REQUEST FOR REGULATIONS AND LETTER OF AUTHORIZATION

FOR THE INCIDENTAL TAKING OF MARINE MAMMALS RESULTING FROM U.S. NAVY TRAINING 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
ASW	Anti-Submarine Warfare
CFR	Code of Federal Regulations
CNMI	Commonwealth of the Northern Mariana Islands
CV	coefficient of variation
dB	decibel(s)
DPS	Distinct Population Segments
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FDM	Farallon de Medinilla
FLS	Forward Looking Sonar
FR	Federal Register
ft.	feet
GUNEX	Gunnery Exercise
Helo	helicopter
HF	High-Frequency
HRC	Hawaii Range Complex
Hz	hertz
in.	inch(es)
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometers
kPa	kilopascal(s)
lb.	pound(s)
LF	Low-Frequency
LOA	Letter of Authorization
m	meter(s)
msec	millisecond(s)
M	Acoustic Modem
MF	Mid-Frequency
mi.	mile(s)
min.	minute(s)
MIRC	Mariana Islands Range Complex
MISSILEX	Missile Exercise
MISTCS	Mariana Islands Sea Turtle and Cetacean Survey
MITT	Mariana Islands Training and Testing
MMPA	Marine Mammal Protection Act
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
OEIS	Overseas Environmental Impact Statement
OPNAV 45	Chief of Naval Operations Energy and Environmental Readiness
Pa-s	Pascal seconds
PCAD	Population Consequences of Acoustic Disturbance
psi	pounds per square inch
PTS	Permanent Threshold Shift
R (1)	Restricted Area
R (2)	Acoustic Release
re	relative to
S-S	Surface-to-Surface
SAR	Stock Assessment Report
SEIS	Supplemental Environmental Impact Statement
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SUS	Signal Underwater Sound
TNT	trinitrotoluene
TORP	Torpedo
TORPEX	Torpedo Exercise
TRACKEX	Tracking Exercise
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
VHF	Very High-Frequency
W	Warning Area
yd.	yard(s)

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1 Description of Specified Activity

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, Type of Incidental Taking Authorization Requested) of marine mammals during training and testing activities within the Mariana Islands Training and Testing (MITT) Study Area (Figure 1.1-1). The Navy is requesting a 7-year LOA for these activities, proposed to be conducted from 2020 through 2027.

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

Pursuant to the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114 (*Environmental Impacts Abroad of Major Federal Actions*), the Navy is preparing a Supplement (the MITT Draft Supplemental Environmental Impact Statement/Overseas EIS [SEIS/OEIS]) to the May 2015 Mariana Islands Training and Testing Activities Environmental Impact Statement (EIS)/ OEIS (U.S. Department of the Navy, 2015b), hereinafter referred to as the 2015 MITT Final EIS/OEIS. These documents assess the potential environmental impacts associated with proposed training and testing activities to be conducted at sea and on land at Farallon de Medinilla (FDM). The proposed activities in the SEIS/OEIS are generally a continuation of ongoing training and testing activities at sea and on FDM, as analyzed in the 2015 MITT Final EIS/OEIS, and are representative of the type of activities the military has conducted in the area for decades. These training and testing activities include the use of active sonar and explosives at sea off the coasts of Guam and the Commonwealth of the Northern Mariana Islands (CNMI), throughout the in-water areas around the Mariana Islands Range Complex (MIRC), the transit corridor between the MIRC and the Hawaii Range Complex (HRC), and at select pierside and harbor locations.

A description of the Study Area (Figure 1.1-1) and the various components of that area are provided in Chapter 2 (Dates, Duration, and Specified Geographic Region). A description of the activities for which the Navy is requesting incidental take authorization is provided in the following sections. This request for an LOA is based on the proposed activities in the Navy's Preferred Alternative (Alternative 2 in the MITT Draft SEIS/OEIS, referred to in this document as the Proposed Action). The MITT Draft SEIS/OEIS considers ongoing and future activities conducted at sea and on FDM, updates training and testing requirements, incorporates new information from an updated acoustic effects model, updates marine mammal density data, and incorporates evolving and emergent best available applicable science.

