer of 2012 (Hill et al. 2013).

Population and Abundance – There are estimated to be about 127,800 spotted dolphins in the waters surrounding the Mariana Islands (Miyashita 1993). There were an estimated 12,981 (CV = 0.70) pantropical spotted dolphins in the Study Area based on the 2007 survey data (Fulling et al. 2011). Pantropical spotted dolphins are one of the focus species of an ongoing photo-identification project in the Study Area; however, data collected to date still need to be processed for creation of photo-identification catalogs (Hill et al. 2013).

Striped Dolphin (*Stenella coeruleoalba*)

Status – This species is protected under the MMPA and is not listed under the ESA. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. Pacific Exclusive Economic Zone into two separate areas: (1) waters off California, Oregon, and Washington; and (2) waters around Hawaii, including animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2010). In the western north Pacific, three migratory stocks are provisionally recognized (Kishiro and Kasuya 1993).

Distribution and Seasonal Distribution – Striped dolphins have a cosmopolitan distribution in tropical to warm temperate waters (Perrin et al. 1994). Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella* (spotted and spinner dolphins) (Baird et al. 1993). Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990). This species is well documented in both the western and eastern Pacific off the coasts of Japan and North America (Perrin et al. 1994); the northern limits are the Sea of Japan, Hokkaido, Washington state, and along roughly 40°N across the western and central Pacific (Reeves et al. 2002). In some areas, this species appears to avoid waters with sea temperatures less than 68°F (20°C) (Van Waerebeek et al. 1998).

Prior to the 2007 survey of the Study Area (Fulling et al. 2011), striped dolphins were only known from two strandings; one recorded in July 1985 (Eldredge 1991, 2003) and a second in 1993 off Saipan (Trianni and Tenorio 2012). However, striped dolphins were sighted throughout the Study Area during the 2007 survey in waters with variable bottom depth, ranging from 7,749 to 24,835 ft. (2,348 to 7,526 m) (Fulling et al. 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group size ranged from 7 to 44 individuals, and several sightings included calves. There were no sightings south of Guam (approximately 13°N). In early April 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there were two striped dolphin sightings south of Guam, both on the 143.8 longitude line (Oleson and Hill 2010). The first sighting was of an estimated 6 animals at 11.384 °N, and the second was a sighting of an estimated 12 animals at 10.286 °N (Oleson and Hill 2010).

Population and Abundance – The population of striped dolphins south of 30^{o} N in the western Pacific was estimated to be around 52,600 dolphins (Miyashita 1993). Based on the 2007 survey data, there were an estimated 3,531 (CV = 0.54) striped dolphins in the Study Area (Fulling et al. 2011).

Spinner Dolphin (*Stenella longirostris*)

Four well differentiated geographical forms of spinner dolphins have been described as separate subspecies: *Stenella longirostris longirostris* (Gray's spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and

Stenella longirostris roseiventris (dwarf spinner dolphin). The latter three subspecies have restricted distributions and are unlikely to occur in the Study Area; hence, *Stenella longirostris longirostris* is probably the one that occurs there (Trianni and Kessler 2002; Bearzi et al. 2012; Carretta et al. 2012).

Status – The spinner dolphin is protected under the MMPA and is not listed under the ESA. The eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA. Under the MMPA, there are seven Pacific management stocks for Gray's spinner dolphin (*Stenella longirostris longirostris)*: (1) American Samoa, (2) Hawaii Island, (3) Oahu/4-islands, (4) Kauai/Niihau, (5) Pearl & Hermes Reef, (6) Kure/Midway, and (7) Hawaii Pelagic, including animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Hill et al. 2010; Carretta et al. 2012). Little is known about the stock structure of spinner dolphins in the MITT Study Area. However, based on recent sighting data (summarized below) and what is known of the Hawaiian Islands stocks, it is likely that there are both island-associated and pelagic populations of spinner dolphins in the MITT Study Area.

Distribution and Seasonal Distribution – The spinner dolphin is found in tropical and subtropical waters worldwide, generally between 40°N and 40°S (Norris and Dohl 1980; Perrin and Gilpatrick 1994; Jefferson et al. 2008). Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman 1985; Reilly 1990; Perrin 2008b). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. Coastal populations are usually found in island archipelagos, where they are tied to trophic and habitat resources associated with the coast (Norris and Dohl 1980; Lammers 2004; Thorne et al. 2012).

Spinner dolphins at islands and atolls rest during daytime hours in shallow, wind-sheltered nearshore waters and forage over deep waters at night (Norris et al. 1994; Östman 1994; Gannier 2000, 2002; Benoit-Bird and Au 2003; Lammers 2004; Östman-Lind et al. 2004; Oremus et al. 2007; Benoit-Bird and Au 2009; Andrews et al. 2010). Spinner dolphins are expected to occur in shallow water (about 164 ft. [50 m] or less) resting areas throughout the middle of the day, moving into deep waters offshore during the night to feed. Preferred resting habitat is usually more sheltered from prevailing trade winds than adjacent areas and the bottom substrate is generally dominated by large stretches of white sand bottom rather than reef and rock bottom (Norris et al. 1994; Lammers 2004). These clear, calm waters and light bottom substrates provide a less cryptic backdrop for predators like tiger sharks (Norris et al. 1994; Lammers 2004).

Spinner dolphins travel among the Mariana Islands chain (Trianni and Kessler 2002), and are expected to occur throughout the Marianas, except there have been no documented sightings within Apra Harbor. High-use areas at Guam include Bile Bay, Tumon Bay, Double Reef, north Agat Bay, and off Merizo (Cocos Lagoon area), where these animals congregate during the day to rest (Eldredge 1991; Amesbury et al. 2001). Spinner dolphins have also been seen at FDM (Trianni and Kessler 2002; Vogt 2008) and Rota (Jefferson et al. 2006). Spinner dolphins have been reported in the Saipan Lagoon at Saipan nearly every year; typically, sightings are from the northern part of the lagoon, referred to as Tanapag Lagoon (Trianni and Kessler 2002).

During the 2007 survey of the Study Area, there was one sighting of spinner dolphins northeast of Saipan in waters with a bottom depth of 1,398 ft. (424 m) (Fulling et al. 2011). Spinner dolphins have been sighted during the Navy's routine aerial surveys of FDM on several occasions, including one sighting in March 2006, approximately 1,312 ft. (400 m) east of the island, and another sighting in July 2007, approximately 31 mi. (50 km) north of Saipan (Vogt 2008). There were a total of 14 spinner dolphin sightings during small boat surveys around Guam (8 sightings) and Saipan (6 sightings) in February and early March 2010 (Oleson and Hill 2010; Ligon et al. 2011). Of the eight total sightings off Guam, seven were in Agat Bay and there was a single sighting just south of Facpi Point, all inshore of the 328 ft. (100 m) isobath (Ligon et al. 2011). An additional four sightings were made in shallow (less than 328 ft. [100 m]) waters off Saipan, and another two sightings in shallow waters near Marpi Reef, northeast of Saipan (Ligon et al. 2011). During small boat surveys around the western and northern side of Guam in February 2011, there were a total of 7 sightings of spinner dolphins on 5 different days, with group sizes ranging from 3 to 35 animals (HDR 2011). There were a total of 22 spinner dolphin sightings during small boat surveys around Guam and the CNMI in August and early September 2011 (Hill et al. 2011). All of the sightings were in waters less than 656 ft. (200 m) deep, either directly off the coasts of Guam, Saipan, Tinian, Aguijan, and Rota, or in shallow waters off Marpi Reef and Rota Bank north of Guam (Hill et al. 2011). There were five sightings of spinner dolphins during small boat surveys in March 2012, one sighting off the western coast of Guam and four sightings off Saipan (HDR EOC 2012). There were also several sightings of spinner dolphins off Guam and the CNMI during summer surveys in 2012 (Hill et al. 2013).

Population and Abundance – Although there are multiple sighting records of spinner dolphins around the Mariana Islands, no abundance estimate is available for the region. The only systematic line-transect survey of the Study Area was the 2007 survey, for which there was only one sighting of this species (Fulling et al. 2011). Between 22 February 2011 and 16 June 2012, as part of an ongoing photo-identification project, a total of 8,047 photos were analyzed from 29 sightings of spinner dolphins in the Study Area (Hill et al. 2013). Across all locations and years, 89 individual spinner dolphins were identified (Hill et al. 2013).

Rough-Toothed Dolphin (*Steno bredanensis*)

Status – This species is protected under the MMPA and is not listed under the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson et al. 2008; Jefferson 2009). There are two Pacific management stocks recognized by NMFS for stock assessment purposes: (1) an American Samoa stock and (2) a Hawaiian Islands stock including animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Carretta et al. 2011). Little is known about the stock structure of rough-toothed dolphins in the MITT Study Area.

Distribution and Seasonal Distribution – Rough-toothed dolphins are typically found in tropical and warm temperate waters, rarely ranging north of 40°N or south of 35°S (Miyazaki and Perrin 1994). The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth as observed at the Windward Islands (French Polynesia) (Gannier and West 2005; Baird et al. 2008; Oremus et al. 2012). It rarely occurs close to land, except around islands with steep drop-offs nearshore (Gannier and West 2005), similar to the Study Area. In some areas, this species may be found in coastal waters and areas with shallow bottom depths (Davis et al. 1998; Mignucci-Giannoni 1998; Lodi and Hetzel 1999; Ritter 2002; Fulling et al. 2011). Rough-toothed dolphins can often be found in mixed-species groups with other species such as pilot whales, bottlenose dolphins, or melon-headed whales (e.g., Fulling et al. 2011). At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 ft. (100 m) to more than 9,845 ft.

(more than 3,000 m), although they apparently favored the 1,640 to 4,920 ft. (500 to 1,500 m) range (Gannier 2000).

In July 2004, there was a sighting of an undetermined smaller number of rough-toothed dolphins mixed in with a school of an estimated 500 to 700 melon-headed whales at Sasanhayan Bay (Rota) in waters with a bottom depth of 249 ft. (75.9 m) (Jefferson et al. 2006). During marine mammal monitoring for Valiant Shield 07, a group of 8 rough-toothed dolphins was observed about 102 nm east of Guam (Mobley 2007). During the 2007 survey of the Study Area, there were two sightings of rough-toothed dolphins, both in groups of nine individuals with calves present in one sighting (Fulling et al. 2011). Both sightings were in deep waters, ranging from 3,343 to 14,731 ft. (1,013 to 4,464 m). One sighting was off the island of Guguan, while the other was at the southern edge of the Study Area (Fulling et al. 2011).

Population and Abundance – There are no abundance estimates for the rough-toothed dolphin in the western Pacific. Rough-toothed dolphins are common in tropical areas, but not nearly as abundant as some other dolphin species (Reeves et al. 2002). During the only systematic line-transect survey of the Study Area in 2007, there was only one on-effort sighting of this species (Fulling et al. 2011).

Fraser's Dolphin (*Lagenodelphis hosei*)

Since its discovery in 1956, Fraser's dolphin was known only from skeletal specimens until it was once again identified in the early 1970s (Perrin et al. 1973). Fraser's dolphin has become much better described as a species in recent years, although it is still one of the least-known species of cetaceans.

Status – Fraser's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Carretta et al. 2010). Little is known about the stock structure of Fraser's dolphin in the MITT Study Area.

Distribution and Seasonal Distribution – Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar 2008). Species found outside 30°N and 30°S are probably there due to temporary oceanographic events (Dolar 2008). In the Gulf of Mexico, this species has been seen in waters over the abyssal plain (Leatherwood et al. 1993). In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman 1985). This species has been found off the Pacific coast of Japan (Amano et al. 1996). Fraser's dolphin does not appear to be a migratory species, and little is known about its potential migrations. No specific information regarding routes, seasons, or re-sighting rates in specific areas is available. As noted above, data on Fraser's dolphin are lacking, and there are only a few scattered reports of stranding (Hersh and Odell 1986). They are often found with other species of cetaceans; they have been observed with melon-headed whales, sperm whales, short-finned pilot whales, false killer whales, Risso's dolphins, pantropical spotted dolphins, spinner dolphins, and striped dolphins (Jefferson and Leatherwood 1994).

Population and Abundance – Fraser's dolphin is not considered to be extremely abundant in any region in the world, although there is little concern regarding its global conservation status (Dolar 2008; Jefferson et al. 2008). There are no abundance estimates for Fraser's dolphin in the Study Area.

Risso's Dolphin (*Grampus griseus*)

Status – Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. Exclusive Economic Zone are divided into two separate areas: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters, including animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Carretta et al. 2010). Little is known about the stock structure of Risso's dolphins in the MITT Study Area.

Distribution and Seasonal Distribution – Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Leatherwood et al. 1980; Au and Perryman 1985; Miyashita 1993; Miyashita et al. 1996; Wang et al. 2001; Carretta et al. 2010). Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Green et al. 1992; Baumgartner 1997; Davis et al. 1998; Mignucci-Giannoni 1998; Kruse et al. 1999; Cañadas et al. 2002). Risso's dolphins are also found over submarine canyons (Mussi et al. 2004). Shane (1994) reported sightings of Risso's dolphins in shallow waters in the northeastern Pacific, including near oceanic islands. These sites are in areas where the continental shelf is narrow and deep water is closer to the shore (Gannier 2000, 2002).

On 30 March 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there was a single Risso's dolphin sighting of three individuals, at approximately 17 °N, more than 60 nm north of FDM (Oleson and Hill 2010).

Population and Abundance – This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins (Bearzi et al. 2011). Miyashita (1993) used Japanese survey data to estimate that about 7,000 Risso's dolphins occur in the area north of the Mariana Islands.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Status – Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. Exclusive Economic Zone waters: (1) Alaska, (2) California, Oregon, and Washington, and (3) Hawaii, including animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Carretta et al. 2010). Little is known about the stock structure of Cuvier's beaked whale in the MITT Study Area (Allen et al. 2012).

Distribution and Seasonal Distribution – Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Pitman et al. 1988; Ferguson 2005; Ferguson et al. 2006; Jefferson et al. 2008). Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. They are commonly sighted around seamounts, escarpments, and canyons (MacLeod et al. 2004). Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 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). Little is known about potential migration. A study spanning 21 years off the west coast of the Island of Hawaii suggests that this species may show long-term site fidelity in certain areas (McSweeney et al. 2007).

During marine mammal monitoring for Valiant Shield 07, a single Cuvier's beaked whale was observed about 65 nm south of Guam at the edge of the Mariana Trench (Mobley 2007). One ziphiid whale was observed in deep water during the 2007 survey of the Study Area, but was not identified to the species level (Fulling et al. 2011). In August 2011, two stranded Cuvier's beaked whales were found on and near Micro Beach, Saipan (one alive and one dead); a necropsy conducted on the live stranded animal after euthanization revealed abnormalities in the animal's kidneys and intestines but further investigation is needed in order to determine if the stranding or morbidity should be categorized as natural or human-related (Saipan Tribune 2011; Hawaii Pacific University 2012).

Population and Abundance – No abundance estimates for Cuvier's beaked whale are available for the Study Area.

Blainville's Beaked Whale (*Mesoplodon densirostris*)

Status – Blainville's beaked whale is protected under the MMPA and is not listed under the ESA. Although little is known about the stock structure of this species, based on re-sightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaiian stock of Blainville's beaked whale, including animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Carretta et al. 2010). However, little is known about the stock structure of Blainville's beaked whale in the MITT Study Area.

Distribution and Seasonal Distribution – Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (MacLeod et al. 2006; Jefferson et al. 2008), and occur in temperate and tropical waters of all oceans (Jefferson et al. 1993; Jefferson et al. 2008). Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific and in the eastern south Pacific (Mead 1989; Pastene et al. 1990; Leslie et al. 2005; MacLeod and Mitchell 2006). In the eastern Pacific, where there are about a half-dozen *Mesoplodon* species known, Blainville's beaked whale is second only to the pygmy beaked whale (*Mesoplodon peruvianus*) in abundance in tropical waters (Wade and Gerrodette 1993). In waters of the western Pacific, Blainville's beaked whale is probably the most common and abundant tropical species of *Mesoplodon* (Jefferson et al. 2008). Studies suggest that some beaked whale species (Blainville's beaked whales, Cuvier's beaked whales, and northern bottlenose whales) may show long-term site fidelity in certain areas (Hooker et al. 2002; McSweeney et al. 2007).

There were two *Mesopolodon* whale sightings during the 2007 survey of the Study Area, over the West Mariana Ridge, but they were not identified to the species level (Fulling et al. 2011). During small boat surveys off Rota on 3 June 2012, two to three unidentified *Mesoplodon* whales were seen off the southwest tip of the island in 3,385 ft. (1,032 m) deep water (Hill et al. 2013).

Population and Abundance – There are no abundance estimates for Blainville's beaked whales in the Study Area.

Longman's Beaked Whale (*Indopacetus pacificus*)

Status – Longman's beaked whale is protected under the MMPA and is not listed under the ESA. Longman's beaked whale is a rare beaked whale species and, until recently, was considered to be the world's rarest cetacean; the spade-toothed whale now holds that position (Dalebout et al. 2003; Pitman 2008; Thompson et al. 2012). NMFS identifies only one Pacific stock, the Hawaiian stock, which includes animals found both within the Hawaiian Islands Exclusive Economic Zone and in adjacent international waters (Carretta et al. 2010). Little is known about the stock structure of Longman's beaked whale in the MITT Study Area.

Distribution and Seasonal Distribution – Longman's beaked whale generally is found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 79°F (26°C)

(Anderson et al. 2006; MacLeod et al. 2006). Longman's beaked whale is not as rare as previously thought but is not as common as the Cuvier's and *Mesoplodon* beaked whales (Ferguson and Barlow 2001). Although the full extent of this species distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Moore 1972; Dalebout et al. 2002; Dalebout et al. 2003; Afsal et al. 2009). Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings were south of 25°N.

Records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico. Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 ft. [200 m]), and are only occasionally reported in waters over the continental shelf (Waring et al. 2001; Cañadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008). There were no sightings of Longman's beaked whale during the 2007 survey of the Study Area (Fulling et al. 2011).

Population and Abundance – There are no abundance estimates available for Longman's beaked whales in the Study Area.

Ginkgo-Toothed Beaked Whale (*Mesoplodon ginkgodens*)

Due to the similarities between the species, the ginkgo-toothed beaked whale may be virtually indistinguishable at sea from other *Mesoplodon* species. Species identification is generally restricted to strandings as a result of a lack of obvious morphological differences between beaked whale species. Adult males can be identified by their distinctively ginkgo leaf-shaped teeth, but females and juveniles are almost impossible to identify by species (MacLeod et al. 2006; Dalebout et al. 2012; Moore and Barlow 2013).

Status – The ginkgo-toothed beaked whale is protected under the MMPA and is not listed under the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another, the ginkgo-toothed beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2010). The ginkgo-toothed whale is known only from strandings in tropical waters of the Pacific and Indian Oceans (Mead 1989; Palacios and Mate 1996), and there are no occurrence records for this species in the Study Area. However, this area is within the known distribution range for this species (Taylor et al. 2008).

Distribution and Seasonal Distribution – Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 655 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Waring et al. 2001; Cañadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008). Based on stranding records in the eastern Pacific Ocean, Palacios and Mate (1996) suggested that ginkgo-toothed beaked whales may select relatively cool, upwelling-modified habitats, such as those found in the California and Peru Currents and along the equatorial front. This species probably occurs only in the temperate and tropical waters of the Indo-Pacific; however, no specific information regarding migration is available (MacLeod and D'Amico 2006; Jefferson et al. 2008).

There were two *Mesopolodon* whale sightings during the 2007 survey of the Study Area, over the West Mariana Ridge, but they were not identified to the species level (Fulling et al. 2011). During small boat surveys off Rota on 3 June 2012, two to three unidentified *Mesoplodon* whales were seen off the southwest tip of the island in 3,385 ft (1,032 m) deep water (Hill et al. 2013).

Population and Abundance – There are no abundance estimates available for gingko-toothed beaked whales in the Study Area.

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 and testing activities in the MITT Study Area for the period from July 2015 through July 2020. The term "take," as defined in Section 3 (16 U.S.C. § 1362 (13)) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of "harassment," Level A (potential injury) and Level B (potential disturbance).

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

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

The MITT EISOEIS considered all training and testing activities proposed to occur in the Study Area that have the potential to result in the MMPA defined take of marine mammals. The stressors associated with these activities included the following:

- Acoustic (sonar and other active acoustic sources; explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance and strikes (vessels, in-water devices, military expended materials, seafloor devices)
- Entanglement (fiber-optic cables and guidance wires, parachutes)
- Ingestion (military expended materials from munitions, military expended materials other than munitions)
- Secondary stressors (impacts to habitat [sediment and water quality, air quality] or prey availability)

The Navy determined three stressors could potentially result in the incidental taking of marine mammals from training and testing activities within the Study Area: (1) non-impulse acoustic stressors (active sonar and other active acoustic sources), (2) impulse acoustic stressors (explosives and swimmer defense airguns), and (3) vessel strikes. Non-impulse acoustic stressors have the potential to result in incidental takes of marine mammals by Level A or Level B harassment. Impulse acoustic stressors have the potential to result in incidental takes of marine mammals by harassment, injury, or mortality. Vessel strikes have the potential to result in incidental take from direct injury or mortality.