This Request for Regulations and LOA for the Incidental Taking of Marine Mammals 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 108–136) and further amended by the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115-232). The request for an LOA is based on (1) the analysis of spatial and temporal distributions of protected marine mammals in the Study Area, (2) the review of proposed activities analyzed in the MITT Draft SEIS/OEIS that have the potential to incidentally take marine mammals, and (3) a technical risk assessment to determine the likelihood of effects from those activities.

This chapter describes those 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 Draft SEIS/OEIS, the Navy has determined that only the use of sonar and other transducers and in-water detonations have the potential to affect marine mammals to a level that would constitute harassment under the MMPA.

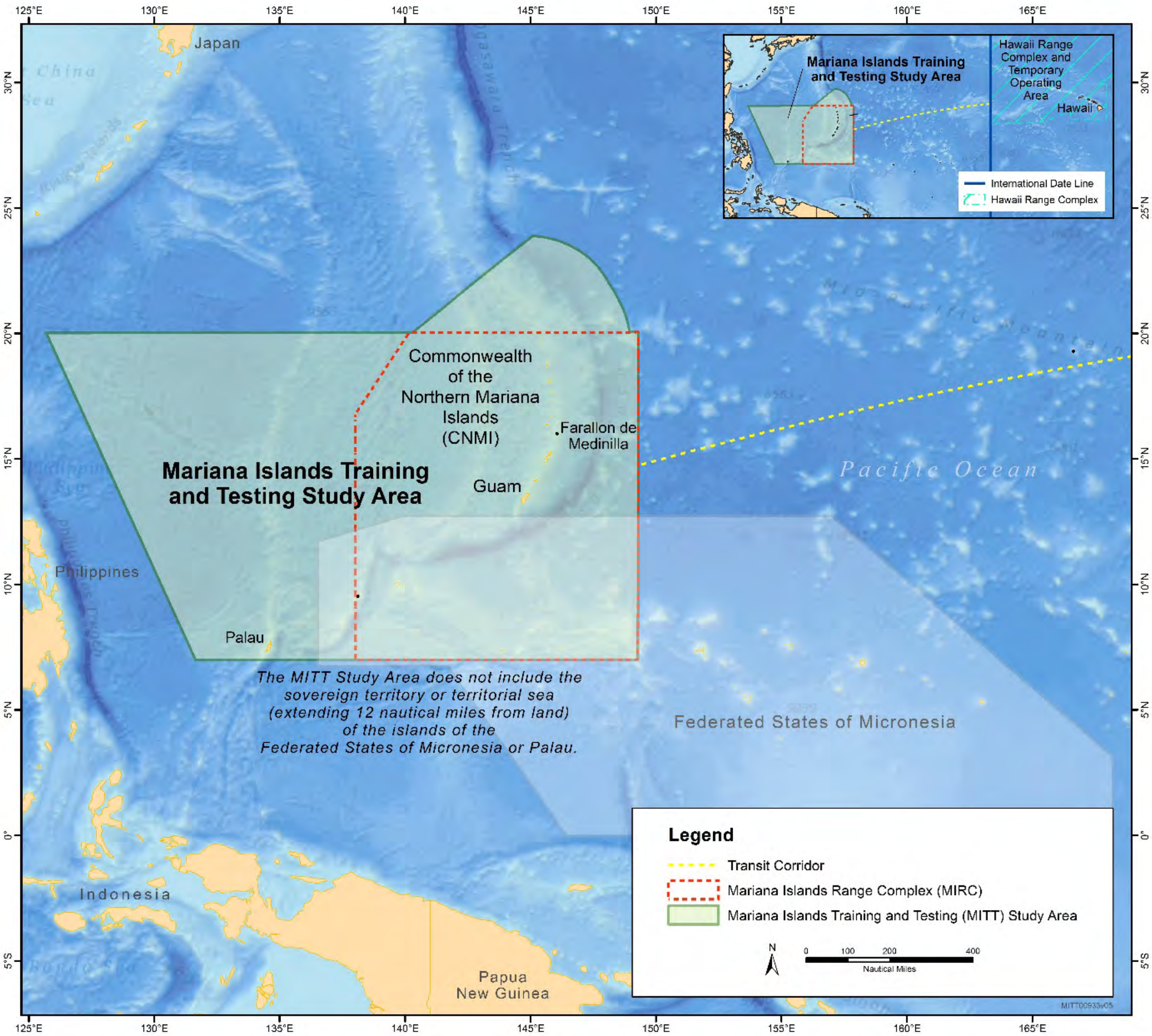


Figure 1.1-1: Mariana Islands Training and Testing Study Area

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. section 5062), which requires the readiness of the naval forces of the United

States.[1] The Navy executes this responsibility by establishing and executing training programs, including at-sea training and exercises, and ensuring naval forces have access to the ranges, operating areas, and airspace needed to develop and maintain skills for conducting naval activities. Further, the Navy's testing activities ensure naval forces are equipped with well-maintained systems that take advantage of the latest technological advances. The Navy's research and acquisition community conducts military readiness activities that involve testing. The Navy tests ships, aircraft, weapons, combat systems, sensors, and related equipment, and conducts scientific research activities to achieve and maintain military readiness.

The Navy is preparing the SEIS/OEIS to reassess the potential environmental impacts associated with proposed Naval activities in the Study Area. The Navy is the lead agency for the MITT Draft SEIS/OEIS, and National Marine Fisheries Service (NMFS) is a cooperating agency pursuant to 40 Code of Federal Regulations (CFR) sections 1501.6 and 1508.5. Additionally, this analysis considers at-sea training activities conducted by the other services of the U.S. Department of Defense and the U.S. Coast Guard under the authority of the Navy. Since the Navy is the agency requesting Authorization, these agencies are collectively referred to as the "Navy" throughout this document.

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

1.3 Overview of Training and Testing Activities

1.3.1 Primary Mission Areas

The Navy categorizes its at-sea activities into functional warfare areas called primary mission areas. MITT activities fall into eight primary mission areas:

- air warfare
- amphibious warfare
- anti-submarine warfare
- electronic warfare
- expeditionary warfare
- mine warfare
- strike warfare
- surface warfare

Most activities conducted in MITT are categorized under one of these primary mission areas; activities that do not fall within one of these areas are listed as "other activities." Each warfare community (surface, subsurface, aviation, and expeditionary warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes most, but not all, of its testing activities under these primary mission areas. A description of the sonar, munitions, targets, systems, and other material used during training and testing activities within these primary mission areas is provided in the MITT Draft SEIS/OEIS Appendix A (Training and Testing Activities Descriptions).

The Navy describes and analyzes the effects of its activities within the MITT Draft SEIS/OEIS (U.S. Department of the Navy, 2018b). In its assessment, the Navy concluded that sonar and other transducers and underwater detonations were the stressors most likely to result in impacts on marine mammals that could rise to the level of harassment as defined under the MMPA. Therefore, this LOA

[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."

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. Those mission areas include the following:

- amphibious warfare (underwater detonations)
- anti-submarine warfare (sonar and other transducers, underwater detonations)
- mine warfare (sonar and other transducers, underwater detonations)
- surface warfare (underwater detonations)
- other (sonar and other transducers)

The Navy's activities in air warfare, electronic warfare, and expeditionary warfare do not involve sonar and other transducers, underwater detonations, 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 LOA request, but are analyzed fully in the Navy's MITT Draft SEIS/OEIS.

1.3.2 Amphibious Warfare

The mission of amphibious warfare is to project military power from the sea to the shore (i.e., attack a threat on land by a military force embarked on ships) through the use of naval firepower and expeditionary landing forces. Amphibious warfare operations range from small unit reconnaissance or raid missions to large-scale amphibious exercises involving multiple ships and aircraft combined into a strike group.

Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Such training includes shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and attacks on targets that are in close proximity to friendly forces.

Testing of guns, munitions, aircraft, ships, and amphibious vessels and vehicles used in amphibious warfare are often integrated into training activities and, in most cases, the systems are used in the same manner in which they are used for training activities. Amphibious warfare tests, when integrated with training activities or conducted separately as full operational evaluations on existing amphibious vessels and vehicles following maintenance, repair, or modernization, may be conducted independently or in conjunction with other amphibious ship and aircraft activities. Testing is performed to ensure effective ship-to-shore coordination and transport of personnel, equipment, and supplies. Tests may also be conducted periodically on other systems, vessels, and aircraft intended for amphibious operations to assess operability and to investigate efficacy of new technologies.