5.1 Incidental Take Request for Training and Testing Activities

5.1.1 Impulse and Non-Impulse Sources

A detailed analysis of effects due to marine mammal exposures to impulse and non-impulse sources in the MITT Study Area is presented in Chapter 6 (Number and Species Taken). Based on analysis described in Chapter 6 (Number and Species Taken), Table 5-1 summarizes the Navy's final take request for training and testing activities for an annual maximum year (a notional 12-month period when all annual events could occur) and the summation over a 5-year period (annual events occurring five times).

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

MMPA Category	Source	Training Activities	
		Annual Authorization Sought	**5-Year Authorization Sought**
Mortality	Vessel strike	No more than 1 large whale mortality in any given year[1]	No more than 5 large whale mortalities over five years[1]
Mortality	Unspecified	2 mortalities to beaked whales[2]	10 mortalities to beaked whales over five years[2]
Level A	Impulse and Non-Impulse	56 – Species specific data shown in Table 5-2	280 – Species specific data shown in Table 5-2
Level B	Impulse and Non-Impulse	81,906 – Species specific data shown in Table 5-2	409,530 – Species specific data shown in Table 5-2

[1]The Navy cannot quantifiably predict that proposed takes from training or testing will be of any particular species, and therefore seeks take authorization for any large whale species (gray whale, fin whale, blue whale, humpback whale, Bryde's whale, Omura's whale, sei whale, minke whale, or sperm whale), but of the 5 takes over 5 years no more than 2 of any one species of blue whale, fin whale, humpback whale, sei whale, or sperm whale is requested

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

Table 5-2 summarizes the Navy's final take request for training and testing activities by species from the modeling estimates. Derivation of these values is described in more detail within Chapter 6 (Number and Species Taken).

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

Species	ANNUALLY			TOTAL OVER 5-YEAR RULE		
	Level B	Level A	Mortality	Level B	Level A	Mortality
Humpback Whale	860	0	0	4,300	0	0
Blue whale	28	0	0	140	0	0
Fin Whale	28	0	0	140	0	0
Sei Whale	319	0	0	1,595	0	0
Bryde’s Whale	398	0	0	1,990	0	0
Common Minke Whale	101	0	0	505	0	0
Omura's Whale	103	0	0	515	0	0
Sperm Whale	506	0	0	2,530	0	0
Pygmy Sperm Whale	5,579	15	0	27,895	75	0
Dwarf Sperm Whale	14,217	41	0	71,085	205	0
Killer Whale	84	0	0	420	0	0
False Killer Whale	555	0	0	2,775	0	0
Pygmy Killer Whale	105	0	0	525	0	0
Short-finned Pilot Whale	1,815	0	0	9,075	0	0
Melon-headed Whale	2,085	0	0	10,425	0	0
Bottlenose Dolphin	741	0	0	3,705	0	0
Pantropical Spotted Dolphin	12,811	0	0	64,055	0	0
Striped Dolphin	3,298	0	0	16,490	0	0
Spinner Dolphin	589	0	0	2,945	0	0
Rough Toothed Dolphin	1,819	0	0	9,095	0	0
Fraser's Dolphin	2,572	0	0	12,860	0	0
Risso's Dolphin	505	0	0	2,525	0	0
Cuvier's Beaked Whale	22,541	0	0	112,705	0	0
Blaineville’s Beaked Whale	4,426	0	0	22,130	0	0
Longman's Beaked Whale	1,924	0	0	9,620	0	0
Ginkgo-toothed Beaked Whale	3,897	0	0	19,485	0	0

5.2 Vessel Strike Take Request From Training and Testing Activities

Vessel strike to marine mammals is not associated with any specific training or testing activity but rather a limited, sporadic, and accidental result of Navy vessel movement. In order to account for the accidental nature of vessel strikes to large whales in general, and the potential risk from any vessel movement within the MITT Study Area (Figure 1-1), the Navy is seeking take authorization in the event a Navy vessel strike does occur while conducting training or testing during the 5-year period of NMFS' final authorization. A detailed analysis of strike data is contained in Section 6.3.4 (Estimated Take of Large Whales by Vessel Strike).

The Navy does not anticipate ship strikes to marine mammals within the MITT Study Area as a result of training or testing activities under Alternative 1 (Preferred Alternative). There are no records of any Navy vessel strikes to marine mammals in the MITT Study Area. In areas outside the MITT Study Area (for example, Hawaii and Southern California), there have been Navy strikes of large whales. However, these areas differ significantly from the MITT Study Area given that both Hawaii and Southern California have a much higher number of Navy vessel activities[4] and much higher densities of large whales. However, in order to account for the accidental nature of ship strikes in general, and potential risk from any vessel movement within the MITT Study Area, the Navy is seeking take authorization in the event a Navy ship strike does occur within the MITT Study Area during the 5-year period of NMFS' final authorization.

In terms of this LOA application, the Navy requests takes of large marine mammals over the course of the 5 years of the MITT regulations from training and testing activities as presented below:

- The take by vessel strike during training or testing activities in any given year of no more than one large whale of any species including blue whale, Bryde's whale, fin whale, humpback whale, minke whale, Omura's whale, sei whale, or sperm whale.
- The take by vessel strike of no more than five large whales from training or testing activities over the course of the 5 years of the MITT regulations. The five takes over the 5-year period of the authorization would be no more than two of any one species of blue whale, fin whale, humpback whale, sei whale, or sperm whale, in any given year.

[4] There are four Navy vessels homeported in Guam in comparison to 59 in San Diego and 30 in Pearl Harbor. For detailed comparison with the Hawaii and Southern California Training and Testing (HSTT) activities, see the HSTT EIS/OEIS Chapter 3.4 (Marine Mammals), Table 3.4-1 for marine mammal densities in the HSTT Study Area and Section 3.4.3.7.1 (Impact from Vessel Strike), for a discussion of the potential for vessel strikes of large whales in those areas.

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 IMPULSE AND NON-IMPULSE SOURCES

Given the scope of the Navy activities at sea and the current state of the science regarding marine mammals, there is no known method to determine or predict the age, sex, reproductive condition of the various species of marine mammals predicted to be taken as a result of the proposed Navy training and testing. There are 26 marine mammal species, all managed by NMFS, known to occur in the Study Area with regular or rare occurrence. It is possible that other species not listed in Table 3.1 could occur in the Study Area but only as an extralimital occurrence, meaning that the species would not normally occur in the area. An estimate of population density for a species with extralimital occurrence would be negligible (see Table 3-1). The method for estimating the number and types of take is described in the sections below beginning with presentation of the criteria used for each type of take followed by the method for quantifying exposures of marine mammals to sources of energy exceeding those threshold values.

6.1.1 CONCEPTUAL FRAMEWORK FOR ASSESSING EFFECTS FROM SOUND-PRODUCING ACTIVITIES

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

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

The major categories of potential effects are:

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

Direct trauma refers to injury to organs or tissues of an animal as a direct result of an intense sound wave or shock wave impinging upon or passing through its body. Potential impacts on an animal's internal tissues and organs are assessed by considering the characteristics of the exposure and the response characteristics of the tissues. Trauma can be mild and fully recoverable, with no long-term repercussions to the individual or population, or more severe, with the potential for lasting effects or, in some cases, mortality.

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

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

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

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

6.1.1.1 Flowchart

Figure 6-1 is a flowchart that diagrams the process used to evaluate the potential effects on marine animals from sound-producing activities. The shape and color of each box on the flowchart represent either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles).

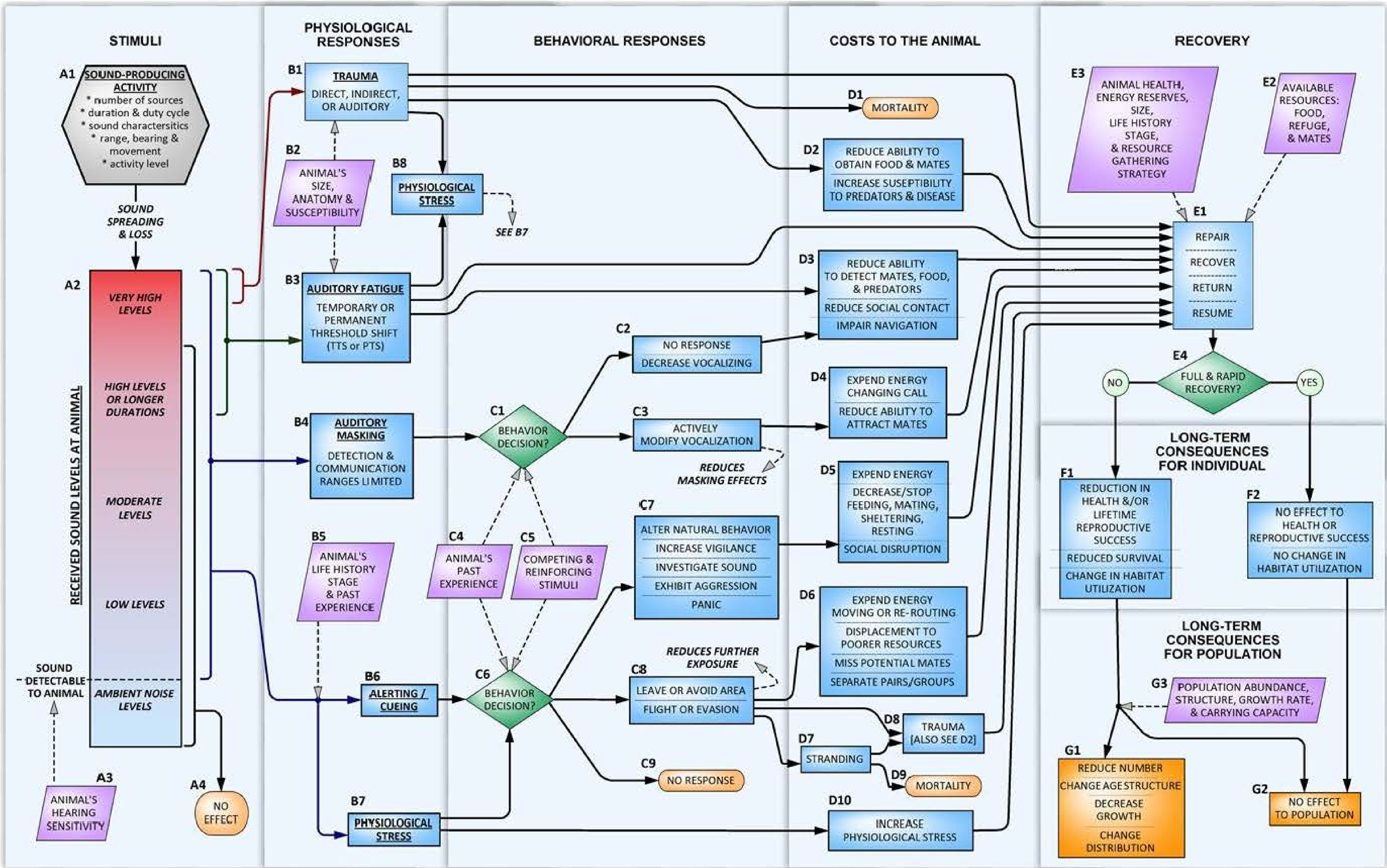

Figure 6-1: Flow Chart of the Evaluation Process of Sound-Producing Activities

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

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

6.1.1.2 Stimuli

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

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

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

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

6.1.1.3 Physiological Responses

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

Trauma

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

Direct trauma includes both auditory and non-auditory trauma. Auditory trauma is the direct mechanical injury to hearing-related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma differs from auditory fatigue in that the latter involves the overstimulation of the auditory system at levels below those capable of causing direct mechanical damage. Auditory trauma can be temporary. One of the most common consequences of auditory trauma is hearing loss (see Section 6.1.2.6).

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

Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of indirect trauma to marine animals. The risk of bubble formation from one of these processes, called rectified diffusion, is based on the amplitude, frequency, and duration of the sound (Crum and Mao 1996) and an animal's tissue nitrogen gas saturation at the time of the exposure. Rectified diffusion is the growth of a bubble that fluctuates in size because of the changing pressure field caused by the sound wave. An alternative, but related, hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of gas-supersaturated tissues. Bubbles have also been hypothesized to result from changes in the dive behavior of marine mammals as a result of sound exposure (Jepson et al. 2003).

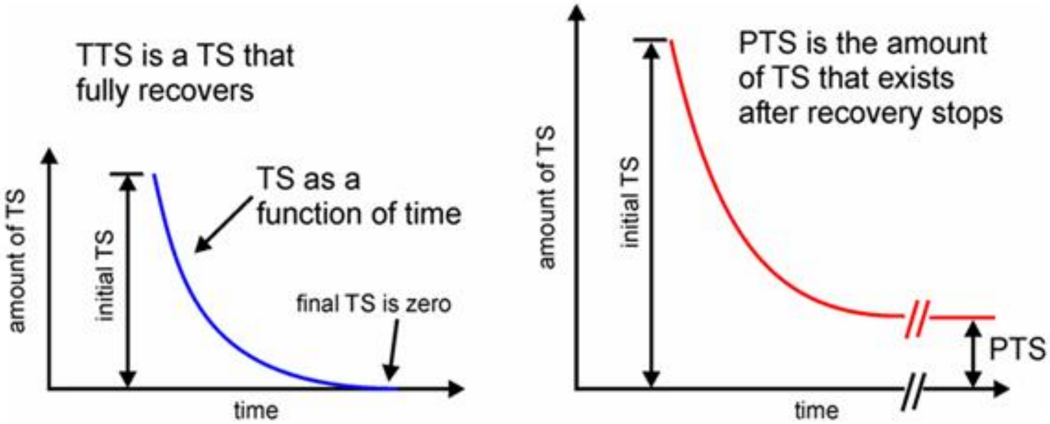
Vascular bubbles produced by this mechanism would not be a physiological response to the sound exposure, but a cost to the animal because of the change in behavior (see Costs to the Animal in this section). Under either of these hypotheses, several things could happen: (1) bubbles could grow to the extent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

Auditory Fatigue

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

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

The distinction between PTS and TTS is based on whether there is a complete recovery of hearing sensitivity following a sound exposure. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 6-2 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.



TTS – temporary threshold shift
TS – threshold shift
PTS – permanent threshold shift

Figure 6-2: Two Hypothetical Threshold Shifts

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

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

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

Auditory Masking

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

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

Physiological Stress

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

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

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

6.1.1.4 Behavioral Responses

Any number of behavioral responses can result from a physiological response. An animal “decides” how it will behave in response to the stimulus based on a number of factors in addition to the severity of the physiological response. An animal's experience with the sound (or similar sounds), the context of the acoustic exposure, and the presence of other stimuli contribute to determining its reaction from a suite of possible behaviors.

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

Trauma and Auditory Fatigue

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

Auditory Masking

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

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

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

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

Other stimuli present in the environment can influence an animal's behavior decision (Box C5). These stimuli can be other acoustic stimuli not directly related to the sound-producing activity; they can be visual, olfactory, or tactile stimuli; the stimuli can be conspecifics or predators in the area; or the stimuli can be the strong drive to engage in a natural behavior. Competing stimuli tend to suppress any potential behavioral reaction. For example, an animal involved in mating or foraging may not react with the same degree of severity as it may have otherwise. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, awareness of a predator in the area coupled with the acoustic stimuli may illicit a stronger reaction than the acoustic stimuli itself otherwise would have. The visual stimulus of seeing ships and aircraft, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response.

Behavioral Reactions and Physiological Stress

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

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

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

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

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

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

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

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

6.1.1.5 Costs to the Animal

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

Trauma

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

Auditory Fatigue and Auditory Masking

Auditory fatigue and masking can impair an animal’s ability to hear biologically important sounds (Box D3), especially fainter and distant sounds. Sounds could belong to conspecifics such as other individuals in a social group (e.g., pod, school, etc.), potential mates, potential competitors, or parents/offspring. Biologically important sounds could also be an animal’s own biosonar echoes used to detect prey, predators, and the physical environment. Therefore, auditory masking or a hearing loss could reduce an animal's ability to contact social groups, offspring, or parents, and reduce opportunities to detect or attract more distant mates. Animals may also use sounds to gain information about their physical environment by detecting the reverberation of sounds in the underwater space or sensing the sound of crashing waves on a nearby shoreline. These cues could be used by some animals to migrate long distances or navigate their immediate environment. Therefore, an animal's ability to navigate may be impaired if the animal uses acoustic cues from the physical environment to help identify its location. Auditory masking and fatigue both effectively reduce the animal’s acoustic space and the ocean volume in which detection and communication are effective.

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

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

Behavioral Reactions and Physiological Stress

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

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

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

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

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

Recovery

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

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

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

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

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

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

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

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

6.1.1.6 Long-Term Consequences to the Individual and the Population

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

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

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

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

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

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

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

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

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

6.1.2 Analysis Background and Framework

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

- Sonar and other active acoustic sound sources (non-impulse sources) – Level A and Level B
- Explosives (impulse sources) –Level A and Level B

In this analysis, marine mammal species are grouped together based on similar biology (such as hearing) or behaviors (such as feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship and discussed as follows: mysticetes (baleen whales) and odontocetes (toothed whales, dolphins, and porpoise).

Methods used to predict acoustic effects on marine mammals build on the Conceptual Framework for Assessing Effects from Sound Producing Activities (Section 6.1.1 (Conceptual Framework for Assessing Effects from Sound Producing Activities). Additional research specific to marine mammals is presented where available.

6.1.2.1 Direct Injury

The potential for direct injury to marine mammals is inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Ketten 1997). Additionally, non-injurious effects on marine mammals are extrapolated to injurious effects based on data from terrestrial mammals to estimate the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ due to anatomical and physiological adaptations to the marine environment (e.g., some characteristics such as a reinforced trachea and flexible thoracic cavity [Ridgway and Dailey 1972] may or may not decrease the risk of lung injury).

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

6.1.2.2 Primary Blast Injury and Barotrauma

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

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving impulse sources (use of explosives) occurred in March 2011 when a group of long-beaked common dolphins entered the 640-m mitigation zone surrounding an explosive with a net explosive weight of 8.75 lb (3.97 kg) set at a depth of 48 feet, approximately 0.5-0.75 nm from shore. One minute after detonation, three animals were observed at the surface, and a fourth animal stranded 42.3 miles (68 km) to the north of the detonation site three days later. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Ledger 2011).

For information on Navy mitigations and protective measures see Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). There is no mortality or serious injury predicted by the analysis of the modeling for the training and testing activities in the Study Area.

6.1.2.3 Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023 lb.) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to 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 (Ketten 1997).

6.1.2.4 Acoustic Resonance

In 2002, NMFS convened a panel of government and private scientists to address the issue of mid-frequency sonar-induced resonance of gas-containing structures (Evans and Miller 2003). It modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of Commerce and U.S. Department of the Navy 2001). The conclusions of that group were that resonance in air-filled structures was not likely to have caused a mass stranding event in the Bahamas in 2000 (Evans and Miller 2003). The frequencies at which resonance was predicted to occur were below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations were not considered to be of sufficient magnitude to cause tissue damage, even at the worst-case resonant frequencies that would lead to the greatest vibratory response. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance leading to tissue damage is not likely under realistic conditions during training and testing, and this type of impact is not considered further in this analysis.

6.1.2.5 Bubble Formation

A suggested indirect cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. The process depends on many factors, including the sound pressure level and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that an immune response is triggered or nervous system tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based on what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate nitrogen gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (for example, beaked whales) are theoretically predicted to induce greater nitrogen gas supersaturation (Houser et al. 2010). If rectified diffusion were possible in marine mammals exposed to a high level of sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness (e.g., nausea, disorientation, localized pain, breathing problems, etc.).

It is unlikely that the short duration of sonar or explosion sounds would last long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis is also suggested: stable microbubbles could be destabilized by high-level sound exposures so bubble growth would occur through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to become a problematic size. Recent research with ex vivo supersaturated bovine tissues suggests that for a 37 kHz signal, a sound exposure of approximately 215 dB relative 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, a whale would need to be within 33 ft. (10 m) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400 to 700 kilopascals (commonly referred to as kPa) for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400 to 700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2010; Saunders et al. 2008). It is improbable that this mechanism would be responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert.

There is considerable disagreement among scientists as to the likelihood of bubble formation in diving marine mammals (Evans and Miller 2003; Piantadosi and Thalmann 2004). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernández et al. 2005; Jepson et al. 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Moore et al. 2009; Dennison et al. 2011; Bernaldo de Quiros et al. 2012). Prior experimental work demonstrates that the postmortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980).

6.1.2.6 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). The mechanism for bubble formation from nitrogen 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 (Fernández et al. 2005; Jepson et al. 2003; 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 suggests that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Zimmer and Tyack (2007) suggested that emboli observed in animals exposed to mid-frequency active (MFA) sonar (Fernández et al. 2005; Jepson et al. 2003) 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, 2012). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in bycatch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 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 livers 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 over what may otherwise occur normally in individual marine mammals.

As a result of these recent findings and for purposes of this analysis, the potential for acoustically mediated bubble growth and the potential for bubble formation as a result of behavioral altered dive profiles are not addressed further.