1.3.3 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine forces that threaten Navy surface forces. Anti-submarine warfare is based on the principle that surveillance and attack aircraft, ships, and submarines all search for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack submarine threats.

Anti-submarine warfare training addresses basic skills such as detecting and classifying submarines, as well as evaluating sounds to distinguish between enemy submarines and friendly submarines, ships, and marine life. More advanced training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes (i.e., torpedoes that do not contain a warhead) or simulated weapons. These integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft.

Testing of anti-submarine warfare systems is conducted to develop new technologies and assess weapon performance and operability with new systems and platforms, such as unmanned systems. Testing uses ships, submarines, and aircraft to demonstrate capabilities of torpedoes, missiles, countermeasure systems, and underwater surveillance and communications systems. Tests may be conducted as part of a large-scale training event involving submarines, ships, fixed-wing aircraft, and helicopters. These integrated training events offer opportunities to conduct research and acquisition activities and to train aircrew in the use of new or newly enhanced systems during a large-scale, complex exercise.

1.3.4 MINE WARFARE

The mission of mine warfare is to detect, classify, and avoid or neutralize (disable) 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 of or deny the enemy access to sea space. Naval mines can be laid by ships, submarines, or aircraft.

Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, unmanned vehicles, or marine mammal detection systems search for mine shapes. Personnel train to destroy or disable mines by attaching underwater explosives to or near the mine or using remotely operated vehicles to destroy the mine. Towed influence mine sweep systems mimic a particular ship's magnetic and acoustic signature, which would trigger a real mine causing it to explode.

Testing and development of mine warfare systems is conducted to improve sonar, laser, and magnetic detectors intended to hunt, locate, and record the positions of mines for avoidance or subsequent neutralization. Mine warfare testing and development falls into two primary categories: mine detection and classification, and mine countermeasure and neutralization testing. Mine detection and classification testing involves the use of air, surface, and subsurface vessels and uses sonar, including towed and side-scan sonar, and unmanned vehicles to locate and identify objects underwater. Mine detection and classification systems are sometimes used in conjunction with a mine neutralization system. Mine countermeasure and neutralization testing includes the use of air, surface, and subsurface units and uses tracking devices, countermeasure and neutralization systems, and general purpose bombs to evaluate the effectiveness of neutralizing mine threats. Most neutralization tests use mine shapes, or non-explosive practice mines, to accomplish the requirements of the activity. For example, during a mine neutralization test, a previously located mine is destroyed or rendered nonfunctional using a helicopter or manned/unmanned surface vehicle-based system that may involve the deployment of a towed neutralization system.

Most training and testing activities use mine shapes, or non-explosive practice mines, to accomplish the requirements of the activity. A small percentage of mine warfare activities require the use of high-explosive mines to evaluate and confirm the ability of the system or the crews conducting the training to neutralize a high-explosive mine under operational conditions. The majority of mine warfare systems are deployed by ships, helicopters, and unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

1.3.5 Surface Warfare

The mission of surface warfare is to obtain control of sea space from which naval forces may operate, which entails offensive action against surface targets while also defending against aggressive actions by enemy forces. In the conduct of surface warfare, aircraft use guns, air-launched cruise missiles, or other precision-guided munitions; ships employ naval guns and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

Surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, submarine missile or torpedo launch activities, and other munitions against surface targets.

Testing of weapons used in surface warfare is conducted to develop new technologies and to assess weapon performance and operability with new systems and platforms, such as unmanned systems. Tests include various air-to-surface guns and missiles, surface-to-surface guns and missiles, and bombing tests. Testing activities may be integrated into training activities to test aircraft or aircraft systems in the delivery of munitions on a surface target. In most cases the tested systems are used in the same manner in which they are used for training activities.