6.1.2.7 Hearing Loss

The most familiar effect of exposure to high intensity (loud) sound is hearing loss, meaning an increase in the hearing threshold so that a sound of a particular frequency has to be more intense to be heard. The meaning of the term “hearing loss” does not equate to “deafness.” In simple terms, after an exposure to intense sound, a subsequent sound at that same frequency would have to be “louder” (at a higher dB level) than was previously required for that sound to be heard. This phenomenon associated with hearing loss is called a noise-induced threshold shift, or simply a threshold shift. If high-intensity sound over stimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound's frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS. It is important to understand that threshold shifts and the term "hearing loss" do not equate to the inability to hear any sound; threshold shifts as hearing loss are not equivalent to total deafness in humans[5].

There is also a distinction made between PTS and TTS based on whether there is a complete recovery of a threshold shift following a sufficiently intense sound exposure. If the threshold shift eventually returns to zero (sound can be heard at a normal loudness or otherwise the pre-exposure threshold value), the threshold shift is a TTS. For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals and this recovery is complete within minutes to hours for the small amounts of TTS that have been experimentally induced (Finneran et al. 2005; Nachtigall et al. 2005). The time required for recovery is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Nachtigall et al. 2008). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Again for clarity, PTS as discussed in this document is not the loss of all hearing ability, but instead is the loss of hearing sensitivity over a particular range of frequency. 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.

Both auditory trauma and auditory fatigue may result in hearing loss, the mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. The term "auditory fatigue" is often used to mean "TTS"; however, in this analysis the Navy uses a more general meaning to differentiate between fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) and trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure). Many are familiar with hearing protection devices (e.g., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and then possibly result in hearing loss (a threshold shift as TTS or PTS).

Hearing loss due to auditory fatigue in marine mammals was studied by numerous investigators (Kastak et al. 2007; Mann et al. 2010; Popov et al. 2011; Southall et al. 2007; Finneran et al. 2010a, b; Finneran et al. 2005; Finneran and Schlundt 2010; Finneran et al. 2007; Finneran et al. 2000; Finneran et al. 2002;

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[5] For the onset of PTS in marine mammals in the Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS), Navy uses 40 dB of predicted threshold shift (in any frequency range) as PTS threshold criteria. In humans, a PTS at 40 dB is the approximate point at which speech understanding is reduced, especially in noisy environments; total deafness is considered a threshold shift above 90 dB. This information is only provided here for relative context and by no means meant to suggest that a 40-dB threshold shift in humans or the perception of sound following that threshold shift is in any way equivalent to the PTS threshold criteria used in the EIS/OEIS for the analysis of impacts to marine mammals.

Lucke et al. 2009; Mooney et al. 2009a; Mooney et al. 2009b; Nachtigall et al. 2003; Nachtigall et al. 2004; Schlundt et al. 2000; Kastelein et al. 2012a, 2012b). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicates the amount of TTS. Species studied include the bottlenose dolphin (total of nine individuals), beluga (2), harbor porpoise (1), finless porpoise (2), California sea lion (3), harbor seal (1), and northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels—exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (Schlundt et al. 2000).

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

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

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

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

6.1.2.8 Auditory Masking

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

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

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

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

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

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

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

6.1.2.9 Physiological Stress

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), was demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006). Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally.

Although sample sizes are small, the data collected to date suggest that different types of sounds potentially cause variable degrees of stress in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 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 suggested as being a significant indicator of stress in odontocetes (St. Aubin and Dierauf 2001; St. Aubin and Geraci 1989). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

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

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

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

6.1.2.10 Behavioral Reactions

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

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

Southall et al. (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 depending on the marine mammal species or group allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-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. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during three playbacks of sound breaking off foraging dives at levels below 142 dB sound pressure level, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB sound pressure level (Tyack et al. 2011).

6.1.2.11 Behavioral Reactions to Non-Impulse Sound Sources

Mysticetes

Specific to Navy systems using low-frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. These studies found only short-term responses to low-frequency sound by mysticetes (fin, blue, and humpback whales), including changes in vocal activity and avoidance of the source vessel (Clark and Fristrup 2001; Croll et al. 2001; Fristrup et al. 2003; Miller et al. 2000; Nowacek et al. 2007). Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Croll et al. 2001).

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

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110 to 120 dB re 1 µPa (Melcón et al. 2012). Preliminary results from the 2010–2011 field season of the ongoing behavioral response study in southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2012). These preliminary findings from Melcón et al. (2012) and Southall et al. (2012) are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (see Section 6.3[Quantitative Modeling for Impulse and Non-Impulse Sources], below). The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, the Mediterranean, Cape Hatteras, and Norwegian waters. These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007–2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface. Preliminary results from a similar behavioral response study in southern California waters have been presented for the 2010–2011 field season (Southall et al. 2012). 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 (Defense 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. Killer whales off Norway also exhibited horizontal avoidance of a transducer with outputs in the mid-frequency range (signals in the 1 kHz to 2 kHz and 6 kHz to 7 kHz ranges) (Miller et al. 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al. 2011). In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009).

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

In May 2003, killer whales in Haro Strait, Washington, exhibited what were believed by some observers to be aberrant behaviors, which were observed while the USS SHOUP was in the vicinity and engaged in MFA sonar operations. Sound fields modeled for the USS SHOUP transmissions (U.S. Department of the

Navy 2004; Fromm 2009; National Marine Fisheries Service [Office of Protected Resources] 2005) estimated a mean received sound pressure level of approximately 169.3 dB re 1µPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1µPa).

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

Researchers at the Navy's Marine Mammal Program facility in San Diego, California, have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Finneran et al. 2003; Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt 2004; Schlundt et al. 2000). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002; Schlundt et al. 2000). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa root mean square (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. 2006; Kastelein et al. 2001) and emissions for underwater data transmission (Kastelein et al. 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006), again highlighting the importance in understanding species differences in the tolerance of underwater noise.

6.1.2.12 Behavioral Reactions to Impulse Sound Sources

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 (Gordon et al. 2003; Richardson et al. 1995; Southall et al. 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.

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

Seismic pulses at average received levels of 131 dB re 1 micropascal squared second (μPa^2-sec) 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.

Odontocetes

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

6.1.2.13 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 simply tolerate the disturbance. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat. Longer

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

6.1.2.14 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 (Bradshaw et al. 2006; Culik 2004; Geraci et al. 1999; Geraci and Lounsbury 2005; Hoelzel 2003; National Research Council of the National Academies 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors include, for example, pollution (Hall et al. 2006a, b; Jepson et al. 2005), fisheries interactions, entanglement, and noise (Jepson et al. 2005; Laist et al. 2001).

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 2011). Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single cow-calf pair) that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in the Navy's Marine Mammal Strandings Associated with Navy Sonar Activities Technical Report.

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). 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-impulse 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 (Section 6.1.2.5 [Bubble Formation]) (Houser et al. 2001; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding versus exposure to sonar (Cox et al. 2006).

As the International Council for the Exploration of the Sea 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 (International Council for the Exploration of the Sea 2005). This has also been demonstrated by monitoring in areas where the Navy operates (Bassett et al. 2010; Baumann-Pickering et al. 2010; McDonald et al. 2006; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar-related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

Long-Term Consequences for the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement) (Section 6.1.1.1 [Flowchart]). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a "measurable" cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be "made up" during the life of a normal healthy individual. The same holds true for exposure to human-generated sound sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. The long-term consequence from exposure to human generated sound may not be significant. The importance of brief effects such as short-term masking of a conspecific's social sounds or a single lost feeding opportunity can be exaggerated by focusing on the single event and not on the important variable, which is the individual and its lifetime parameters of growth, reproduction, and survival.

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council 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 recent U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's current mitigation practices. Results from intensive monitoring from 2009 until mid-2012 by independent scientists and Navy observers in the Southern California Range Complex and Hawaii Range Complex (HRC) observed over 256,000 marine mammals with no evidence of distress or unusual behavior observed during Navy activities. Monitoring efforts were also conducted in the Atlantic Ocean during training events from January 2009 – December 2011, as part of the Atlantic Fleet Active Sonar Training (AFAST) letter of authorization. A total of five anti-submarine warfare events were monitored with third party aerial, vessel, and passive acoustic surveys by trained marine mammal observers. A total of 77.5 hours of aerial, 25.1 hours of vessel, and 26.5 hours of towed hydrophone array passive acoustic effort was spent to collect data before, during, and after the exercises. A total of 1,068 marine mammals were observed during these events and no observable behavioral disturbance was noted. Continued monitoring efforts over time will be necessary to begin to evaluate the long-term consequences of exposure to noise sources.

6.1.3 Summary of Observations During Previous Navy Activities

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 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 may provide information relevant to the analysis of impacts to marine mammals, including data on species distribution, habitat use, and evaluating potential animal responses to Navy activities. Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas, and (2) collecting data during individual training or testing activities. Navy also contributes to funding of basic research (as described in Chapter 14 [Research]), including behavioral response studies specifically designed to determine the effects on marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare (ASW) active acoustic (sonar) system.

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

In the Mariana Islands, the first exercise-related monitoring involved an aerial monitoring survey after the Valiant Shield training exercise in July 2007. That survey covered 2,352 km of linear effort. There were no reports of strandings, distressed, or injured animals during that survey effort (Mobley 2007), and stranded animals in the Mariana Islands have never been reported in association with Navy activities.. The first comprehensive marine mammal and sea turtle survey of the Mariana Islands area (the Mariana Islands Sea Turtle and Cetacean Survey [MISTCS]), occurred in 2007 and was funded by the U.S. Pacific Fleet (Fulling et al. 2011; Norris et al. 2012) . Although there was no requirement for the Navy to undertake this survey, the Navy proactively initiated the survey to gather data to support an analysis of potential effects in the Mariana Islands Range Complex Environmental Impact Statement and associated MMPA and ESA consultations.

During the 2010 MIRC LOA development process, the Navy and NMFS agreed that monitoring in the Mariana Islands should focus on augmenting existing baseline data, since regional data on species occurrence and density are extremely limited. Collecting baseline data was deemed a priority prior to focusing on exercise monitoring and behavioral response as is being conducted in other Navy operating areas and ranges. Although there have been marine mammal observation data submitted to NMFS as part of annual exercise reporting, other than an aerial survey conducted in 2007 after a major training exercise called Valiant Shield, there have been no dedicated monitoring efforts during Navy activities in the MITT Study Area.

As discussed in Section 3.1 (Marine Mammal Species) and Chapter 4 (Affected Species Status and Distribution), Navy-and NMFS-sponsored surveys have been conducted since 2007 in the Study Area. The Pacific Islands Fisheries Science Center conducted dedicated small boat surveys around Guam and

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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.

the CNMI, including: (1) surveys off Guam and Saipan from 9 February to 3 March 2010 (Oleson and Hill 2010; Ligon et al. 2011), (2) surveys off Guam from 17 February to 3 March 2011 (HDR 2011), (3) surveys off Guam and other islands in the CNMI from 26 August to 29 September 2011 (Hill et al. 2012), (4) surveys off Guam and Saipan from 15 to 29 March 2012 (HDR EOC 2012), and (5) surveys off Guam and other islands in the CNMI at various times between May and July 2012 (Hill et al. 2013). In addition, NMFS Pacific Islands Fisheries Science Center conducted a large vessel cetacean and oceanographic survey between Honolulu and Guam and within the Exclusive Economic Zones of Guam and CNMI from 20 January to 3 May 2010 (Oleson and Hill 2010).

Hill et al. (2013) reported 17 cetacean sightings during 11 surveys off Guam and 20 cetacean sightings over the course of 20 surveys off the CNMI. Species sighted off Guam included bottlenose dolphins, spinner dolphins, pantropical spotted dolphins, and short-finned pilot whales. During the 20 surveys within waters less than 32 nm from shore in the CNMI, 22 cetacean sightings were recorded. Seventy-two percent of sightings in waters of the CNMI occurred in the waters surrounding the islands of Saipan, Tinian, and Aguijan. However, the encounter rate around the island of Rota was greater than elsewhere in the survey area, and species sighted at Rota were in approximately the same location when they were sighted during surveys conducted in 2011, suggesting that the area is consistently used by those species. Ligon et al. (2011) reported data on sightings over a total of 16 days, 10 of which were conducted off Guam, and 6 off Saipan. The researchers reported 18 sightings consisting of three identified species: spinner dolphin, sperm whale, and pantropical spotted dolphins. The pantropical spotted dolphins were only spotted off Guam, whereas the other species were sighted off both Guam and Saipan. A survey off the western and northern coasts of Guam in February and March of 2011 recorded nine cetacean sightings consisting of seven groups of spinner dolphins, one mixed-species group of short-finned pilot whales and bottlenose dolphins, and one unidentified small dolphin (HDR 2011). The large-scale survey conducted by Oleson and Hill (2010) was divided into four components: 1) a survey along a transit route from Hawaii to Guam, 2) a survey of waters around Micronesia and the CNMI, 3) a survey along a transit route from Guam to Hawaii, and 4) a small-boat survey of the waters surrounding Guam, Saipan, and Tinian. Combined, the four surveys were conducted over 62 days, spanned over 4,000 nm, reported sightings of 73 cetacean groups, compiled over 5,500 photographs, and took 13 biopsies. Hill et al. (2012) conducted small boat surveys of the waters surrounding Guam and the islands of Saipan, Tinian, Rota, and Aguijan in the CNMI. Eight cetacean groups were sighted during the nine surveys conducted off Guam. The species sighted included bottlenose dolphin, spinner dolphin, pantropical spotted dolphin, and short-finned pilot whale. Spinner dolphins were the most frequently encountered species. During the 21 surveys conducted in the CNMI waters, 30 sightings of cetacean groups were recorded. The species encountered included the same four species sighted off Guam as well as pygmy killer whales and a dwarf sperm whale. The species-specific subsections of Chapter 4 (Affected Species Status and Distribution) provide additional details on these recent surveys.

Observations from research occurring in the other Navy range complexes (e.g., HRC and Southern California [SOCAL] are also discussed in this section and demonstrate a continued commitment to expanding the knowledge of marine mammal occurrence and abundance in Navy operating areas. In the Pacific, the vast majority of scientific field work, research, and monitoring efforts have been expended in Southern California and Hawaii where Navy has historically concentrated training and testing activities. Since 2006 across all Navy Range Complexes (in the Atlantic, Gulf of Mexico, and Pacific), there have been a total of 69 reports (Major Exercise Reports, Annual Exercise Reports, and Annual Monitoring Reports) 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. In addition to this multi-year record of reports from across the Navy, there has also been ongoing behavioral response research efforts (in Southern

California and the Bahamas) specifically focused on determining the potential effects from Navy mid-frequency sonar (Tyack et al. 2011). This multi-year compendium of monitoring, observation, study, and broad scientific research is informative with regard to assessing the effects of Navy training and testing in general. Given this record involves the same Navy training and testing activities being considered for the MITT Study Area and includes all the marine mammal taxonomic families present and many of the same species as those expected within the MITT Study Area, this broad record covering Navy activities elsewhere is directly applicable to assessing locations such as the Mariana Islands.

In the Hawaii and Southern California Navy training and testing ranges from 2009 to 2012, Navy-funded marine mammal monitoring research completed over 5,000 hours of visual survey effort covering over 65,000 nautical miles, sighted over 256,000 individual marine mammals, took over 45,600 digital photos and 36 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected over 40,000 hours of passive acoustic recordings. In Hawaii alone between 2006 and 2012, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises.

Based on monitoring conducted before, during, and after Navy training and testing events since 2006, the Navy's assessment is that it is unlikely there will be impacts having any long-term consequences to populations of marine mammals as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy including the MITT Study Area.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities[7]. Citations to evidence indicative of increases or viability of marine mammal populations are not meant to suggest that Navy training and testing events are beneficial to marine mammals. There is, however, no direct evidence from Hawaii or Southern California suggesting Navy training and testing has had or may have any long-term consequences to marine mammals. Barring any evidence to the contrary, therefore, what limited and preliminary evidence there is from the Navy's 69 reports and other focused scientific investigations should be considered. This is especially the case given the seemingly widespread public misperception that Navy training and testing, especially involving use of mid-frequency sonar, will cause large numbers of marine mammals to be injured or die. Examples to the contrary where the Navy has conducted training and testing activities for decades include the following.

Work by Moore and Barlow (2011) indicate that, since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes the SOCAL Range Complex. They predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching "current ecosystem limits." Similar findings have also documented the season range expansion and increasing presence of Bryde's whales south of Point Conception in the Southern California (Kerosky et al. 2012). However, recent research on population trends of beaked whales in the California Current

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

Large Marine Ecosystem indicate a decline in abundance and conclude that anthropogenic sound (including sonar) cannot be ruled out as a possible contributing cause(Moore and Barlow 2013). For humpback whales that winter in the Hawaiian Islands, research has confirmed that the overall humpback whale population in the North Pacific has continued to increase and is now greater than some prior estimates of pre-whaling abundance (Barlow et al. 2011). The Hawaiian Islands, the location of the HRC for decades, continue to function as a critical breeding, calving, and nursing area for this endangered species.

As increases in population would seem to indicate, evidence for the presence and/or residence of marine mammal individuals and populations would also seem to suggest a lack of long-term or detrimental effects from Navy training and testing historically occurring in the same locations. For example, photographic records spanning more than two decades demonstrated there had been re-sightings of individual beaked whales (from two species: Cuvier's and Blainville's beaked whales), suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007). This is specifically an area in the Hawaiian Islands where the Navy has been using mid-frequency sonar during anti-submarine warfare training (including relatively intense choke point or swept channel events) over many years. Passive acoustic detection of Blainsville's and Cuvier's beaked whales in waters surrounding Saipan as well as other areas of the Pacific Ocean (e.g., Wake Atoll and Palmyra Atoll) from 2005 to 2011 indicate long-term sight fidelity in these areas as well (Baumann-Pickering et al. 2012). Similar findings of high site fidelity have been reported for the area west of Hawaii involving pygmy killer whales (*Feresa attenuata*) (McSweeney et al. 2009). Similarly, the intensively used instrumented range at Pacific Missile Range Facility (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 (commonly known as RIMPAC) Exercise. More recently at PMRF, Martin and Kok (2011) reported on the presence of minke whales, humpback whales, beaked whales, pilot whales, and sperm whales on or near the range during a Submarine Commander Course involving three surface ships and a submarine using mid-frequency sonar over the span of the multiple day event. The analysis showed it was possible to evaluate the behavioral response of minke whale and found there did not appear to be a significant reaction by the minke whale to the mid-frequency sonar transmissions, and the training activity in general did not appear to affect the presence of other detected species on or near the range. In Southern California, based on a series of surveys from 2006 to 2008 and the high number encounter rate, Falcone et al. (2009) proposed that their observations suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales. For over three decades, this ocean area west of San Clemente has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the Naval installations in San Diego. The Navy's use of the area has not precluded beaked whales from also continuing to inhabit the area, nor has there been documented declines or beaked whale mortalities associated with Navy training and testing activities. The long-term presence of beaked whales at the Navy range off Southern California is consistent with observations from a similar Navy instrumented range (the Atlantic Undersea Test and Evaluation Center) located off Andros Island in the Bahamas where Blainville's beaked whales (*Mesoplodon densirostris*) are routinely acoustically detected (see Tyack et al 2011; McCarthy et al. 2011).

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for this analysis, as well as oceanographic and species assemblage changes on the U.S. Pacific Coast not thoroughly addressed. Interestingly, however, in the small portion of that area overlapping the Navy's SOCAL Range Complex, long-term residency by individual Cuvier's beaked whales and higher densities provide indications that the proposed decline noted elsewhere is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. Navy funding for monitoring of beaked whale and other marine species (involving visual survey, passive acoustic recording, and tagging studies) will continue in SOCAL to develop additional data towards a clearer understanding of marine mammals inhabiting the Navy's range complexes.

To summarize, while the evidence covers most marine mammal taxonomic suborders, it is limited to a few species and only suggestive of the general viability of those species in intensively used Navy training and testing areas. There is no direct evidence that routine Navy training and testing spanning decades has negatively impacted marine mammal populations at any Navy Range Complex. Although there have been a few strandings associated with use of sonar in other locations, 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." Therefore, based on the best available science (Barlow et al 2011; Falcone et al. 2009; Littnan 2010; Martin and Kok 2011; McCarthy et al. 2011; McSweeney et al. 2007; McSweeney et al. 2009; Moore and Barlow 2011; Tyack et al., 2011; Southall et al. 2012), including data developed in the series of 69 reports submitted to NMFS, the Navy believes that long-term consequences for individuals or populations are unlikely to result from Navy training and testing activities in the MITT Study Area.

Although potential impacts to certain marine mammal species from the Proposed Action may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population.

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

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

6.2.1 Mortality and Injury from Explosions

There is a considerable body of laboratory data on injuries from impulse sound exposure, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep, and other species). Onset mortality, onset slight lung injury, and onset slight gastrointestinal tract injury represent a series of effects with decreasing likelihood of serious injury or lethality. Primary impulse injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998b; Craig Jr. 2001). Criteria and thresholds for predicting mortality and injury to marine mammals from explosions were initially developed for the Navy shock trials of the SEAWOLF submarine (Craig and Hearn 1998b) and WINSTON S. CHURCHILL surface ship (Craig Jr. 2001). NMFS adopted these criteria and thresholds in several Final Rules issued under the MMPA (63 Federal Register [FR] 230; 66 FR 87; 73 FR 121; 73 FR 199). Similar criteria and thresholds also were used for the shock trial of the Navy amphibious transport dock ship MESA VERDE (U.S. Department of Navy 2008a) and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the MESA VERDE shock trial (National Marine Fisheries Service 2008a). Upper and lower frequency limits of hearing are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in the Navy's MITT Draft EIS/OEIS Thresholds and Criteria Technical Report.

Mortality and Slight Lung Injury – In air or submerged, the most commonly reported internal bodily injury was hemorrhaging in the fine structure of the lungs. Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973). Therefore, impulse was used as a metric upon which internal organ injury could be predicted. Impulse (e.g., from explosives) thresholds for onset mortality and slight lung injury are indexed to 75 and 93 lb. (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted, such that a prediction of mortality to larger animals could be determined as a function of impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive lung injury for "1 Percent Mortality" (defined as where most survivors had moderate blast injuries and should survive on their own) and slight lung injury for "0 Percent Mortality" (defined as no mortality, slight blast injuries) were derived for each species. The Navy uses the minimum impulse level predictive of extensive lung injury, the exposure level likely to result in 11 percent mortality of animals in a population (99 percent would be expected to recover from the injury) as the onset of mortality. The scaling of lung volume to depth is conducted for all species, since data is from experiments with terrestrial animals held near the water's surface and marine mammals' gaseous cavities compress with depth making them less vulnerable to impulse injury. The received impulse that is necessary for mortality or slight lung injury must be delivered over a time period that is the lesser of the positive pressure duration or 20 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 impulse delivery time to experience an effect decreases (Goertner 1982).

Species-specific calf masses are used for determining impulse-based thresholds because they most closely represent effects to individual species. *The Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report* (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases, body masses were extrapolated from similar species rather than the listed species. Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria identify the impulse at which these effects are predicted for 11 percent of animals, and the portion of animals affected would increase closer to the explosion. Therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured. There were, however, no mortality or slight lung injury exposures predicted in the analysis of the modeling resulting from the use of explosives during training and testing in the Study Area.

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; Richmond et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the peak pressure of the shock wave and would be independent of the animal's size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak pressure was 237 dB re 1 µPa.

The Navy has elected to include the criterion in this analysis because there are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially near the surface. Gastrointestinal tract injury from small test charges (described as "slight contusions") was observed at peak pressure levels as low as 104 pounds per square inch (psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by Navy and NMFS for ship shock trials (U.S. Department of the Navy 1998, 2001, 2008) (National Marine Fisheries Service 63 FR 230; 66 FR 87; 73 FR 143). There were, however, no gastrointestinal injuries predicted in the analysis of the modeling resulting from the use of explosives during training and testing in the Study Area.

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

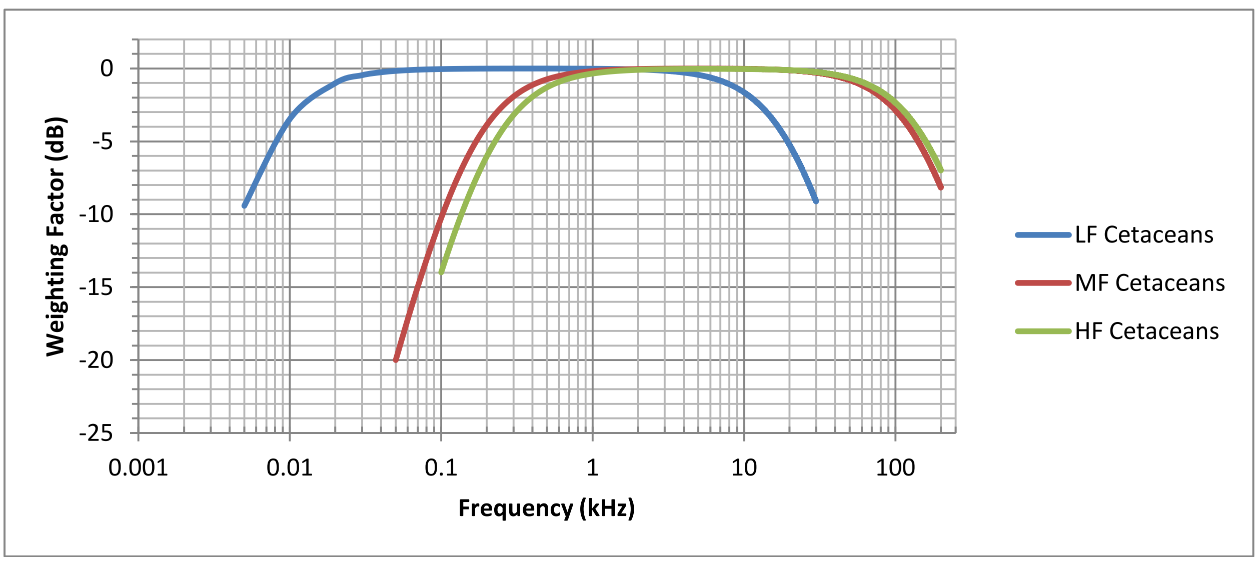

Figure 6-3: Marine Mammal Flat Auditory Weighting Functions Modified from Southall et al. (2007)

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

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

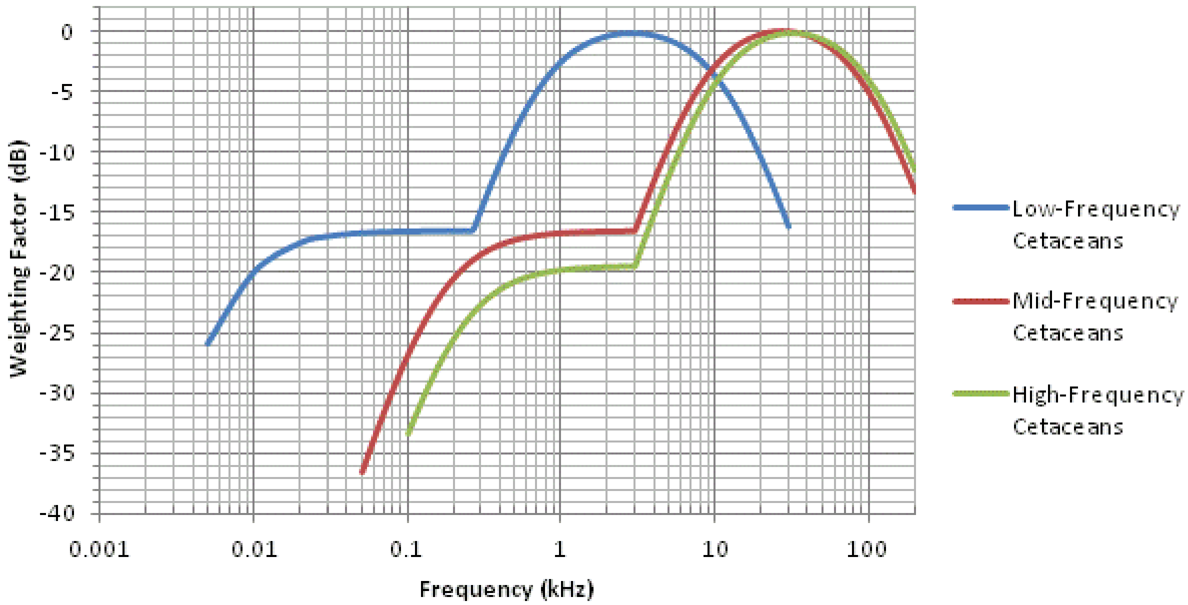

Figure 6-4: New Type II Weighting Functions for Low-, Mid-, and High-Frequency Marine Mammals

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

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

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

Group	Species	Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB SEL (LF_{II})	198 dB SEL (LF_{II})
Mid-Frequency Cetaceans	Most delphinids, beaked whales, medium and large toothed whales	178 dB SEL (MF_{II})	198 dB SEL (MF_{II})
High-Frequency Cetaceans	Porpoises, *Kogia* spp.	152 dB SEL (HF_{II})	172 dB SEL (HF_{II})

Notes: $LF_{II,}$ $MF_{II,}$ HF_{II} are New compound Type II weighting functions (see Finneran and Jenkins [2012]).

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

Group	Species	Behavior		Slight Injury			Mortality
		Behavioral (for >2 pulses/24 hrs)	TTS	PTS	GI Tract	Lung	
Low Frequency Cetaceans	All mysticetes	167 dB SEL (LF_{II})	172 dB SEL (LF_{II}) or 224 dB Peak SPL	187 dB SEL (LF_{II}) or 230 dB Peak SPL			
Mid-Frequency Cetaceans	Most delphinids, medium and large toothed whales	167 dB SEL (MF_{II})	172 dB SEL (MF_{II}) or 224 dB Peak SPL	187 dB SEL (MF_{II}) or 230 dB Peak SPL	237 dB SPL or 104 psi	Equation 1	Equation 2
High Frequency Cetaceans	Porpoises and *Kogia* spp.	141 dB SEL (HF_{II})	146 dB SEL (HF_{II}) or 195 dB Peak SPL	161 dB SEL (HF_{II}) or 201dB Peak SPL			

(1) (2)

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

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

Notes: M = mass of the animals in kg, Drm = depth of the receiver (animal) in meters, SEL = re $1\mu Pa^2$-sec, Sound Pressure Level (SPL) = re 1µPa

6.2.2 Behavioral Responses

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

Non-Impulse Sound – 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 flat Type I weighting functions before the behavioral response function is applied. Beaked whales are the exception. They have unique criteria based on specific research that shows these animals to be especially sensitive to sound. Beaked whale behavioral criteria are unweighted.

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

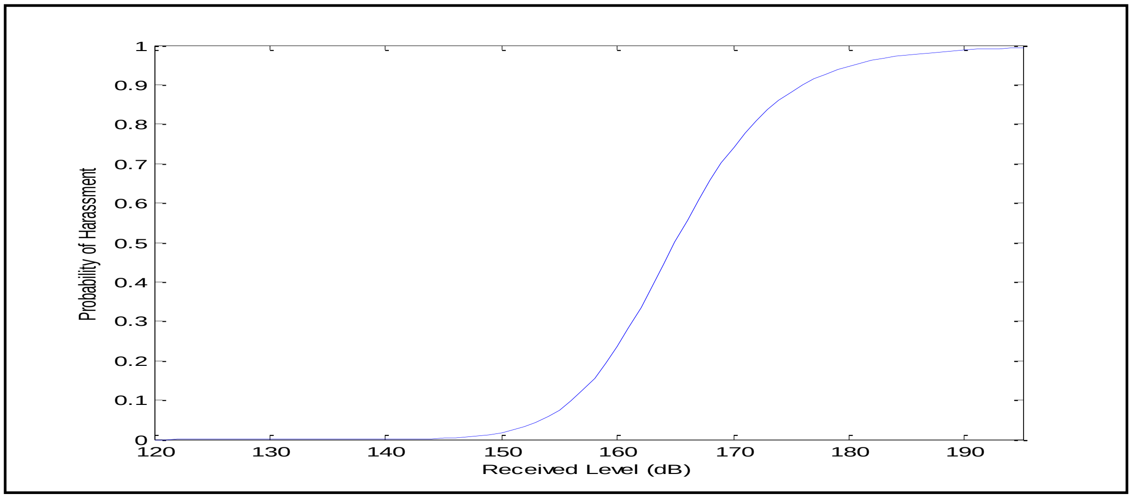

Figure 6-5: Behavioral Response Function Applied to Odontocetes

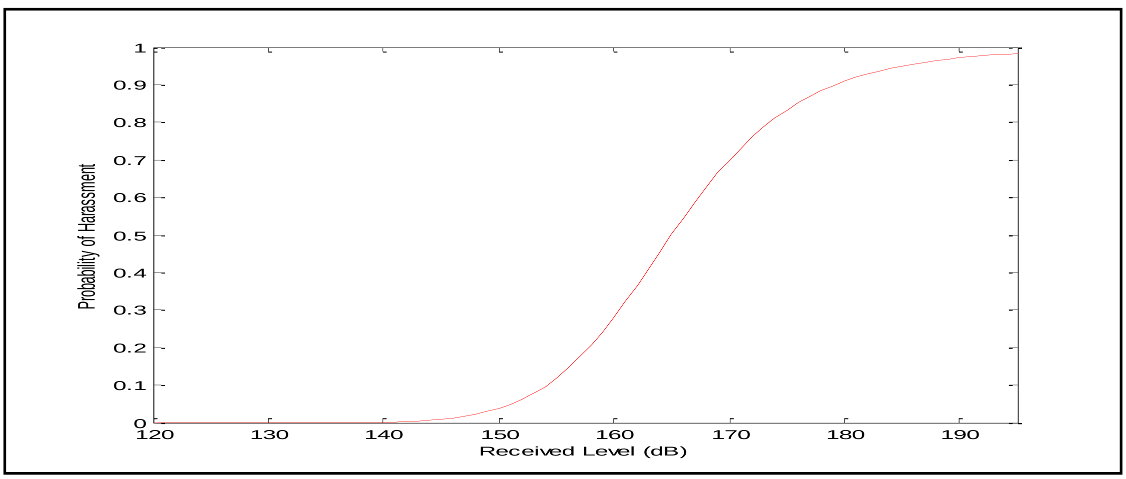

Figure 6-6: Behavioral Response Function Applied to Mysticetes

This effects analysis assumes that the potential consequences of exposure to non-impulse sound on individual animals would be a function of the received sound pressure level (SPL) (dB re 1 µPa). The behavioral response function applied to mysticetes differs from that used for odontocetes in having a shallower slope, which results in the inclusion of more behavioral events at lower amplitudes, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value. The values used in this analysis are based on three sources of data: behavioral observations during TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003, and 2005; Finneran and Schlundt 2004); reconstruction of sound fields produced by the USS SHOUP associated with the behavioral responses of killer whales observed in Haro Strait (National Marine Fisheries Service 2005; 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. (2004a). 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 and testing with MFA sonar) at a given received level of sound. For example, at 165 dB sound pressure level (dB re 1µPa 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. The response function is not applied to individual animals, only to exposed populations.

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Southall et al. 2007; Wartzok et al. 2003). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral 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). Currently 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.

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

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

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

Table 6-3: Behavioral Thresholds for Impulse Sound

Hearing Group	Impulse Behavioral Threshold for >2 pulses/24 hrs	Onset TTS
Low-Frequency Cetaceans	167 dB SEL (LF_{II})	172 dB SEL (MF_{II}) or 224 dB Peak SPL
Mid-Frequency Cetaceans	167 dB SEL (MF_{II})	
High-Frequency Cetaceans	141 dB SEL (HF_{II})	146 dB SEL (HF_{II}) or 195 dB Peak SPL

Notes: LF_{II}, MF_{II}, HF_{II} are New compound Type II weighting functions (See Finneran and Jenkins [2012]). SEL = re 1μPa^2-sec; SPL = re 1μPa

6.3 QUANTITATIVE MODELING FOR IMPULSE AND NON-IMPULSE SOURCES

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

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

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

The additional post-model quantification has been undertaken to further refine the numerical analysis of acoustic effects so as to include animal behavior such as avoidance of sound sources, avoidance of areas of activity before use of a sound source or explosive, during use of repeated explosives, and to account for protections afforded by implementation of standard Navy mitigations. The following sections describe the steps of the quantitative analysis of acoustic effects.

Marine Species Density Data – A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate unit of metric for this type of analysis is density, which is the number of animals present per unit area. Marine species density estimation requires a significant amount of effort to collect and analyze data to produce a usable estimate. The updated marine mammal density estimates used in the acoustic effects analysis are from the Navy Marine Species Density Database (U.S. Department of the Navy 2012b). The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Economic Exclusion Zone. NMFS publishes annual Stock Assessment Reports (SARs) for various regions of U.S. waters, which cover all stocks of marine mammals within those waters. The species that occur in the Study Area are covered by the Pacific Region SAR (Carretta et al. 2011). Other independent researchers often publish density data or research covering a particular marine mammal species, which is integrated into the NMFS SARs. For most cetacean species, abundance is estimated using line-transect methods that employ a standard equation to derive densities based on sighting data collected from systematic ship or aerial surveys. More recently, habitat-based density models have been used effectively to model cetacean density as a function of environmental variables (e.g., Barlow et al. 2009). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional line-transect analyses because cetacean densities are estimated as a continuous function of habitat variables (e.g., sea surface temperature, water depth, etc.). Within most of the world's oceans, however, there have not been enough systematic surveys to allow for line-transect density estimation or the development of habitat models. To get an approximation of the species distribution and abundance for unsurveyed areas, in some cases it is appropriate to extrapolate data from areas with similar oceanic conditions where extensive survey data exist. Habitat Suitability Index 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). There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the MITT 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 (Pacific Islands Fisheries Science Center), adopted a protocol to select the best available data sources based on species, area, and season. The resulting Geographic Information System (commonly referred to as "GIS") database includes one single spatial and seasonal density value for every marine mammal species present within the MITT Study Area. The updated marine mammal density estimates used in the acoustic effects analysis are from the Navy Marine Species Density Database (U.S. Department of the Navy 2012b). In this analysis, marine mammal density data were used as an input in the NAEMO in their original temporal and spatial resolution. Seasons are defined as warm (June through November) and cold (December through May). The density grid cell spatial resolution varied, depending on the original data source utilized, from 10 square kilometers (km^2) to 0.5 $degrees^2$. Where data sources overlap, there might be sudden increase or decrease in density due to different derivation methods or survey data utilized. This is an artifact of attempting to use the best available data for each geographic region. The density data was used as-is in order to preserve the original values. Any attempt to smooth the datasets would either increase or decrease adjacent values, and would inflate the error of those values by an unknown amount. The Navy modeled acoustic effects within representative locations where training and testing is expected to occur. Within the MITT Study Area, the distribution extent for some species did not overlap with any of the affected areas from the sound source locations modeled.

Upper and Lower Frequency Limits – The Navy has adopted a single frequency cutoff at each end of a functional hearing group's frequency range, based on the most liberal interpretations of their composite hearing abilities (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 6-4 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 6-4: 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

Navy Acoustic Effects Model – For this analysis of Navy training and testing 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 (Naval Undersea Warfare Center 2012).

The NAEMO improves upon previous modeling efforts (e.g., U.S. Department of the Navy 2008b; 2008c) in several ways. The following paragraphs provide an overview of the NAEMO process and its more critical data inputs. Using information on the likely density of marine mammals in the area being modeled, NAEMO distributes the resulting number of virtual animals ("animats") into an area bounded by the maximum propagation of energy that has a potential to affect marine mammals. These animats are distributed based on the group (pod) size and known depth distributions (dive profiles). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus, or porpoising with its head occasionally above water. The NAEMO calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing event. This is done taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include all the environmental variation within the Study Area where similar events might occur in the future. The NAEMO then tracks the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats are then converted using actual marine mammal densities, and the highest order effect predicted for a given animal is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine mammal could be impacted during each independent scenario or 24-hour period. The NAEMO provides the initial estimated impacts on marine species with a static horizontal distribution. These model-estimated results are then further analyzed to account for pre-activity avoidance by sensitive species, mitigation (considering sound source and platform), and avoidance of repeated sound exposures by marine mammals, producing the final predictions of effects used in this request for Letters of Authorization.

Model Assumptions – 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. 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 have been chosen:

- Marine mammals (virtual animals called "animats" in the model) are modeled as being underwater, 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 raising its head above water).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in PTS.
- 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 which are implemented during many training and testing activities were not considered in the model (see Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

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

6.3.1 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 over-estimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during explosions is described below and discussed in more detail in Section 6.1.2 (Analysis Background and Framework).

Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Beaked whales have been observed to be especially sensitive to human activity (Tyack et al. 2011), which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonar and other active acoustic sources (see Section 6.1.2 [Analysis Background and Framework]).

Therefore, for certain naval activities preceded by high levels of vessel activity (multiple vessels) or hovering aircraft, 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 beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and injury, respectively, due to animals moving away from the activity and into a lower effect range.

Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injuries (i.e., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active sources and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 6.3.3.2 (Range to Effects for Non-Impulse Sources [Sonar and Other Active Acoustics Sources]), and avoidance of repeated explosive exposures is discussed further in Section 6.3.2.4 (Range to Impulse Effects for Explosives).

6.3.2 Implementing Mitigation to Reduce Sound Exposures

The military implements mitigation measures (described in Chapter 11 [Means of Effecting the Least Practicable Adverse Impact – Mitigation Measures) during sound-producing activities, including halting or delaying use of sonar or another active acoustic source or an explosion when marine mammals are observed in the mitigation zone. Sound-producing activities would not begin or resume until the mitigation zone is observed to be free of marine mammals. The NAEMO estimates acoustic effects without any shutdown or delay of the activity in the presence of marine mammals; therefore, the model over-estimates impacts to marine mammals within mitigation zones. The post-model analysis considers the potential for highly effective mitigation to prevent Level A harassments due to exposure to sonar and other active acoustic sources and Level A harassments and mortalities due to explosions.