1.3.6 Overview of Navy Activities Within the Study Area

Training and testing activities and exercises covered in this request for an LOA are briefly described below and in more detail within the MITT Draft SEIS/OEIS.The Navy has been conducting training and testing 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 changes in force structure (e.g., organization of ships, submarines, aircraft, weapons, and Sailors). Such developments influence the frequency, duration, intensity, and location of required training and testing activities. The activities analyzed are largely a continuation of activities that have been ongoing and were analyzed previously in the 2015 MITT Final EIS/OEIS and the 2010 MIRC EIS/OEIS (U.S. Department of the Navy, 2010c). This request includes the analysis of those at-sea activities necessary to meet readiness requirements beyond 2020 and into the reasonably foreseeable future, includes any changes to those activities previously analyzed, and reflects the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements.

A major training exercise is comprised of several “unit-level” exercises conducted by several units operating together, commanded and controlled by a single Commander, and generating more than 100 hours of active sonar. These exercises typically employ an exercise scenario developed to train and evaluate the exercise participants in tactical and operational tasks. In a major training exercise, most of the activities being directed and coordinated by the exercise commander are identical in nature to the activities conducted during individual, crew, and smaller unit-level training events. In a major training exercise, however, these disparate training tasks are conducted in concert, rather than in isolation.

Exercises may also be categorized as integrated or coordinated anti-submarine warfare (ASW) exercises. The distinction between integrated and coordinated ASW exercises is how the units are being controlled. Integrated ASW exercises are controlled by an existing command structure, and generally occur during the Integrated Phase of the training cycle. Coordinated exercises may have a command structure stood up solely for the event; for example, the commanding officer of a ship may be placed in tactical command of other ships for the duration of the exercise. Not all integrated ASW exercises are considered major training exercises, due to their scale, number of participants, duration, and amount of active sonar. The distinction between large, medium, and small integrated or coordinated exercises is based on the scale of the exercise (i.e., number of ASW units participating), the length of the exercise, and the total number of active sonar hours.

Table 1.4-1 summarizes how the major training exercises and integrated/coordinated ASW exercises were binned to differentiate their differences in scale, duration, and active hull-mounted sonar hours for the purposes of exercise reporting requirements.

The training activities that are part of the Proposed Action for this LOA request are described in Table 1.5-1, which includes the activity name, a short description of the activity, the number of activities proposed, and locations. Appendix A (Training and Testing Activities Descriptions) of the MITT Draft SEIS/OEIS provides more detailed descriptions of the activities.

1.4 Description of Acoustic and Explosive Stressors

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 sound and energy into the environment. The proposed training and testing activities were evaluated to identify specific components that could act as stressors by having direct or indirect impacts on the environment. This analysis included identification of the spatial variation of the identified stressors. The following subsections describe the acoustic and explosive stressors for biological resources within the Study Area in detail. Each description contains a list of activities that may generate the stressor. A preliminary analysis identified the stressor/resource interactions that warrant further analysis in the LOA based on public comment received during scoping, previous NEPA analyses, and opinions of subject matter experts. Stressor/resource interactions that were determined to have negligible or no impacts (e.g., vessel noise, aircraft noise, weapons noise, and explosions in-air) were not carried forward for analysis in the LOA, as is consistent with previous rule-making (National Oceanic and Atmospheric Administration, 2015a).

Table 1.4-1: Major Training Exercises and Integrated/Coordinated Anti-Submarine Warfare Activities Analyzed for this MMPA Authorization Request

	Exercise Group	*Description*	*Scale*	*Location*	*Duration*	*MITT Exercise Examples*	*Modeled Hull-mounted Sonar per Exercise*
Major Training Exercises	Large Integrated ASW	Large scale, longer duration integrated ASW exercises	Up to three Carrier Strike Groups in coordination with other Services, 2 or more submarines, multiple ASW aircraft	Study Area; Apra Harbor	Typically a 10-day exercise	Joint Multi-Strike Group Exercise (e.g., Valiant Shield)	>500 hours
	Medium Integrated ASW	Medium-scale short duration integrated ASW exercises	Typically 15 surface ships, amphibious assault craft, helicopters, maritime patrol aircraft, strike fighter aircraft, 2 submarines, and various unmanned vehicles	Study Area to nearshore; Apra Harbor; Tinian; Guam; Rota; Saipan	Typically a 10-day exercise	Joint Expeditionary Exercise	100-500 hours
Integrated/Coordinated ASW Training	Small Integrated ASW	Small-scale short duration integrated ASW exercises	Approximately 3–6 surface ASW units, at least 1 submarine, 2–6 ASW aircraft	Study Area; Apra Harbor	Generally less than 5 days	Multi-Sail; SWATT	50-100 hours
	Medium Coordinated ASW	Medium-scale short duration coordinated ASW exercises	Approximately 2–4 surface ASW units, 2–5 ASW aircraft, possibly a submarine	Study Area; Apra Harbor	Generally 3–10 days	AnnualEx, GuamEx	Less than 100 hours
	Small Coordinated ASW	Small-scale short duration coordinated ASW exercises	Approximately 2–4 surface ASW units, possibly a submarine, 1–2 ASW aircraft	Study Area; Apra Harbor	Generally 2–4 days	Group Sail	Less than 50 hours