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

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

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

The mitigation effectiveness scores are multiplied by the estimated sightability of each species to estimate the percent of each species model-estimated to experience mortality (explosives only) or injury (all sound-producing activities) that would, in reality, be observed by Lookouts prior to or during a sound-producing activity. Observation of marine mammals prior to or during a sound-producing event would stop or be delayed until the area was cleared as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the MITT EIS/OEIS. For purposes of this delay the sound-producing activity, which would reduce actual marine mammal sound exposures analysis, the sightability is based on availability bias g(0) for vessel and aerial platforms based on recent peer-reviewed literature. While g(0) is based on trained marine mammal observers' ability to identify specific species along a single line transect of a limited width and the animals being available for detection at the surface along that trackline, Lookouts aboard Navy platforms would observe the full mitigation zone prior to and during a sound-producing activity and sound-producing activities would be halted when any marine mammal is observed, regardless of species. Because Lookouts would report any marine mammal observation within the mitigation zone over a period of time preceding and during an activity, g(0) is considered to be a reasonable representation of the sightability of a marine mammal for this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with Lookouts utilized in the activity. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published value for each platform, that individual value is used. For species for which there is a range of published g(0) values, an average of the values, calculated separately for each platform, is used. A g(0) of zero is assigned to species for which there is no data available, unless a g(0) estimate can be extrapolated from similar species/guilds based on the published g(0) values. The g(0) values used in this analysis are provided in Table 6-5.

Table 6-5: Sightability Based on g(0) Values for Marine Mammal Species in the MITT Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Blainville's Beaked Whale	Ziphidae	0.395	0.074
Blue Whale, Fin Whale; Omura's Whale; Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin, Fraser's Dolphin	Delphinidae	0.808	0.96
Bryde's Whale	Balaenopteridae	0.91	0.407
Cuvier's Beaked Whale; Ginkgo-toothed Beaked Whale	Ziphidae	0.23	0.074
Dwarf Sperm Whale, Pygmy Sperm Whale, Kogia spp.	Kogiidae	0.35	0.074
False Killer Whale, Melon-headed Whale	Delphinidae	0.76	0.96
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.91	0.96
Longman's Beaked Whale, Pygmy Killer Whale	Ziphidae, Delphinidae	0.76	0.074
Mesoplodon spp.	Ziphiidae	0.34	0.11
Minke Whale	Balaenopteridae	0.856	0.386
Pantropical Spotted/Risso's/Rough-toothed /Spinner/Striped Dolphin	Delphinidae	0.76	0.96
Short-finned Pilot Whale	Delphinidae	0.76	0.96
Sperm Whale	Physeteridae	0.87	0.495

Note: For species having no data, the g(0) for Cuvier's aircraft value (where g(0)=0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0).

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

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

Table 6-6: Post-Model Acoustic Impact Analysis Process

Sonar or other active acoustic source	Explosives
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	***E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?***
Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated PTS to these species during these activities are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of potential behavioral disturbance). The training and testing activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 6-11.	Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The training and testing activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 6-13.
S-2. Is the range to effects for PTS very small?	
Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10 m) to experience PTS exposures. These model-estimated PTS of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of TTS).	
S-3. Can Lookouts observe the activity-specific mitigation zone (see Chapter 11 [Means of Effecting the Least Practicable Adverse Impact – Mitigation Measures]) up to and during the sound-producing activity?	***E-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 11 [Means of Effecting the Least Practicable Adverse Impact – Mitigation Measures]) 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 exposures are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 6-5. The Mitigation Effectiveness values are provided in Table 6-12.	If Lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 6-5. The Mitigation Effectiveness values for explosive activities are provided in Table 6-15.

Table 6-6: Post-model Acoustic Impact Analysis Process (continued)

Sonar or other active acoustic source	Explosives
S-4. Does the activity cause repeated sound exposures which an animal would likely avoid?	***E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?***
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS exposures by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS exposures to high-frequency cetaceans, and low frequency cetaceans are expected to actually occur (after accounting for mitigation in step S-3). Model estimates of PTS beyond the initial pings are considered to actually be behavioral disturbances, as the animal is assumed to move out of the range to PTS and into the range of TTS.	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS exposures by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS exposures are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS exposures 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 6-14.

6.3.3 Impacts on Marine Mammals

6.3.3.1 Non-Impulse (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-impulse sources such as active sonar is not likely to result in primary blast injuries or barotraumas. Sonar-induced acoustic resonance and bubble formation phenomena are also unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 6.3 (Quantitative Modeling for Impulse and Non-Impulse Sources). Within this acoustic analysis, the number of animals that may receive some form of hearing loss is predicted using the NAEMO. Thresholds for determining hearing were developed using the best available data. The most intense underwater sounds in the Study Area associated with the proposed action are those produced by ASW sonar and explosives. These sounds are likely within the audible range of most cetaceans, but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each. The duty cycle is low with most ASW sonar only transmitting a few times per minute. Furthermore, events are geographically and temporally dispersed and most events are limited to a few hours. Sonar has a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood or severity of these sources causing significant auditory masking in marine mammals. Some object-detecting sonar (i.e., mine warfare sonar) has a high duty cycle producing up to a few pings per second. These sonar typically employ high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher-frequency mine warfare sonar systems are typically outside of the hearing and vocalization ranges of mysticetes (see Section 3.4 [Marine Mammals] of the MITT EIS/OEIS), therefore, mysticetes are unlikely to be able to detect the higher frequency mine warfare sonar, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many mine warfare sonar overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of these sonar is narrow, limiting the likelihood of auditory masking. With any of these activities, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals. For marine mammals, the predicted number of behavioral responses is determined using the NAEMO. Behavioral responses can range from a mild orienting response, or a shifting of attention, to flight and panic. Predicted effects are based on specific behavioral criteria meant to predict when an animal is likely to experience a significant behavioral reaction (see Section 6.3 Quantitative Modeling for Impulse and Non-Impulse Sources). Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year near Navy ports or on fixed Navy ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed herein.

6.3.3.2 Range to Effects for Non-Impulse Sources (Sonar and Other Active Acoustic Sources)

The following section provides range to effects for sonar and other active acoustic sources to specific criteria determined using the NAEMO. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting acoustic impacts, but also in verifying the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher level effects, especially physiological effects to marine mammals. Although the Navy uses a number of sonar and active acoustic sources, the three sonar bins provided in Table 6-7 (i.e., Mid-Frequency [MF]1, MF4, and MF5) represent three of the most powerful sources. This section discusses sonar and other active acoustic source bins included in the analysis. These three sonar bins are often the dominant source in the activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

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 6-7 relative to the marine mammal's functional hearing group (Navy's high frequency sources have a lower source level and more energy loss over distance than these mid-frequency examples and therefore have a shorter range to effects). For a SQS-53C sonar transmitting for one second at 3 kHz and a source level of 235 dB re 1 µPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 100 m (109 yd.). Since any hull-mounted sonar, such as the SQS-53, engaged in ASW training and testing would be moving at between 10 and 15 knots (5.1 to 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m (281 yd.) during the time between those pings (note: 10 knots is the speed used in the NAEMO). As a result, there is little overlap of PTS footprints from successive pings, indicating that, in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). It is unlikely that any animal would receive overlapping PTS level exposures from a second ship, as Navy sonar exercises do not involve ships within such close proximity to each other while using their active sonar. For all other functional hearing groups (low-frequency and mid-frequency cetaceans) single-ping PTS zones are within 70 m (77 yd.) of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship, however, as indicated in Table 6-7, the distances required make a second PTS exposure unlikely. For a Navy vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings that would result in PTS. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are within 20 m (22 yd.), even for multiple pings (up to 10 pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 6-7: Approximate Range 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 Onset PTS for One Ping (meters)[1]		
	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)	Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Source 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

[1] Ranges to TTS represent the sound energy loss due to spherical spreading to reach the furthest distance to the PTS effect criteria.

Notes: ASW = anti-submarine warfare, TTS = temporary threshold shift, PTS = permanent threshold shift

TTS: Table 6-8 illustrates the ranges to the onset of TTS for 1, 5, and 10 pings from four representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to onset-TTS are greater. Therefore, sound energy from successive pings can add together, further increasing the range to onset-TTS[8]. For hull mounted sonar (e.g., the SQS-53), mid-frequency cetaceans have TTS ranges of up to 100 m for 1 ping, up to 224 m for 5 pings, and up to 316 m for 10 pings. This example is greatly simplified, however, since as noted above in the discussion of PTS exposures, any hull mounted sonar, such as the SQS-53, engaged in ASW training and testing would be moving at between 10 and 15 knots (5.1 to 7.7 m/second). Given this speed and nominally pinging every 50 seconds, the vessel (and sonar source) will have traveled a minimum distance of approximately 281 yd. (257 m) during the time between subsequent pings and there would be insufficient sound energy overlap for subsequent pings to result in TTS.

For all other sonar and other active acoustic sources, the range to TTS for up to ten pings is within 50 m for mid-frequency cetaceans (the majority of marine mammals present in the Study Area), making any hearing loss in these species from these sources very unlikely. Low-frequency cetaceans (mysticetes) have TTS ranges for ten pings from ASW hull mounted sonar (e.g., SQS-53) of approximately 2,103 m. Ten pings from an ASW dipping sonar (e.g., AQS-22) would produce a TTS zone of approximately 255 m, with all other active systems producing ranges to TTS of less than 50 m for mysticetes. Ranges to TTS for high-frequency cetaceans are extensive based on a low acoustic effects threshold for these apparently sensitive species. For a hull-mounted sonar (e.g., SQS-53), ranges to TTS for high-frequency cetaceans are 1,000 m for 1 ping, 2,235 m for 5 pings, and 3,131 m for 10 pings. Ranges to TTS for high-frequency cetaceans are much shorter for all other systems: ASW dipping sonar are approximately 215 m for 1 ping

8 This discussion is presenting a simple case for an omni-directional stationary sources and stationary animals. With a moving source such as all hull mounted ASW sonar, the additional volume of energy above the TTS threshold is only present where there is overlap of sufficient acoustic energy from subsequent pings. When a source is moving, the time between pings and the vessel's forward motion can exceed the distance required for sufficient overlap of acoustic energy from the summation of subsequent pings and therefore never exceed the TTS (total energy) threshold. The nominal speed and time between pings for a ship engaged in ASW events will result in the source having traveled approximately 257-359 m between pings. Additional factors such as animals avoiding the source, porpoising behavior, etc. are additional complexities.

Table 6-8: Range to Temporary Threshold Shift for Four Representative Sonar Systems

Functional Hearing Group	Approximate Ranges to the Onset of TTS (meters)[1]											
	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)			Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)			Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)		
	One Ping	Five Pings	Ten Pings	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	100-160	150-730	150-820
Mid-Frequency Cetaceans	150-180	340-440	510-1,750	< 50	< 50	< 50	< 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	< 50	< 50	< 50

and up to 681 m for 10 pings; sonobuoys and mine warfare mine hunting sonar are less than approximately 213 m for 10 pings.

Behavioral: The range to 6 dB from four representative sonar sources and the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete behavioral response function are shown in Table 6-9. See Section 6.2.2 (Behavioral Responses) 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 beaked whales of 140 dB re 1 µPa. Beaked whales would be predicted to have behavioral reactions at distances out to approximately 68 mi. (109 km).

As shown, the range to 120 dB re 1 µPa for other marine mammals varies by system, but can exceed 107 mi. (173 km) for the most powerful hull mounted sonar; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 130 dB re 1 µPa. For context, measurements by Au et al. (2000) of the ambient sound level in Hawaii when humpback whales are at the peak period of their chorusing indicate they raise the ambient underwater sound level off Maui to approximately 120 SPL (dB re 1 µPa). While the low received sound level (approximately 120 dB SPL) from the sonar at that distance is modeled as having some behavioral effects, masking by other ambient sounds have the potential to make perception of the sound by at that distance and reaction to that sound less likely.

Avoidance Behavior and Mitigation Measures as Applied to Sonar and Active Acoustic Sources – As discussed above, within the NAEMO, animats do not move horizontally or react in any way to avoid sound at any level. Furthermore, mitigation measures that are implemented during training and testing activities that reduce the likelihood of physiological impacts are not considered. Therefore, the model overestimates acoustic impacts, especially physiological impacts near the sound source. Various researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement, often at distances of a kilometer or more (Au and Perryman 1982; Tyack et al. 2011; Watkins 1986). See Section 6.2.2(Behavioral Responses), for a review of research and observations of marine mammals' reactions to vessels and active sound sources. The behavioral criteria used as a part of this analysis acknowledges that a behavioral reaction is likely to occur at levels below those required to cause hearing loss (TTS or PTS) or higher order physiological impacts. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around the sound source is the assumed behavioral response for most cases. Additionally, the NAEMO does not account for the implementation of mitigation, which would prevent many of the model-estimated PTS effects. Therefore, the model estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures.

Table 6-9: Non-Impulsive Range in 6-dB Bins and Percentage of Behavioral Harassments in Each Bin under the Behavioral Response Functions for Four Representative Sonar Systems (Nominal values; not specific to the Study Area)

Received Level	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)		Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels
Low Frequency Cetaceans								
120 <= SPL <126	183,000 – 133,000	<1%	71,000 – 65,000	<1%	18,000 – 13,000	<1%	2,300 – 1,700	<1%
126 <= SPL <132	133,000 – 126,000	<1%	65,000 – 60,000	<1%	13,000 – 7,600	<1%	1,700 – 1200	<1%
132 <= SPL <138	126,000 – 73,000	<1%	60,000 – 8,200	42%	7,600 – 2,800	12%	1,200 – 750	<1%
138 <= SPL <144	73,000 – 67,000	<1%	8,200 – 3,500	10%	2,800 - 900	26%	750 – 500	5%
144 <= SPL <150	67,000 – 61,000	3%	3,500 – 1,800	12%	900 - 500	15%	500 – 300	17%
150 <= SPL <156	61,000 – 17,000	68%	1,800 - 950	15%	500 - 250	21%	300 – 150	34%
156 <= SPL <162	17,000 – 10,200	12%	950 - 450	13%	250 - 100	20%	150 – 100	20%
162 <= SPL <168	10,200 – 5,600	9%	450 - 200	6%	100 - <50	6%	100 - <50	24%
168 <= SPL <174	5,600 – 1,600	6%	200 - 100	2%	<50	<1%	<50	<1%
174 <= SPL <180	1,600 - 800	<1%	100 - <50	<1%	<50	<1%	<50	<1%
180 <= SPL <186	800 - 400	<1%	<50	<1%	<50	<1%	<50	<1%
186 <= SPL <192	400 - 200	<1%	<50	<1%	<50	<1%	<50	<1%
192 <= SPL <198	200 - 100	<1%	<50	<1%	<50	<1%	<50	<1%
Mid Frequency Cetaceans								
120 <= SPL <126	184,000 – 133,000	<1%	72,000 – 66,000	<1%	19,000 – 15,000	<1%	3,600 – 2,800	<1%
126 <= SPL <132	133,000 – 126,000	<1%	66,000 – 60,000	<1%	15,000 – 8,500	<1%	2,800 – 2,100	<1%
132 <= SPL <138	126,000 – 73,000	<1%	60,000 – 8,300	41%	8,500 – 3,300	3%	2,100 – 1,500	<1%
138 <= SPL <144	73,000 – 67,000	<1%	8,300 – 3,600	10%	3,300 – 1,000	12%	1,500 – 1,000	3%
144 <= SPL <150	67,000 – 61,000	3%	3,600 – 1,900	12%	1,000 - 500	10%	1,000 – 700	10%
150 <= SPL <156	61,000 – 18,000	68%	1,900 - 950	15%	500 - 300	22%	700 - 450	21%
156 <= SPL <162	18,000 – 10,300	13%	950 - 480	12%	300 - 150	27%	450 - 250	32%
162 <= SPL <168	10,300 – 5,700	9%	480 - 200	7%	150 - <50	25%	250 - 150	19%
168 <= SPL <174	5,700 – 1,700	6%	200 - 100	2%	<50	<1%	150 - 100	9%
174 <= SPL <180	1,700 - 900	<1%	100 - <50	<1%	<50	<1%	100 - <50	6%
180 <= SPL <186	900 - 400	<1%	<50	<1%	<50	<1%	<50	<1%
186 <= SPL <192	400 - 200	<1%	<50	<1%	<50	<1%	<50	<1%
192 <= SPL <198	200 - 100	<1%	<50	<1%	<50	<1%	<50	<1%

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

If sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed above in Avoidance of Human Activity. Table 6-7 shows the ranges to PTS for several sonar systems, including the most powerful system, the SQS-53 in bin MF1. The range to PTS for all systems is generally much less than 100 m, with the exception of high-frequency cetaceans exposed to bin MF1 with a PTS range of approximately 100 m. Because the NAEMO does not include avoidance behavior, the model-estimated effects are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to actually move into the range of TTS prior to the start of the sound-producing activity for the activities listed in Tables 6-10 and 6-11.

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

Training
Fleet Strike Group Exercise
Integrated Anti-Submarine Warfare Exercise
Joint Expeditionary Exercise
Joint Multi-Strike Group Exercise
Marine Air Ground Task Force Exercise (Amphibious) - Battalion
Maritime Homeland Defense/Security Mine Countermeasures
Mine Countermeasure (MCM) - Towed Mine Detection
Mine Countermeasure Exercise - MCM Surface Ship Sonar
Mine Countermeasures Exercise - Surface
Ship Squadron Anti-Submarine Warfare (ASW) Exercise
Tracking Exercise/Torpedo Exercise – Helicopter
Testing
ASW Tracking Test – MPA
At-Sea Sonar Testing
Countermeasure Testing
ASW Mission Package Testing
MCM Mission Package Testing
Pierside Integrated Swimmer Defense
Ship Signature Testing
Torpedo Testing

Notes: MPA = maritime patrol aircraft, ASW = anti-submarine warfare, MCM = mine countermeasures

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 6.3.2 (Implementing Mitigation to Reduce Sound Exposures), to account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during use of the sound source, considering the mitigation effectiveness (Table 6-11) and sightability of a species based on g(0) (see Table 6-5). The model-estimated PTS are reduced by the portion of animals that are likely to be seen (Mitigation Effectiveness x Sightability); these animals are instead assumed to be present within the range to TTS.

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

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

Table 6-11: Non-Impulse Activities Adjustment Factors Integrating Implementation of Mitigation into Modeling Analyses for the Study Area

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Training		
Airborne Mine Countermeasure - Mine Detection	1	Aircraft
Maritime Homeland Defense/Security Mine Countermeasures	1	Vessel
Major Training Activities	1	Vessel
Kilo Dip	1	Aircraft
Mine Countermeasures Exercise (MCM) - Ship Sonar	1	Vessel
Mine Neutralization - ROV	1	Vessel or Aircraft
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Sonar Maintenance	1	Vessel
TRACKEX/TORPEX - MPA Sonobuoy	0.5	Aircraft
TRACKEX/TORPEX - Surface	0.5	Vessel
TRACKEX/TORPEX - Helo	0.5	Aircraft
Testing		
ASW Tracking Test – MPA	1	Aircraft
Countermeasure Testing	0.5	Vessel
MCM Mission Package Testing	1	Vessel or Aircraft
ASW Mission Package Testing	1	Vessel
At-Sea Sonar Testing	0.5	Vessel
Pierside Integrated Swimmer Defense	1	Vessel
Ship Signature Testing	1	Vessel
Torpedo Testing	0.5	Vessel

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

[2] If less than half of the mitigation zone cannot be continuously visually observed due to the type of mitigation platform used for this assessment, number of Lookouts, and size of the mitigation zone, mitigation is not used as a factor adjusting the acoustic effects analysis of that activity and the activity is not listed in this table.
Notes: MCM = mine countermeasure, ROV = remotely operated vehicle, TRACKEX = Tracking Exercise, TORPEX = Torpedo Exercise, MPA = maritime patrol aircraft

6.3.3.1 Impulse (In-Water Explosives)

Explosions associated with Navy proposed training and testing activities could occur throughout the Study Area. These activities include anti-surface warfare, anti--submarine warfare, and mine warfare. Activities that involve explosions are described in Chapter 2 (Description of Proposed Action and Alternatives) of the MITT EIS/OEIS. Predicted impacts on marine mammals from at-sea explosions are based on a modeling approach that considers many factors. The equations for the models consider the net explosive weight, the properties of detonations underwater, and environmental factors such as depth of the explosion, overall water depth, water temperature, and bottom type. The net explosive weight accounts for the mass and type of explosive material. Section 6.3 (Quantitative Modeling for

Impulse and Non-Impulse Sources) presents a review of observations and experiments involving marine mammals and reactions to impulse sounds, including explosives. Energy from explosions is capable of causing mortality, injury to the lungs or gastrointestinal tract, permanent or TTS, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population.