1.4.1 Acoustic Stressors

This section describes the characteristics of sounds produced during naval training and testing and the relative magnitude and location of these sound-producing activities. This provides the basis for analysis of acoustic impacts on resources in Chapter 6 (Take Estimates for Marine Mammals). Explanations of the terminology and metrics used when describing sound in this LOA are in Appendix H (Acoustic and Explosive Concepts) of the MITT Draft SEIS/OEIS.

Acoustic stressors include acoustic signals emitted into the water for a specific purpose, such as sonar, other transducers (devices that convert energy from one form to another—in this case, into sound waves), as well as incidental sources of broadband sound produced as a byproduct of vessel movement, aircraft transits, and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique hazardous characteristics (Section 1.4.2, Explosive Stressors). Characteristics of each of these sound sources are described in the following sections.

In order to better organize and facilitate the analysis of approximately 300 sources of underwater sound used by the Navy, including sonar and other transducers and explosives, a series of source classifications, or source bins, were developed. The source classification bins do not include the broadband sounds produced incidental to vessel and aircraft transits, and weapons firing, and bow shocks. Noise from vessels, aircraft, and weapons firing are not carried forward for analysis in the LOA, for the reasons stated above.

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;”
- improves efficiency of source utilization data collection and reporting requirements anticipated under the MMPA authorizations;
- ensures a precautionary approach to all impact estimates, as all sources within a given class are modeled as the most impactful source (highest source level, longest duty cycle, or largest net explosive weight) within that bin;
- allows analyses to be conducted in a more efficient manner, without any compromise of analytical results; and
- provides a framework to support the reallocation of source usage (hours/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.

1.4.1.1 Sonar and Other Transducers

Active sonar and other transducers emit non-impulsive sound waves into the water to detect objects, navigate safely, and communicate. Passive sonars differ from active sound sources in that they do not emit acoustic signals; rather, they only receive acoustic information about the environment, or listen. In this LOA request, the terms sonar and other transducers will be used to indicate active sound sources unless otherwise specified.

The Navy employs a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track enemy submarines; high-frequency small object detection sonars used to detect mines; high-frequency underwater modems used to transfer data over short ranges; and extremely high-frequency (greater than 200 kilohertz [kHz]) doppler sonars are used for navigation, like those used on commercial and private vessels. The characteristics of these sonars and other transducers, such as source level, beam width, directivity, and frequency, depend on the purpose of the source. Higher frequencies can carry more information or provide more information about objects off which they reflect, but attenuate more rapidly. Lower frequencies attenuate less rapidly, so may detect objects over a longer distance, but with less detail.

Propagation of sound produced underwater is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors, including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency sounds propagate. The effects of these factors are explained in Appendix H (Acoustic and Explosive Concepts) of the MITT Draft SEIS/OEIS. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

The sound sources and platforms typically used in naval activities analyzed in the LOA are described in Appendix A (Training and Testing Activities Descriptions) of the MITT Draft SEIS/OEIS. Sonars and other transducers used to obtain and transmit information underwater during Navy training and testing activities generally fall into several categories of use described below.

1.4.1.1.1 Anti-Submarine Warfare

Sonar used during anti-submarine warfare training and testing would impart the greatest amount of acoustic energy of any category of sonar and other transducers analyzed in this LOA request. Types of sonars used to detect vessels include hull-mounted, towed, line array, sonobuoy, helicopter dipping, and torpedo sonars. In addition, acoustic targets and decoys (countermeasures) may be deployed to emulate the sound signatures of vessels or repeat received signals.