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

6.3.3.2 Range to Effects for Impulse Sources

The Navy Acoustic Effects Model (U.S. Department of the Navy 2012b), in conjunction with the explosive thresholds and criteria are used to predict impacts on marine mammals from underwater explosions. Table 6-12 shows the average approximate ranges to the potential effect based on the thresholds described in Section 6.2 (Thresholds and Criteria for Predicting Non-Impulse and Impulse Acoustic Impacts on Marine Mammals). Marine mammals within these ranges would be predicted to receive the associated effect. The range to effects is important information in estimating the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher-level effects, especially physiological effects such as injury and mortality. The ranges to effects are shown in Table 6-12 for explosive bins E3 (0.6 lb. to 2.6 lb. NEW) to E12 (up to 1,000 lb. NEW). The ranges 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.

Furthermore, the ranges for onset slight lung injury and onset mortality are based on the smallest calf weight in each category and therefore likely overestimate the potential effect since populations contain many animals larger than calves and are therefore less susceptible to injurious effects. Animals within these water volumes would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point. Note that the actual modeling of proposed activities used species-specific masses and not the representative animal masses presented in Table 6-12.

In interpreting the results presented in Table 6-12, it is important to note that explosions were modeled at the depths at which the explosive sources would typically be detonated during a training or testing activity. The depths at which explosives are detonated are not the same for all bins. The propagation of the energy generated by an explosion varies with depth and can lead to results that are contrary to the expected increase in distance with an increase in NEW (e.g., compare ranges for bin E7 to bin E9).

Table 6-12 shows the minimum and maximum ranges to the potential effect based on the thresholds described in Section 6.3 (Quantitative Modeling for Impulse and Non-Impulse Sources). Table 6-12 also shows the ranges to onset mortality for mid-frequency and high frequency cetaceans for a representative range of charge sizes. Ranges for onset slight lung injury and onset mortality are based on the smallest and largest calf weight in each category and represent conservative estimates (i.e., longer ranges) based on assuming all impulses are one second in duration. In fact, most impulses are much less than one second and therefore contain less energy than what is being used to produce the estimated ranges below.

Table 6-12: Average Approximate Range to Effects from a Single Explosion for Marine Mammals across Representative Acoustic Environments (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 (0.6-2.6 lb. NEW)	Bin E5 (6-10 lb. NEW)	Bin E7 (21-60 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E10 (251-500 lb. NEW)	Bin E12 (>650-1,000 lb. NEW)
Low-frequency Cetaceans (calf weight 200 kg)						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655
Mid-frequency Cetaceans (calf weight 5 kg)						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-Frequency Cetaceans (calf weight 4 kg)						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705

Note: NEW = net explosive weight, GI = gastrointestinal, PTS = permanent threshold shift, TTS = temporary threshold shift

Avoidance Behavior and Mitigation Measures as Applied to Explosions – As discussed above, within the NAEMO, animats 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

6.1.2 (Analysis Background and Framework) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives. 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 6.3 [Quantitative Modeling for Impulse and Non-Impulse Source Effects]).

If explosive activities are preceded by multiple vessels or hovering aircraft, beaked whales are assumed to move beyond the range to onset mortality before detonations occur. The range to onset mortality for all net explosive weights is less than 260 m, which is conservatively based on range to onset mortality for a calf. Because the Navy 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.

Table 6-13: Activities Using Impulse Sources Preceded by Multiple Vessel Movements or Hovering Helicopters for the Mariana Islands Training and Testing Study Area

Training
Maritime Security Operations
Mine Countermeasure – Mine Neutralization
Maritime Homeland Defense/Security Mine Countermeasures
Gunnery Exercise (Surface-to-Surface) Ship/Boat – Medium-caliber
Mine Neutralization – Explosive Ordnance Disposal
Mine Neutralization - Remotely Operated Vehicle
Sinking Exercise
Underwater Demolition Qualification / Certification
Testing
Anti-Surface Warfare Tracking Test - Maritime Patrol Aircraft
Mine Counter Measure Mission Package Testing
Pierside Integrated Swimmer Defense
Torpedo Testing

The NAEMO does not consider mitigation, discussed in detail in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). As explained in Section 6.3.2 (Implementing Mitigation Measures 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 dedicated Lookouts up to and during the use of explosives, considering the mitigation effectiveness (Table 6-14) and sightability of a species based on g(0) (Table 6-5). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness x Sightability, g(0)]; these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

Table 6-14: Impulse Activities Adjustment Factors Integrating Implementation of Mitigation into Modeling Analyses for the Mariana Islands Training and Testing Study Area

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]		Mitigation Platform Used for Assessment
	Injury Zone	Mortality Zone	
Training			
BOMBEX [A-S] (HF/LF)	0	1	Aircraft
BOMBEX [A-S] (MF)	0.5	1	Aircraft
Maritime Homeland Defense/Security Mine Countermeasures	1	1	Vessel
Maritime Security Operations	0.5	0.5	Both[3]
Mine Neutralization – EOD	0.5	1	Vessel
Fleet Strike Group Exercise	0.5	0.5	Both[3]
GUNEX [A-S] - Medium Caliber (BW/HF)	0.5	0.5	Aircraft
GUNEX [A-S] - Medium Caliber (LF/MF)	1	1	Aircraft
GUNEX [S-S] - Boat - Medium Caliber (BW/HF)	0.5	0.5	Vessel
GUNEX [S-S] - Boat - Medium Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] - Ship - Medium Caliber (BW/HF)	0.5	0.5	Vessel
GUNEX [S-S] - Ship - Medium Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] - Ship - Large Caliber	0	0	Vessel
Joint Expeditionary Exercise	0.5	0.5	Both[3]
Joint Multi-CSG Exercise	0.5	0.5	Both[3]
MISSILEX [A-S]	0	0	Aircraft
MISSILEX [A-S] – Rocket	0	0	Aircraft
SINKEX (HF/LF)	0.5	1	Aircraft
SINKEX (MF)	0.5	1	Aircraft
TRACKEX/TORPEX - MPA AEER/IEER	0.5	0.5	Aircraft
Underwater Demolition Qualification/Certification	1	1	Vessel
Testing			
Anti-Surface Warfare Tracking Test – MPA	0	1	Aircraft
MCM Mission Package Testing	1	1	Vessel
Torpedo Testing	0.5	1	Aircraft

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

[2] A zero value is provided if the predicted maximum zone for the criteria is large and exceeds what mitigation procedures are likely to affect; a zero value indicates mitigation did not adjust or reduce the predicted exposures under that criteria.

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

Notes: HF = high-frequency, LF = low-frequency, MF = mid- frequency, MCM = mine countermeasures, ASUW = anti-surface warfare, MPA = maritime patrol aircraft, BOMBEX = Bombing Exercise, A-S = air-to-surface, EOD = Explosive Ordnance Disposal; GUNEX = Gun Exercise, S-S = surface-to-surface, CSG = Carrier Strike Group, MISSILEX = Missile Exercise, SINKEX = Sinking Exercise, TRACKEX = Tracking Exercise, TORPEX = Torpedo Exercise, MPA = Maritime Patrol Aircraft, AEER = Advanced Extended Echo Ranging, IEER = Improved Extended Echo Ranging, LCS = Littoral Combat Ship, MCM = mine countermeasure, ASUW = Anti-Surface Warfare

During an activity with a series of explosions (not concurrent multiple explosions) (Table 6-15), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 6-12. Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion. Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Mooney et al. 2008; Kastelein et al. 2005). 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 are considered to be TTS due to avoidance.

Table 6-15: Activities with Multiple Non-Concurrent Impulses or Explosions

Training
BOMBEX [A-S]
GUNEX [S-S] – Medium-Caliber
Mine Neutralization - EOD
SINKEX
Testing
MCM Mission Package Testing
ASUW Mission Package Testing
Pierside Integrated Swimmer Defense

Notes: BOMBEX = Bombing Exercise, A-S = air-to-surface, GUNEX = Gun Exercise, S-S = surface-to-surface, EOD = Explosive Ordnance Disposal, SINKEX = Sinking Exercise, MCM = mine countermeasure
ASUW = Anti-Surface Warfare

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

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

- The onset mortality criterion is based on one percent of the animals receiving an injury that would not be recoverable and lead to mortality. Therefore, many animals that are estimated to suffer mortality in this analysis may actually recover from their injuries.
- The onset slight lung injury criteria is based on one percent of the animals exposed at the threshold receiving a slight lung injury in which full recovery would be expected. Therefore, many animals that are estimated to suffer slight lung injury in this analysis may actually not incur injuries.
- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal's mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that

species newborn calf or pup weight. Since many individuals in a population are obviously larger than a newborn calf or pup of that species, this assumption causes the acoustic model to overestimate the number of animals that may suffer slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

- Many explosions from ordnances such as bombs and missiles actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at 1 m depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.

6.3.4 Estimated Take of Large Whales by Vessel Strike

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

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

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

Vessel strikes from commercial, recreational, and military vessels are known to affect large whales in other areas and have resulted in serious injury and occasional fatalities to cetaceans (National Marine Fisheries Service 2010, Calambokidis 2012). Reviews of the literature on ship strikes mainly involve collisions between commercial vessels and whales (e.g., Laist et al. 2001; Jensen and Silber 2004). The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal. Key points in discussion of Navy vessels in relationship to potential ship strike include:

- On most Navy ships the bridge is positioned close to the bow, offering good visibility ahead of the ship.
- Aircraft are often associated with the training or testing activity, allowing for the detection of marine mammals in the vicinity or ahead of a vessel's present course.
- Navy ships are generally much more maneuverable than commercial merchant vessels if marine mammals are spotted and the need to change direction necessary. Navy ships operate at the slowest speed possible consistent with either transit needs, or training or testing need. While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include better ability to spot and avoid objects in the water including marine mammals.
- Standard operating procedure is for Navy vessels to 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, so long as safety of navigation is not imperiled.
- In many cases, Navy ships will move randomly or with a specific pattern within a sub-area of the MITT for a period of time from 1 day to 2 weeks as compared to straight line point-to-point commercial shipping. This affords for more detection availability for animals in the area or for animals to avoid an area of activity.
- Navy vessels' overall crew size is much larger than merchant ships, allowing for more potential observers on the bridge. At all times when vessels are underway, trained Lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including marine mammals. Additional Lookouts, beyond already stationed bridge watch and navigation teams, are stationed during some training events.
- Navy Lookouts receive extensive training including Marine Species Awareness Training designed to provide marine species detection cues and information necessary to assist in avoiding interactions with marine mammals.

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

Mysticetes – Navy vessel strikes to marine mammals have been documented for almost all of the rorqual whale species; however, there are no records of Navy vessel strikes to marine mammals in the MITT Study Area. In areas outside of the MITT Study Area (e.g., in waters surrounding Hawaii and offshore of Southern California), there were a total of 21 Navy vessel strikes of marine mammals recorded from 1991 through 2010 (mostly larger whales; although some were to unidentified species). Species known to be hit by Navy vessels operating in those two areas include blue whales, fin whales, gray whales, sperm whales, and humpback whales. Of the 16 Navy vessel strikes over the 20-year period in waters off Southern California, there were seven mortalities and nine injuries reported. All five Navy vessel strikes in waters surrounding Hawaii were reported as injury strikes.

Odontocetes – Sperm whales may be exceptionally vulnerable to vessel strikes as they spend extended periods of time "rafting" at the surface in order to restore oxygen levels within their tissues after deep dives (Watkins et al. 1999). There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (Aguilar de Soto et al. 2006). In general, odontocetes move quickly and seem to be less vulnerable to vessel strikes than other cetaceans; however, most small whale and dolphin species have at least occasionally suffered from vessel strikes including: killer whale (Van Waerebeek et al. 2007), short-finned and long-finned pilot whales (Aguilar de Soto et al. 2008), bottlenose dolphin (Van Waerebeek et al. 2007), spinner dolphin (Van Waerebeek et al. 2007), striped dolphin (Van Waerebeek et al. 2007), and pygmy sperm whales (*Kogia breviceps*) (Van Waerebeek et al. 2007). Beaked whales documented in vessel strikes include: Cuvier's beaked whale (Van Waerebeek et al. 2007), and several species of *Mesoplodon* beaked whale (Van Waerebeek et al. 2007). However, evidence suggests that beaked whales may be able to hear the low-frequency sounds of large vessels and thus avoid collision (Ketten 1998). In 2007, a Navy vessel struck a sperm whale in waters surrounding Hawaii.

Probability of Navy Vessel Strike of Large Whale Species – The Navy does not anticipate vessel strikes to marine mammals within the MITT Study Area as a result of training or testing activities under Alternative 1 (Preferred Alternative). There are no records of any Navy vessel strikes to marine mammals in the MITT Study Area. In areas outside the MITT Study Area (for example, Hawaii and Southern California), there have been Navy vessel strikes of large whales. However, these areas differ significantly from the MITT Study Area given both have a much higher number of Navy vessel activities[9] and much higher densities of large whales.

6.4 Summary of All Estimated Impulse and Non-Impulse Source Effects

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

[9] There are four Navy vessels (three submarines and one submarine tender) homeported in Guam in comparison to 59 in San Diego and 30 in Pearl Harbor. For detailed comparison with the HSTT activities, see the HSTT EIS/OEIS Chapter 3.4 (Marine Mammals), Table 3.4-1 for marine mammal densities in the HSTT Study Area and Section 3.4.3.7.1 (Impact from Vessel Strike), for a discussion of the potential for vessel strikes of large whales in those areas.

7 IMPACTS ON MARINE MAMMAL SPECIES OR STOCKS

The anticipated impact of the activity upon the species or stock of marine mammal.

The Navy's analysis supports a negligible impact finding on marine mammal species and stocks for the following reasons:

- Most acoustic harassments are within the non-injurious TTS or behavioral effects zones (Level B harassment).
- Although the numbers presented in Tables 5-1 and 5-2 represent estimated modeled harassment under the MMPA, they are conservative (i.e., over predictive) estimates of harassment, primarily by behavioral disturbance. The model calculates harassment without taking into consideration standard mitigation measures, and is not indicative of the limited likelihood of either injury or harm.
- Marine mammal densities inputted into the model are also overly conservative, particularly when considering species where data is limited in portions of the MITT Study Area and the seasonal migrations that extend throughout 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 physiological effects and to achieve the least practicable adverse effect on marine mammal species or stocks.
- Years of monitoring of Navy activities (since 2006) have documented hundreds of thousands of marine mammal on the range complexes and there are only two instances of overt behavioral change that have been observed.
- Years of monitoring of Navy activities have documented no instances of injury to marine mammals as a result of non-impulse acoustic sources.
- In at least three decades of similar activities, only one instance of injury to marine mammals (25 March 2011; three long-beaked common dolphin) has been documented as a result of training or testing using an impulse source (underwater explosion).

This LOA application assumes that short-term non-injurious sound exposure levels 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 and explosives, and long-term abandonment or significant alteration of behavioral patterns in marine mammals.

Consideration of negligible impact is required for the NMFS to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates).

Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Recent behavioral studies indicate that reactions to sounds, if any, are highly contextual and vary between species and individuals within a species (Moretti et al. 2010; Southall et al. 2012; Thompson et al. 2010; Tyack 2009; Tyack et al. 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. When sound becomes potentially disruptive, cetaceans at rest become active, 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 dolphin 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 marine mammals from an important feeding or breeding area for a prolonged period and they do not have an alternate equally desirable area, impacts on the marine mammal could be negative because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive. These key elements could be defined as follows:

- Growth: adverse effects on ability to feed;
- Reproduction: the range at which reproductive displays can be heard and the quality of mating/calving grounds (e.g., gray whales); and
- Survival: sound exposure may directly affect survival.

The importance of the disruption and degree of consequence for individual marine mammals often has much to do with the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as sonar use and explosive activities within the MITT 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 established near a concentrated area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. If the marine mammals fail to habituate or become sensitized to disturbance and, as a consequence, are excluded from an important area or are subject to stress while at the important area, long-term effects could occur to individuals or the population.

The Context of Behavioral Disruption and TTS – Biological Significance To Populations

The exposure estimates calculated by predictive models currently available reliably predict propagation of sound and received levels and measure a short-term, immediate response of an individual using applicable criteria. Consequences to populations are much more difficult to predict and empirical measurement of population effects from anthropogenic stressors is limited (National Research Council of the National Academies 2005). To predict indirect, long-term, and cumulative effects, the processes must be well understood and the underlying data available for models. In response to the National Research Council of the National Academies (2005) review, the 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.

Based on each species' life history information, expected behavioral patterns in MITT training locations, the majority of modeled exposures resulting in temporary behavioral disturbance, few expected injury or mortality, and the application of robust mitigation procedures proposed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), MITT training and testing is anticipated to have a negligible impact on marine mammal stocks within the MIRC, and the transit corridor portions of the Study Area.

Conclusion – The Navy concludes that training and testing activities proposed in the MITT Study Area could result in Level B, Level A, and mortality takes, 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 MITT 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 reasons listed at the beginning of Chapter 7 (Impacts on Marine Mammals Species or Stocks).

Consideration of negligible impact is required for the 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 of 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 MITT 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.

Potential impacts to marine mammals from the Proposed Action in the MITT Study Area would be limited to individuals located in the Study Area. There are no marine mammal species in the Study Area for which subsistence requirements exist; therefore, no impacts on the availability of marine mammal species or stocks for subsistence use are anticipated. No further analysis is presented.

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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 exposures resulting from anti-submarine warfare activities. However, the exposures do not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of limited duration and are intermittent in time. Surface vessels associated with the activities are present in limited duration and are intermittent as they are continuously and relatively rapidly moving through any given area. Activities that use explosives such as bombing exercises, gunnery exercises, missile exercises, and sinking exercises do not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of limited duration and are intermittent in time.

The use of explosives for mine or obstruction clearance and amphibious landings occurs in sandy shallow areas and will not affect known marine mammal foraging habitats. Temporary impacts and disturbance to marine mammal prey (i.e., krill, squid, fish, etc.) are not expected to be significant in terms of impacts on forage species with a wide distribution throughout the Mariana Islands and with known high recruitment and biomass (Allen 2006).

Other sources that may affect marine mammal habitat were considered and potentially include the introduction of fuel, expended materials, ordnance, and chemical residues into the water column. The effects of each of these components were considered in the MITT EIS/OEIS.

Based on the detailed review within the MITT EIS/OEIS, there would be no effects to marine mammals resulting from loss or modification of marine mammal habitat, including water and sediment quality, and food resources.

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10 IMPACTS ON MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed training and testing events for the Mariana Islands Training and Testing Study Area are not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations. Based on the discussions in Chapter 9 (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 or testing activities. In particular, the rapid oscillation between high and low-pressure peaks has the potential to burst the swim bladders and other gas-containing organs of fish (Keevin and Hempen 1997). Sub-lethal effects, such as changes in behavior of fish, have been observed in several occasions as a result of noise produced by explosives (National Research Council of the National Academies 2003; Wright 1982). The abundances of various fish and invertebrates near the detonation point could be altered for a few hours before animals from surrounding areas repopulate the area; however these populations would be replenished as waters near the detonation point are mixed with adjacent waters. Military expended materials resulting from training and testing activities could potentially result in minor long-term changes to benthic habitat. Similar to an artificial reef structure, the structure would be colonized overtime by benthic organisms that prefer hard substrate and would provide structure that could attract some species of fish.

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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. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the proposed activities that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. Most of the procedures discussed in this chapter are currently or were previously implemented as a result of past environmental compliance documents, 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 and System Command stakeholder's perspective, mitigation is consistent with existing training and testing objectives, range procedures, and safety measures.

11.1 Lookout Procedural Measures

The Navy will have two types of Lookouts for the purposes of conducting visual observations: (1) those positioned on ships, and (2) those positioned in aircraft or small boats. Lookouts positioned on ships will be dedicated solely to diligent observation of the air and surface of the water. They will have multiple observation objectives, which include but are not limited to detecting the presence of biological resources and recreational or fishing boats, observing buffer zones, and monitoring for vessel and personnel safety concerns.

Due to aircraft and small boat manning and space restrictions, Lookouts positioned in aircraft or on small boats may include the aircraft crew, pilot, or boat crew. Lookouts positioned in aircraft and small boats 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, aircraft and small boat Lookouts will, to the maximum extent practicable and consistent with safety and training and testing requirements, comply with the observation objectives described above for Lookouts positioned on ships.

The procedural measures described below primarily consist of having Lookouts during specific training and testing activities.

11.1.1 Specialized Training

11.1.1.1 Training for Personnel Standing Watch and Lookouts (United States Navy Afloat Environmental Compliance Training Series)

The Navy is proposing to continue implementing the Marine Species Awareness Training and to add the requirement for personnel to complete one or more additional environmental training modules.

The Navy has developed the United States Navy Afloat Environmental Compliance Training Series to help ensure Navy-wide compliance with environmental requirements, and to help Navy personnel gain a better understanding of their personal roles and responsibilities. The training series contains four interactive multimedia training modules. Personnel will be required to complete all modules identified in their career path training plan.

The first module is the Introduction to the U.S. Navy Afloat Environmental Compliance Training Series. The introduction module provides information on environmental laws (e.g., Endangered Species Act and Marine Mammal Protection Act) and responsibilities relevant to Navy training and testing activities. The material is put into context of why environmental compliance is important to the Navy, from the most junior sailor to Commanding Officers.