Most anti-submarine warfare sonars are mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets with distance over which threats can be identified. However, some sources may use higher or lower frequencies. Duty cycles can vary widely, from rarely used to continuously active. Anti-submarine warfare sonars can be wide-ranging in a search mode or highly directional in a track mode.

Most anti-submarine warfare activities involving submarines or submarine targets would occur in waters greater than 600 feet (ft.) deep due to safety concerns about running aground at shallower depths. Sonars used for anti-submarine warfare activities would typically be used beyond 12 nautical miles (NM) from shore. Exceptions include use of dipping sonar by helicopters, maintenance of systems while in Apra Harbor, and system checks while transiting to or from Apra Harbor.

1.4.1.1.2 Mine Warfare, Small Object Detection, and Imaging

Sonars used to locate mines and other small objects, as well those used in imaging (e.g., for hull inspections or imaging of the seafloor), are typically high frequency or very high frequency. Higher frequencies allow for greater resolution and, due to their greater attenuation, are most effective over shorter distances. Mine detection sonar can be deployed (towed or vessel hull-mounted) at variable depths on moving platforms (ships, helicopters, or unmanned vehicles) to sweep a suspected mined area. Hull-mounted anti-submarine sonars can also be used in an object detection mode known as “Kingfisher” mode. Sonars used for imaging are usually used in close proximity to the area of interest, such as pointing downward near the seafloor.

Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft., and at established training minefields, temporary minefields close to strategic ports and harbors, or at targets of opportunity such as navigation buoys. Kingfisher mode on vessels is most likely to be used when transiting to and from port. Sound sources used for imaging could be used throughout the Study Area.

1.4.1.1.3 Navigation and Safety

Similar to commercial and private vessels, Navy vessels employ navigational acoustic devices including speed logs, Doppler sonars for ship positioning, and fathometers. These may be in use at any time for safe vessel operation. These sources are typically highly directional to obtain specific navigational data.

1.4.1.1.4 Communication

Sound sources used to transmit data (such as underwater modems), provide location (pingers), or send a single brief release signal to bottom-mounted devices (acoustic release) may be used throughout the Study Area. These sources typically have low duty cycles and are usually only used when it is desirable to send a detectable acoustic message.

1.4.1.1.5 Classification of Sonar and Other Transducers

Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. As detailed below, classes are further sorted into bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used. Unless stated otherwise, a reference distance of 1 meter (m) is used for sonar and other transducers:

- Frequency of the non-impulsive acoustic source
  - Low-frequency sources operate below 1 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
- Sound pressure level
  - Greater than 160 decibels (dB) referenced to 1 micropascal (dB re 1 µPa), but less than 180 dB re 1 µPa
  - Equal to 180 dB re 1 µPa and up to 200 dB re 1 µPa
  - Greater than 200 dB re 1 µPa
- Application in which the source would be used
  - Sources with similar functions that have similar characteristics, such as pulse length (duration of each pulse), beam pattern, and duty cycle

The bins used for classifying active sonars and transducers that are quantitatively analyzed in the Study Area are shown in Table 1.4-2. While general parameters or source characteristics are shown in the table, actual source parameters are classified.

Table 1.4-2: Sonar and Other Transducers Quantitatively Analyzed

Source Class Category	*Bin*	*Description*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF4	LF sources equal to 180 dB and up to 200 dB
	LF5	LF sources less than 180 dB
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-60)
	MF1K	Kingfisher mode associated with MF1 sonars
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Underwater sound signal devices (e.g., MK 84 SUS)
	MF9	Sources (equal to 180 dB and up to 200 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	HF3	Other hull-mounted submarine sonars (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF6	Sources (equal to 180 dB and up to 200 dB) not otherwise binned
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)
	ASW5	MF sonobuoys with high duty cycles
Torpedoes (TORP): 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)
	TORP3	Heavyweight torpedo (e.g., MK 48)
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns
Acoustic Modems (M): Sources used to transmit data	M3	MF acoustic modems (greater than 190 dB)
Synthetic Aperture Sonars (SAS): Sonars used to form high-resolution images of the seafloor	SAS2	HF SAS systems
	SAS4	MF to HF broadband mine countermeasure sonar

1.4.2 EXPLOSIVE STRESSORS

This section describes the characteristics of explosions during naval training and testing. The activities analyzed in this LOA request that use explosives are described in Appendix A (Training and Testing Activities Descriptions) of the MITT Draft SEIS/OEIS. Explanations of the terminology and metrics used when describing explosives are provided in Appendix H (Acoustic and Explosive Concepts) of the MITT Draft SEIS/OEIS.