The second module is the U.S. Navy Marine Species Awareness Training. Consistent with current requirements, 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 Marine Species Awareness Training prior to standing watch or serving as a Lookout. The module contained within the U.S. Navy Environmental Compliance Training Series is an update to the current Marine Species Awareness Training version 3.1. The updated training is designed to improve the effectiveness of visual observations for marine resources, including marine mammals and sea turtles. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures.

The third module is on the U.S. Navy Protective Measures Assessment Protocol. Protective Measures Assessment Protocol is a decision support and situational awareness software tool that the Navy uses to facilitate compliance with worldwide mitigation measures during the conduct of training and testing activities at sea. The module provides instruction for generating and reviewing Protective Measures Assessment Protocol reports. The fourth module is on the U.S. Navy Sonar Positional Reporting System and marine mammal incident reporting. The Navy developed the Sonar Positional Reporting System as its official record of underwater sound sources used under its Marine Mammal Protection Act permits. Marine mammal incidents include vessel strikes and animal strandings. The module provides instruction on the reporting requirements and procedures.

11.1.2 LOOKOUTS

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

11.1.2.1 Acoustic Stressors – Non-Impulse Sound

Low-frequency and Hull Mounted Mid-frequency Active Sonar

Mitigation measures do not currently exist for low-frequency active sonar sources analyzed in this Draft EIS/OEIS with new platforms or systems, such as the Littoral Combat Ship. The Navy is proposing to (1) add mitigation measures for low-frequency active sonar, and (2) maintain the number of Lookouts currently implemented for ships using hull mounted mid-frequency active sonar. The recommended measures are provided below.

Ships using low-frequency or hull-mounted mid-frequency active sonar sources associated with anti-submarine warfare and mine warfare activities at sea (with the exception of ships less than 65 ft.[20 m] in length, the Littoral Combat Ship, and similar ships which are minimally manned) will have two

Lookouts at the forward position. For the purposes of this document, low-frequency active sonar does not include Surveillance Towed Array Sensor System Low-Frequency Active Sonar.

While using low-frequency or hull-mounted mid-frequency active sonar sources associated with anti-submarine warfare and mine warfare activities at sea, ships less than 65 ft. (20 m) in length, the Littoral Combat Ship, and similar ships which are minimally manned will have one Lookout at the forward position of the vessel due to space and manning restrictions.

Ships conducting active sonar activities while moored or at anchor (including pierside) will maintain one Lookout.

High-frequency and Non-Hull Mounted Mid-frequency Active Sonar

Mitigation measures do not currently exist for high-frequency active sonar activities associated with anti-submarine warfare and mine warfare, or for new platforms, such as the Littoral Combat Ship; therefore, the Navy is proposing to add a new measure for these activities or platforms. The Navy is proposing to continue using the number of Lookouts currently implemented for ships or aircraft conducting non-hull mounted mid-frequency active sonar, such as helicopter dipping sonar systems. The recommended measure is provided below.

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

11.1.2.2 Acoustic Stressors –Impulse Sound

Improved Extended Echo Ranging Sonobuoys

The Navy is proposing to continue using the number of Lookouts currently implemented for this activity. The Navy will have one Lookout in aircraft conducting improved extended echo ranging sonobuoy activities.

Explosive Sonobuoys Using 0.6–2.5 Pound Net Explosive Weight

Lookout measures do not currently exist for explosive sonobuoy exercises using 0.6-2.5 pound (lb.) net explosive weight. The Navy is proposing to add this measure. Aircraft conducting explosive sonobuoy exercises using 0.6-2.5 lb. net explosive weight will have one Lookout.

Anti-swimmer Grenades

Lookout measures do not currently exist for activities using anti-swimmer grenades. The Navy is proposing to add this measure. The Navy will have one Lookout on the vessel conducting anti-swimmer grenade activities. Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

As background, mine countermeasure and neutralization activities can be divided into two main categories: (1) general activities that can be conducted from a variety of platforms and locations, and (2) activities involving the use of diver-placed charges that typically occur close to shore. When either of these activities are conducted using a positive control firing device, the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation.

Lookout measures do not currently exist for general mine countermeasure and neutralization activities (those not involving diver-placed charges) using positive control firing devices. The Navy is proposing to add this measure. During general mine countermeasure and neutralization activities using up to a 20 lb. net explosive weight detonation (bin E6 and below), vessels greater than 200 ft. (61 m) will have two Lookouts, while vessels less than 200 ft. (61 m) will have one Lookout.

The Navy is proposing to clarify the number of Lookouts implemented for mine neutralization activities involving positive control diver-placed charges using up to a 20 lb. net explosive weight detonation. A charge with a 20 lb. net explosive weight is the maximum net explosive weight proposed for activities involving diver-placed charges in the Study Area. The recommended measures are below.

- During activities involving diver-placed charges under positive control, activities using up to a 20 lb. net explosive weight (bin E6) detonation will have a total of two Lookouts (one Lookout positioned on two small boats, or one small boat in combination with a helicopter).

- All divers placing the charges on mines will support the Lookouts while performing their regular duties. The Lookouts, divers, and any other personnel who may spot marine mammals and sea turtles will report all marine mammal and sea turtle sightings to their dive support vessel or Range Safety Officer.

Mine Countermeasure and Neutralization Activities Using Diver-Placed Time Delay Firing Devices

As background, when mine neutralization activities using diver placed charges (up to a 20 lb. net explosive weight) are conducted with a time-delay firing device, the detonation is fused with a specified time delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated. During these activities, the detonation cannot be terminated once the fuse is initiated due to human safety concerns.

The Navy is proposing to modify the number of Lookouts currently used for mine neutralization activities using diver-placed time-delay firing devices. As a reference, the current mitigation involves the use of six Lookouts and three small boats (two Lookouts positioned in each of the three boats) for mitigation zones equal to or larger than 1,400 yd. (1,280 m), or four Lookouts and two boats for mitigation zones smaller than 1,400 yd. (1,280 m). Using six Lookouts and three boats in the long-term is impracticable to implement from an operational standpoint due to the unacceptable impact that it is causing on resource requirements (i.e., limited personnel resources and boat availability). The recommended measures are provided below.

During activities using up to a 20 lb. net explosive weight (bin E6) detonation, the Navy will have four Lookouts and two small boats (two Lookouts positioned in each of the two boats). In addition, when aircraft are used, the pilot or member of the aircrew will serve as an additional Lookout. All divers placing the charges on mines will support the Lookouts while performing their regular duties. The divers will report all marine mammal and sea turtle sightings to their supporting small boat or Range Safety Officer.

Gunnery Exercises – Small-, Medium-, and Large-Caliber Using a Surface Target

Lookout measures do not currently exist for small-and medium-caliber gunnery exercises using a surface target. The Navy is proposing to add this measure. The Navy will have one Lookout on the vessel or aircraft conducting small- and medium-caliber gunnery exercises against a surface target.

Missile Exercises (Including Rockets) Up to 250 Pound Net Explosive Weight Using Surface Target

The Navy is proposing to clarify the number of Lookouts currently implemented for this activity. When aircraft are conducting missile exercises up to 250 lb. net explosive weight against a surface target, the Navy will have one Lookout positioned in an aircraft.

Missile Exercises Up to 251 to 500 Pound Net Explosive Weight Using Surface Target

Lookout measures do not currently exist for missile exercises using from 251 to 500 lb. net explosive weight against a surface target. The Navy is proposing to add this measure. When aircraft are conducting missile exercises from 251 to 500 lb. net explosive weight against a surface target, the Navy will have one Lookout positioned in an aircraft.

Bombing Exercises

The Navy is proposing to clarify the number of Lookouts currently implemented for this activity. The Navy will have one Lookout positioned in an aircraft conducting bombing exercises.Torpedo (Explosive) Testing

Lookout measures do not currently exist for torpedo (explosive) testing. The Navy is proposing to add this measure. The Navy will have one Lookout positioned in an aircraft during torpedo (explosive) testing.

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 surface vessel) during sinking exercises.

At-Sea Explosive Testing

Lookout measures do not currently exist for at-sea explosives testing. The Navy is proposing to add this measure. The Navy will have a minimum of one Lookout on each vessel supporting at-sea explosive testing.

11.1.3 Physical Strike and Disturbance

11.1.3.1 Vessels and In-Water Devices

Vessels

The Navy is proposing to continue using the mitigation measures currently implemented for this activity. While underway, vessels will have a minimum of one Lookout.

Towed In-Water Devices

The Navy is proposing to clarify the number of Lookouts currently implemented for activities using towed in-water devices (e.g., towed mine neutralization). The Navy will have one Lookout during activities using towed in-water devices when towed from a manned platform.

11.1.3.2 Non-Explosive Practice Munitions

Small-, Medium-, and Large-Caliber Gunnery Exercises Using a Surface Target

The Navy is proposing to clarify 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.

Non-Explosive Practice Munitions - Bombing Exercises

The Navy is proposing to clarify the number of Lookouts currently implemented for these activities. The Navy will have one Lookout positioned in an aircraft during non-explosive bombing exercises.

11.1.3.3 Effectiveness Assessment for Lookouts

Personnel standing watch in accordance with Navy standard operating procedures have multiple job responsibilities. While on duty, these standard personnel standing watch often conduct marine species observation in addition to their primary job duties (e.g., aiding in the navigation of the vessel). By having one or more Lookouts dedicated solely to observing the air and surface of the water during certain training and testing activities, the Navy increases the likelihood that marine species will be detected.

Although using Lookouts is expected to increase the likelihood that marine species will be detected at the surface of the water, it is unlikely that using Lookouts will be able to help avoid impacts on all species entirely due to the inherent limitations of sighting marine mammals, as discussed in the sections below.

11.2 MITIGATION ZONE PROCEDURAL MEASURES

Safety zones are zones designed for human safety, whereas this section will introduce mitigation zones. A mitigation zone is designed solely for the purpose of reducing potential impacts on marine mammals and sea turtles from training and testing activities. Mitigation zones are measured as the radius from a source. Unique to each activity category, each radius represents a distance that the Navy will visually observe to help reduce injury to marine species. Visual detections of applicable marine species will be communicated immediately to the appropriate watch station for information dissemination and appropriate action. If the presence of marine mammals is detected acoustically, Lookouts posted in aircraft and on 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 mitigation zones for activities that involve the use of impulsive and non-impulsive sources were originally designed to reduce the potential for onset of temporary threshold shift (TTS). For the MITT EIS/OEIS, the Navy updated the acoustic propagation modeling to incorporate updated hearing threshold metrics (i.e., upper and lower frequency limits), updated density data for marine mammals, and factors such as an animal's likely presence at various depths. An explanation of the acoustic propagation modeling process can be found in the *Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Mariana Islands Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement* technical report (Marine Species Modeling Team 2013).

As a result of the updates to the acoustic propagation modeling, in some cases the ranges to effects are much larger than those output by previous models. Due to the ineffectiveness and unacceptable operational impacts associated with mitigating such large areas, the Navy is unable to mitigate for onset of TTS for every activity. However, in some cases the ranges to effects are smaller than previous models estimated, and the mitigation zones were adjusted accordingly to provide consistency across the measures. Navy developed each proposed mitigation zone to avoid or reduce the potential for onset of the lowest level of injury, permanent threshold shift (PTS), out to the predicted maximum range. Mitigating to the predicted maximum range to PTS consequently also mitigates to the predicted maximum range to onset mortality (1 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 turtle functional hearing groups. Therefore, the mitigation zones are even more protective for the remaining functional hearing groups (i.e., low-frequency cetaceans and mid-frequency cetaceans) and likely cover a larger portion of the potential range to onset of TTS..

In some instances, the Navy recommends mitigation zones that are larger or smaller than the predicted maximum range to PTS based on the effectiveness and operational assessments. The Navy will only recommend implementing mitigation that results in avoidance or reduction of an impact to a resource and that has acceptable operational impacts to a particular proposed activity

Table 11-1: Predicted Range to Effects and Recommended Mitigation Zones

Activity Category	Representative Source (Bin)*	Predicted Average (Longest) Range to TTS	Predicted Average (Longest) Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Non-Impulsive Sound					
Low-frequency and Hull Mounted Mid-frequency Active Sonar	SQS-53 ASW hull-mounted sonar (MF1)	4,251 yd. (3,887 m)	281 yd. (257 m)	<292 yd. (<267 m)	6 dB power down at 1,000 yd. (914 m); 4 dB power down at 500 yd. (457 m); and shutdown at 200 yd. (183 m)
	Low-frequency sonar (LF4)**	4,251 yd. (3,887 m)	281 yd. (257 m)	<292 yd. (<267 m)	200 yd. (183 m)**
High-frequency and Non-hull Mounted Mid-frequency Active Sonar	AQS-22 ASW dipping sonar (MF4)	226 yd. (207 m)	<55 yd. (<50 m)	<55 yd. (<50 m)	200 yd. (183 m)
Explosive and Impulsive Sound					
Improved Extended Echo Ranging Sonobuoys	Explosive sonobuoy (E4)	434 yd. (397 m)	156 yd. (143 m)	563 yd. (515 m)	600 yd. (549 m)
Explosive Sonobuoys using 0.6–2.5 lb. NEW	Explosive sonobuoy (E3)	290 yd. (265 m)	113 yd. (103 m)	309 yd. (283 m)	350 yd. (320 m)
Anti-swimmer Grenades	Up to 0.5 lb. NEW (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices	NEW dependent				
Mine Neutralization Activities Using Diver-Placed Time-Delay Firing Devices	Up to 20 lb. NEW (E6)	407 yd. (372 m)	98 yd. (90 m)	102 (93 m) yd.	1,000 yd. (915 m)
Gunnery Exercises – Small- and Medium-Caliber Using a Surface Target	40 mm projectile (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Gunnery Exercises – Large-Caliber Using a Surface Target	5 in. projectiles (E5 at the surface***)	453 yd. (414 m)	186 yd. (170 m)	526 yd. (481 m)	600 yd. (549 m)
Missile Exercises up to 250 lb. NEW Using a Surface Target	Maverick missile (E9)	949 yd. (868 m)	398 yd. (364 m)	699 yd. (639 m)	900 yd. (823 m)
Missile Exercises from 251 to 500 lb. NEW Using a Surface Target	Harpoon missile (E10)	1,832 yd. (1,675 m)	731 yd. (668 m)	1,883 yd. (1,721 m)	2,000 yd. (1.8 km)
Bombing Exercises	MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2,500 yd. (2.3 km)**
Torpedo (Explosive) Testing	MK-48 torpedo (E11)	1,632 yd. (1.5 km)	697 yd. (637 m)	2,021 yd. (1.8 km)	2,100 yd. (1.9 km)

Table 11-1: Predicted Range to Effects and Recommended Mitigation Zones (continued)

Activity Category	Representative Source (Bin)	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Explosive and Impulsive Sound					
Sinking Exercises	Various sources up to the MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2.5 nm (4.6 km)**
At-sea Explosive Testing	Various sources less than 10 lb. NEW (E5 at various depths***)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	1,600 yd. (1.4 km)**

Notes: ASW = anti-submarine warfare, NEW = net explosive weight, PTS = permanent threshold shift, TTS = temporary threshold shift

* This table does not provide an inclusive list of source bins; bins presented here represent the source bin with the largest range to effects within the given activity category.

** Recommended mitigation zones are larger than the modeled injury zones to account for multiple types of sources or charges being used.

*** The representative source bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).

11.2.1 Acoustic Stressors

11.2.1.1 Non-Impulse Sound

Low-frequency and Hull Mounted Mid-frequency Active Sonar

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation measures do not currently exist for low-frequency active sonar sources analyzed in the MITT EIS/OEIS and associated with new platforms or systems, such as the Littoral Combat Ship. The Navy is proposing to (1) add mitigation measures for low-frequency active sonar (2) continue implementing the current measures for mid-frequency active sonar, and (3) clarify the conditions needed to recommence an activity after a sighting. The recommended measures are below.

Training and testing activities that involve the use of low-frequency and hull-mounted mid-frequency active sonar (including pierside) will use Lookouts for visual observation from a ship immediately before and during the exercise. With the exception of certain low-frequency sources that are not able to be powered down during the activity (e.g., low-frequency sources within bin LF4), mitigation will involve powering down the sonar by 6 dB when a marine mammal or sea turtle is sighted within 1,000 yd. (914 m), and by an additional 4 dB when sighted within 500 yd. (457 m) from the source, for a total reduction of 10 dB. If the source can be turned off during the activity, active transmissions will cease if a marine mammal or sea turtle 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 min., (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 vessel bow.

If the source is not able to be powered down during the activity (e.g., low-frequency sources within bin LF4), mitigation will involve ceasing active transmission if a marine mammal or sea turtle 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 existing the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the ship has transited more than 400 yd. (366 m) beyond the location of the last sighting.

High-frequency and Non-hull Mounted Mid-frequency Active Sonar

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation measures do not currently exist for all high-frequency and non-hull mounted mid-frequency active sonar activities (i.e., new sources or sources not previously analyzed). 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 min. before the first deployment of active dipping sonar. 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 min. for an aircraft-deployed source, (4) the mitigation zone has been clear from any additional sightings for a period of 30 min. for a vessel-deployed source, (5) the vessel or aircraft has repositioned itself more than 400 yd. (366 m) away from the location of the last sighting, or (6) 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).

11.2.1.2 Explosive and Impulse Sound

Improved Extended Echo Ranging Sonobuoys

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

The Navy is proposing to (1) modify the mitigation measures currently implemented for this activity by reducing the marine mammal and sea turtle mitigation zone from 1,000 yd. (914 m) to 600 yd. (549 m), and (2) clarify the conditions needed to recommence an activity after a sighting for ease of implementation. The recommended measures are provided below.

Mitigation will include pre-exercise aerial observation and passive acoustic monitoring, which will begin 30 min. before the first source/receiver pair detonation and continue throughout the duration of the exercise within a mitigation zone of 600 yd. (549 m) around an Improved Extended Echo Ranging sonobuoy. The pre-exercise aerial observation will include the time it takes to deploy the sonobuoy pattern (deployment is conducted by aircraft dropping sonobuoys in the water). Explosive detonations will cease if a marine mammal or sea turtle is sighted within the mitigation zone. Detonations will recommence if any one of the following conditions is met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Passive acoustic monitoring would be conducted with Navy assets, such as sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft and on vessels in order to increase vigilance of their visual surveillance.

Explosive Sonobuoys Using 0.6 to 2.5 Pound Net Explosive Weight

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation measures do not currently exist for this activity. The Navy is proposing to add the recommended measures provided below.

Mitigation will include pre-exercise aerial monitoring during deployment of the field of sonobuoy pairs (typically up to 20 min.) and continuing throughout the duration of the exercise within a mitigation zone of 350 yd. (320 m) around an explosive sonobuoy. Explosive detonations will cease if a marine mammal or sea turtle is sighted within the mitigation zone. Detonations will recommence if any one of the following conditions is met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 10 min.

Passive acoustic monitoring will also be conducted with Navy assets, such as sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft in order to increase vigilance of their visual surveillance.

Anti-swimmer Grenades

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation measures do not currently exist for this activity. The Navy is proposing to add the recommended measures provided below.

Mitigation will include visual observation from a small boat immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around an anti-swimmer grenade. Explosive detonations will cease if a marine mammal or sea turtle is sighted within the mitigation zone. Detonations will recommence if any one of the following conditions is met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the activity has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

A summary of the estimated range to effects for each of the charge sizes in this category can be found in Table 11-2. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

As Background, mine countermeasure and neutralization activities can be divided into two main categories: (1) general activities that can be conducted from a variety of platforms and locations, and (2) activities involving the use of diver-placed charges that typically occur close to shore. When either of these activities are conducted using a positive control firing device, the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation.

Mitigation measures do not currently exist for general mine countermeasures and neutralization activities. The Navy is proposing to use the mitigation zones outlined in 11-2 during general mine countermeasure activities using positive control firing devices. General mine countermeasure and neutralization activity mitigation will include visual surveillance from small boats or aircraft beginning 30 min. before, during, and 30 min. after the completion of the exercise within the mitigation zones around the detonation site. Explosive detonations will cease if a marine mammal, sea turtle, flock of seabirds, or individual foraging seabird is sighted within the mitigation zone. Detonations will recommence if any one of the following conditions is met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

For activities involving positive control diver-placed charges, the Navy is proposing to (1) modify the currently implemented mitigation measures for activities involving up to a 20 lb. net explosive weight detonation, and (2) clarify the conditions needed to recommence an activity after a sighting. For comparison, the currently implemented mitigation zone for up to 10 lb. net explosive weight charges is 700 yd. (640 m). The recommended measures for activities involving positive control diver-placed activities are provided below.

The Navy is proposing to use the mitigation zones outlined in Table 11-2 during activities involving positive control diver-placed charges. Visual observation will be conducted by either two small boats, or one small boat in combination with one helicopter. Boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius and human safety zone) and travel in a circular pattern around the detonation location. When using two boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. If used, helicopters will travel in a circular pattern around the detonation location.

Explosive detonations will cease if a marine mammal, sea turtle, flock of seabirds, or individual foraging seabird is sighted in the water portion of the mitigation zone (i.e., not on shore). Detonations will recommence if any one of the following conditions is met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Immediately following the detonation, visual monitoring for birds within the mitigation zone will take place for 30 min. The Navy will report all injured or dead seabirds sighted during the post-detonation observations to the appropriate Navy Region Environmental Director, Navy Pacific Fleet Environmental Office, and local base wildlife biologist.

For training exercises that include the use of multiple detonations, the second (or third, etc.) detonation will occur either immediately after the preceding detonation (i.e., within 10 seconds of the preceding detonation) or after 30 min. have passed.

Table 11-2: Predicted Range to Effects and Mitigation Zone Radius for Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

Charge Size Net Explosive Weight (Bins)	General Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices*				Mine Countermeasure and Neutralization Activities Using Diver-Placed Charges under Positive Control**			
	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
2.6–5 lb. (E4)	434 yd. (474 m)	197 yd. (180 m)	563 yd. (515 m)	600 yd. (549 m)	545 yd. (498 m)	169 yd. (155 m)	301 yd. (275 m)	350 yd. (320 m)
6–10 lb. (E5)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	800 yd. (732 m)	587 yd. (537 m)	203 yd. (185 m)	464 yd. (424 m)	500 yd. (457 m)
11–20 lb. (E6)	766 yd. (700 m)	288 yd. (263 m)	648 yd. (593 m)	800 yd. (732 m)	647 yd. (592 m)	232 yd. (212 m)	469 yd. (429 m)	500 yd. (457 m)

* These mitigation zones are applicable to all mine countermeasure and neutralization activities conducted in all locations that Tables 2.8-1 through 2.8-5 specifies.

** These mitigation zones are only applicable to mine countermeasure and neutralization activities involving the use of diver placed charges. These activities are conducted in shallow-water and the mitigation zones are based only on the functional hearing groups with species that occur in these areas (mid-frequency cetaceans and sea turtles).

Notes: lb. = pounds, yd. = yards, m = meters, PTS = permanent threshold shift, TTS = temporary threshold shift

Mine Neutralization Diver-Placed Mines Using Time-delay Firing Device

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

As background, when mine neutralization activities using diver-placed charges (up to a 20 lb. net explosive weight) are conducted with a time-delay firing device, the detonation is fused with a specified time-delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated. During these activities, the detonation cannot be terminated once the fuse is initiated due to human safety concerns.

Mitigation measures do not currently exist for activities using diver-placed charges (up to a 20 lb. net explosive weight) with a time-delay firing device. The Navy is recommending the measures provided below.The Navy is proposing to (1) modify the mitigation zones and observation requirements currently implemented for mine countermeasure and neutralization activities using diver-placed time-delay firing devices, and (2) clarify the conditions needed to recommence an activity after a sighting. For comparison, the current mitigation zones are based on size of charge and length of time-delay, ranging from a 1,000 yd. (914 m) mitigation zone for a 5 lb. net explosive weight charge using a 5- min. time-delay to a 1,400 yd. (1,280 m) mitigation zone for a 10 lb. net explosive weight charge using a 10 min. time-delay. The current requirement is for two boats to be used for observation in mitigation zones that are less than 1,400 yd. (1,280 m). The recommended measures for activities involving diver-placed time-delay firing devices are provided below.

The Navy recommends one mitigation zone for all net explosive weights and lengths of time-delay. Mine neutralization activities involving diver-placed charges will not include time-delay longer than 10 min. Mitigation will include visual surveillance from small boats or aircraft commencing 30 min. before, during, and until 30 min. after the completion of the exercise within a mitigation zone of 1,000 yd. (915 m) around the detonation site. During activities using time-delay firing devices involving up to a 20 lb. net explosive weight charge, visual observation will take place using two small boats. The fuse initiation will cease if a marine mammal or sea turtle is sighted within the water portion of the mitigation zone (i.e., not on shore). Fuse initiation 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 min.

Survey boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius/human safety zone) and travel in a circular pattern around the detonation location. One Lookout from each boat will look inward toward the detonation site and the other Lookout will look outward away from the detonation site. When using two small boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. If available for use, helicopters will travel in a circular pattern around the detonation location.

Gunnery Exercises – Small- and Medium-Caliber Using Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation measures do not currently exist for small- and medium-caliber gunnery using a surface target. The Navy is recommending the measures 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. 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. Firing will cease if a marine mammal or sea turtle 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 min. for a firing aircraft, (4) the mitigation zone has been clear from any additional sightings for a period of 30 min. 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.

Gunnery Exercises – Large-Caliber Using a Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

The Navy is proposing to (1) continue using the currently implemented mitigation zone for this activity, (2) clarify the conditions needed to recommence an activity after a sighting, and (3) modify the seafloor habitat mitigation area. 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. Firing will cease if a marine mammal or sea turtle 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 min.

Missile Exercises (Including Rockets) up to 250 Pound Net Explosive Weight Using aSurface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

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, and (3) modify the platform of observation to eliminate the requirement to observe when ships are firing.

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. 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 min. or 30 min. (depending on aircraft type).

Missile Exercises from 251 to 500 Pound Net Explosive Weight Using a Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

The Navy is proposing to modify the mitigation measures currently implemented for this activity by increasing the mitigation zone from 1,800 yd. (1.6 km) to 2,000 yd. (1.8 km). When aircraft are 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. Firing will cease if a marine mammal or sea turtle 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 min. or 30 min. (depending on aircraft type).

Bombing Exercises

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

The Navy is proposing to (1) modify the mitigation measures currently implemented for this activity by increasing the mitigation zone from 1,000 yd. (914 m) to 2,500 yd. (2.3 km), and (2) clarify the conditions needed to recommence an activity after a sighting.

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. Bombing will cease if a marine mammal or sea turtle 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 min.

Torpedo (Explosive) Testing

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation measures do not currently exist for torpedo (explosive) testing. The Navy is recommending the measures provided below.

Mitigation will include visual observation by aircraft (with the exception of platforms operating at high altitudes) immediately before, during, and after the exercise within a mitigation zone of 2,100 yd. (1.9 km) around the intended impact location. Firing will cease if a marine mammal, sea turtle, or aggregation of jellyfish 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 min. or 30 min. (depending on aircraft type)

In addition to visual observation, passive acoustic monitoring would be conducted with Navy assets, such as passive ships sonar systems or sonobuoys, already participating in the activity. Passive acoustic observation would be accomplished through the use of remote acoustic sensors or expendable sonobuoys, or via passive acoustic sensors on submarines when they participate in the Proposed Action. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to the Lookout posted in the aircraft in order to increase vigilance of the visual surveillance and to the person in control of the activity for their consideration in determining when the mitigation zone is determined free of visible marine mammals.

Sinking Exercises

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

The Navy is proposing to (1) modify the mitigation measures currently implemented for this activity by increasing the mitigation zone from 2.0 nm (3.7 km) to 2.5 nm (4.6 km), (2) clarify the conditions needed to recommence an activity after a sighting, and (3) 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 (4.6 km) around the target ship hulk. Sinking exercises will include aerial observation beginning 90 min. 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 net explosive weight 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 its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min. 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).

At-Sea Explosive Testing

Mitigation measures do not currently exist for at-sea explosive testing activities.

Mitigation during at-sea explosive testing, such as the sinking of a vessel by a sequential firing of multiple small charges (e.g., explosives in bin E5) for use as an artificial reef, will include visual observation from supporting vessels immediately before and during the activity within a mitigation zone of 1,600 yd. (1.4 km) around the intended impact location. Detonations will cease if a marine mammal or sea turtle is sighted within the mitigation zone. Detonations will recommence if any one of the following conditions is met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.3 Weapons Firing Noise

Gunnery Exercises – Large Caliber

The Navy is proposing to implement the following mitigation measure, which only applies to the firing side of the ship as provided below.

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. (64 m) within 30 degrees on either side of the gun target line on the firing side. Firing will cease if a marine mammal or sea turtle 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 min., or (4) the vessel has repositioned itself more than 140 yd. (128 m) away from the location of the last sighting.

11.2.2 Physical Strike and Disturbance

11.2.2.1 Vessels and In-Water Devices

Vessel Movement

The Navy is proposing to clarify using the mitigation measures currently implemented. The recommended measures are provided below.

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.

Towed In-Water Devices

The Navy is proposing to continue using the mitigation measures currently implemented. The recommended measures are provided below.

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.

11.2.2.2 Non-Explosive Practice Munitions

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 a vessel or aircraft immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around the intended impact location. Firing will cease if a marine mammal or sea turtle 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 min. for a firing aircraft, (4) the mitigation zone has been clear from any additional sightings for a period of 30 min. 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.

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. Bombing will cease if a marine mammal or sea turtle 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 min.

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 MITT LOA application, none of the proposed training or testing activities in the MITT Study Area occur in or near the Arctic. Based on the discussions and conclusions in Chapters 7 (Impacts on Marine Mammal Species or Stocks) and 8 (Impacts on Subsistence Use), there are no anticipated impacts on any species or stocks migrating through the Study Area that might be available 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 fleet monitoring program is composed of a collection of "range-specific" monitoring plans, each developed individually as part of the MMPA/ESA process as environmental compliance documentation was previously completed. These individual plans establish specific monitoring requirements for each range complex based on a set of initial field metrics. The Navy's related, but separate marine mammal research and development program is described in Chapter 14 (Research).

Concurrent with development of the range complex specific monitoring plans, from 2009 to 2010 the Navy designed and worked with the NMFS to update a more overarching program plan in which range complex specific monitoring would occur. This plan is called the Integrated Comprehensive Monitoring Program (ICMP) (U.S. Department of the Navy 2011). The ICMP has been developed in direct response to Navy permitting requirements established in various MMPA Final Rules, ESA consultations, Biological Opinions, and applicable regulations. As a framework document, the ICMP applies by regulation to those activities on ranges and operating areas for which the Navy is seeking or has sought incidental take authorizations. The ICMP is intended to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of effort for each range complex based on set of standardized research goals, and in acknowledgement of regional scientific value and resource availability.

The ICMP is designed to be a flexible, scalable, and adjustable plan. The ICMP is evaluated annually through the adaptive management process to assess progress, provide a matrix of goals for the following year, and make recommendations for refinement.

An October 2010 Navy Monitoring meeting in Arlington, VA, initiated a process to critically evaluate current Navy monitoring plans and begin development of revisions to existing region-specific monitoring plans and associated updates to the ICMP. Discussions at that meeting as well as through the Navy/NMFS adaptive management process established a way ahead for continued refinement of the Navy's monitoring program. This process included establishing a Scientific Advisory Group (SAG) composed of technical experts to provide objective scientific guidance for Navy consideration. The Navy established the SAG in early 2011 with the initial task of evaluating current Navy monitoring approaches under the ICMP and existing LOA and developing objective scientific recommendations that will serve as the basis for a future Strategic Implementation Plan for Navy monitoring. The SAG was convened for an initial workshop in San Diego, CA in March 2011. The SAG was composed of leading academic and civilian scientists with significant expertise in marine species monitoring, acoustics, ecology, and modeling.

13.2 Monitoring Plans and Methods

Limited exercise monitoring began in 2007 (Mobley 2007); however, regular monitoring for compliance with the MMPA LOA and ESA consultation began in 2010. The Navy and NMFS determined during the permitting process that monitoring in the Mariana Islands should focus on augmenting existing baseline data, such as that collected during the Navy-sponsored, large-vessel Mariana Islands Sea Turtle and Cetacean Survey (Fulling et al. 2011), instead of focusing on exercise monitoring in the Mariana Islands. Monitoring plans therefore presently include specific levels of small vessel surveys, passive acoustic monitoring, and acoustic data analysis. The results from the Navy's monitoring efforts to date have been posted on the NMFS' Office of Protected resources website as well as on the Navy's Marine Species Monitoring website, www.navymarinespeciesmonitoring.us. In the Mariana Islands, Navy-funded marine mammal monitoring from 2007 to 2012 has accomplished small boat surveys during 2010, 2011, and 2012 off Guam, Saipan, Rota, and Aguigan and the deployment of passive acoustic recording buoys (with analysis currently ongoing). In addition to the Navy directed monitoring described above, the Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Island Fisheries Science Center from 2009 through 2012. The U.S. Pacific Fleet funding share as part of the overall Navy-wide funding in marine mammal research and monitoring in MIRC was over $1.4 million from 2010 to 2012.

Finally, there were 39 additional sightings of marine mammals reported by Navy Lookouts aboard Navy ships within the MITT Study Area from 2009 to 2011 as presented in the Annual Exercise Reports submitted to NMFS. During these observations, mainly from major at-sea training events, there were no reported observations of adverse reactions by marine mammals.

13.3 Monitoring Adaptation and Improvement

Discussions at the SAG March 2011 meeting along with continued Navy and NMFS dialog in June 2011 and an October 2011 annual adaptive management meeting established a way ahead for continued refinement of the Navy's monitoring program. Consensus was that the ICMP and associated implementation components would continue the evolution of Navy marine species monitoring towards a single integrated program, incorporate SAG recommendations where warranted and logistically feasible, and establish a more transparent framework for soliciting, evaluating, and implementing future monitoring across the all Navy range complexes and ocean basins. Although the ICMP does not specify actual monitoring field work or projects, it does establish top-level goals that have been developed in coordination with the NMFS. As the ICMP is implemented at the range complex level, detailed and specific studies will be developed which support the Navy's top-level goals. The following excerpt from the 2010 update of the Navy ICMP states the current top-level goals as developed through coordination with the NMFS. In essence, the ICMP directs that monitoring measures prescribed in a range or project-specific monitoring plan and Navy-funded research relating to the effects of Navy training and testing activities on marine species should be designed to accomplish one or more of the following top-level 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 impulse 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.

On 9 March 2012, the Navy submitted a three-year LOA renewal request to NMFS for activities associated with on-going military training in the Mariana Islands Range Complex (U.S. Department of the Navy 2012c). On 11 April 2012, the Navy submitted an Annual Monitoring Report on marine species monitoring efforts in the Mariana Islands Range Complex Study Area, which summarizes the results of the surveys described in Section 6.1.3 (Summary of Observations During Previous Navy Activities) (U.S. Department of the Navy 2012d). Through adaptive management review, the Navy, in coordination with NMFS, is developing a new “Strategic Planning Process” as a component of the ICMP to provide a conceptual framework for improving the monitoring program across all range complexes. Appendix E of the 2012 Annual Monitoring Report is an updated monitoring plan for fiscal years 2012 through 2015. Revisions to the current monitoring plan are described in Section 13.4 below.

13.4 MITT MONITORING IMPLEMENTATION

Based on the June and October 2011 NMFS-Navy meetings, future monitoring will address the ICMP top-level goals through a series of regional and ocean basin study questions with a priority study and funding focus on species of interest as indentified for each range complex. The ICMP will also address relative investments to different range complexes based on goals across all range complexes, and monitoring will leverage multiple techniques for data acquisition and analysis whenever possible.

Navy marine species monitoring conducted in the MIRC from FY10 to FY12 utilized a combination of visual line-transect surveys, non-random/non-systematic visual surveys, and analysis of archived acoustic data and deployment of autonomous passive acoustic monitoring devices. Through the process of adaptive management, input was solicited from an independent scientific advisory group and incorporated into the 2012-2015 Monitoring Plan (U.S. Department of the Navy 2012c). In order to meet the top-level goals established by the Navy and NMFS and through the lessons learned from past monitoring, the Navy has incorporated revisions to the monitoring methods for 2012-2015. The monitoring plan includes visual survey from either a vessel or shore-based station, maintenance of autonomous passive acoustic monitoring devices in FY13 and FY14 and subsequent analysis, use of a dipping hydrophone during vessel surveys, support for collection of biopsy samples (including preliminary analysis and archiving) per year, support for satellite tagging including purchase of tags and analysis of data per year, mark-recapture abundance estimates, and either line transect diving sea turtle surveys per year or turtle tagging.

Implementation of the monitoring program will subsequently focus on addressing the following five questions:

1. What species of beaked whales and other odontocetes occur around Guam and Saipan?
2. Are there locations of greater relative cetacean and/or sea turtle abundance around Guam and Saipan?
3. What is the baseline abundance and population structure of odontocetes which may be exposed to sonar and/or explosives in the near shore areas of Guam, Saipan, Tinian, and Rota?
4. What is the seasonal occurrence of baleen whales around Guam, Saipan, Tinian, and Rota?

In support of this LOA application and in line with the NMFS-Navy recommendations for continuing monitoring improvements, Navy monitoring within the MITT Study Area (and concurrently in other areas of the Pacific Ocean) will be structured to address the region-specific study questions. Specific allocation of monitoring (effort, studies, and species) within the MITT Study Area starting in 2015 will be contained in a monitoring plan to be developed in cooperation 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 Navy is one of the world's leading organizations in assessing the effects of human activities on the marine environment, including marine mammals. Navy scientists work cooperatively with other government researchers and scientists, universities, industry, and non-governmental conservation organizations in collecting, evaluating, and modeling information on marine resources. They also develop approaches to ensure that these resources are minimally impacted by existing and future Navy operations. It is imperative that the Navy's research and development (R&D) efforts related to marine mammals are conducted in an open, transparent manner with validated study needs and requirements. The goal of the Navy's R&D program is to enable collection and publication of scientifically valid research as well as development of techniques and tools for Navy, academic, and commercial use. Historically, R&D programs are funded and developed by the Navy's Chief of Naval Operations Energy and Environmental Readiness (OPNAV N45) and ONR, Code 322 Marine Mammals and Biological Oceanography Program. Primary focus of these programs since the 1990s is on understanding the effects of sound on marine mammals, including physiological, behavioral and ecological effects.

ONR's current Marine Mammals and Biology Program thrusts include, but are not limited to: (1) monitoring and detection research; (2) integrated ecosystem research including sensor and tag development; (3) effects of sound on marine life [such as hearing, behavioral response studies, physiology (diving and stress), 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. The goal of the LMR Program is to identify and fill knowledge gaps and to demonstrate, validate, and integrate new processes and technologies to minimize potential effects to marine mammals and other marine resources. Key elements of the LMR program include:

- Develop an open and transparent process with a dedicated web site for both project management and public review
- Provide program management and execution including inputs from various Navy commands involved in monitoring and research
- Ensure funding of research and development projects that include internationally respected and authoritative researchers and institutions
- Establish and validate critical needs and requirements with input from a Navy Regional Advisory Committee (RAC)
- Interact with key stakeholders outside of the Navy via the RAC
- Identify key enabling capabilities and investment areas with advice and assistance from a Navy Technical Review Committee
- Maintain close interaction and coordination with the ONR basic and early stage applied research program
- Develop effective information for Navy environmental planners and operators
- Provide effective management of project funding

14.2 NAVY RESEARCH AND DEVELOPMENT

Navy Funded Research – At this time, there are no LMR or ONR funded research and development projects in the MITT Study Area, however, when projects are initiated, the Navy's monitoring program will be coordinated with the research and development monitoring program to leverage research objectives, assets, and studies where possible under the ICMP (see Chapter 13 [Monitoring and Reporting Measures).

The integration between the Navy's new LMR Program and related Fleet and SYSCOM MITT monitoring will continue and improve during this Letter of Authorization application period with applicable R&D results presented in the MITT annual monitoring reports.

Other National Department of Defense Funded Initiative – Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) are the Department of Defense's environmental research programs, harnessing the latest science and technology to improve environmental performance, reduce costs, and enhance and sustain mission capabilities. The Programs respond to environmental technology requirements that are common to all of the military Services, complementing the Services' research programs. SERDP and ESTCP promote partnerships and collaboration among academia, industry, the military Services, and other Federal agencies. They are independent programs managed from a joint office to coordinate the full spectrum of efforts, from basic and applied research to field demonstration and validation. Beginning in March 2012, an ESTCP project that might eventually be applicable to future Navy training and testing includes:

Biodegradable Sonobuoy Decelerators (WP-201222)

http://www.serdp.org/Program-Areas/Weapons-Systems-and-Platforms/Waste-Reduction-and-Treatment-in-DoD-Operations/WP-201222/WP-201222/(language)/eng-US
The objective of this project is to develop a dissolving and biodegradable material for use in Navy sonobuoy parachutes which will address concerns associated with shelf life management, storage, reutilization, and environmental impact. The scope of this effort includes parachute and packaging design, selection and evaluation of materials, and drop tests.

- Optimize biodegradable parachute material to produce a parachute that meets Navy performance requirements.
- Develop packaging to optimize shelf life and storage, maximize biodegradability of all components, and perform environmental evaluation of technology versus traditional nylon parachute.
- Conduct system verification and operational validation testing.

Eventual goal of this project is to seek a replacement for existing sonobuoy parachutes using new biodegradable materials. Traditional nylon parachute fabric is being replaced with a polyvinyl alcohol (PVOH) based film. Because the material properties for the PVOH film are not identical to the woven nylon fabric, the sonobuoy parachute design had to be modified. This modified design has been field tested from a helicopter and meets Navy design and performance criteria thus far. PVOH is a non-toxic, water soluble synthetic polymer. When PVOH film is submersed in water, it dissolves in less than one minute and will biodegrade in a matter of weeks. Laboratory testing to determine rate of dissolution and biodegradation is being conducted at the Natick Soldier Research, Development Center, and Marine Biodegradation Laboratory.

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