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive in the warhead, the type of explosive material, the boundaries and characteristics of the propagation medium, and, in water, the detonation depth. The net explosive weight, which is the explosive power of a charge expressed as the equivalent weight of trinitrotoluene (TNT), accounts for the first two parameters. The effects of these factors are explained in Appendix H (Acoustic and Explosive Concepts) of the MITT Draft SEIS/OEIS.

1.4.2.1 Explosions in Water

Explosive detonations during training and testing activities are associated with high-explosive munitions, including, but not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations during training and testing involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Detonations would typically occur in waters greater than 200 ft. in depth, and greater than 3 NM from shore, with the exception of existing mine warfare areas, including Outer Apra Harbor, Piti, and Agat.

In order to better organize and facilitate the analysis of explosives used by the Navy during training and testing that could detonate in water or at the water surface, explosive classification bins were developed. The use of explosive classification bins provides the same benefits as described for acoustic source classification bins in Section 1.4.1 (Acoustic Stressors).

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the Study Area are shown in Table 1.4-3.

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency components of explosive broadband noise can propagate. Appendix H (Acoustic and Explosive Concepts) of the MITT Draft SEIS/OEIS explains the characteristics of explosive detonations and how the above factors affect the propagation of explosive energy in the water. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the Study Area.

Table 1.4-3: Explosive Sources Quantitatively Analyzed that Could Be Used Underwater or at the Water Surface in the Study Area

Bin	*Net Explosive Weight (lb.)*	*Example Explosive Source*	*Modeled Detonation Depths (ft.)*
E1	0.1–0.25	Medium-caliber projectiles	0.3, 60
E2	> 0.25–0.5	Anti-swimmer grenade	0.3
E3	> 0.5–2.5	57 mm projectile	0.3, 60
E4	> 2.5–5	Mine neutralization charge	33, 197
E5	> 5–10	5 in. projectiles	0.3, 10, 98
E6	> 10–20	Hellfire missile	0.3, 98
E8	> 60–100	250 lb. bomb; Lightweight torpedo	0.3, 150
E9	> 100–250	500 lb. bomb	0.3
E10	> 250–500	1,000 lb. bomb	0.3
E11	> 500–650	Heavyweight torpedo	150, 300
E12	> 650–1,000	2,000 lb. bomb	0.3

Notes: (1) Net Explosive Weight refers to the equivalent amount of TNT the actual weight of a munition may be larger due to other components; (2) in. = inch(es), lb. = pound(s), ft. = feet

1.5 Proposed Action

The Navy proposes to continue conducting training and testing activities within the Study Area. The Navy has conducted training and testing activities in the Study Area for decades. Most recently, these activities were analyzed in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015b). That document, its associated MMPA authorization (National Oceanic and Atmospheric Administration, 2015a), and associated Biological Opinion (National Marine Fisheries Service, 2015b) describe the training and testing activities currently conducted in the Study Area, which are similar to those proposed in this LOA request. The Study Area is the same as described in the 2015 MITT Final EIS/OEIS (Section 2.2, Primary Mission Areas) and current LOA.

1.5.1 Training and Testing Activities

The training and testing activities that the Navy proposes to conduct in the Study Area, and that may result in MMPA takes of marine mammals, are described in Table 1.5-1. The table is organized according to primary mission areas and includes the activity name, associated stressor(s), description of the activity, sound source bin, the areas where the activity is conducted, the number of events per year, and the number over seven years. Not all sound sources are used with each activity. Under the "Annual # of Events" column, events show either a single number or a range of numbers to indicate the maximum number of times that activity could occur during any single year. The "7-Year # of Events" is the maximum times an activity would occur over any 7-year period of Navy training and testing. More detailed activity descriptions can be found in the MITT Draft SEIS/OEIS.

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Major Training Event – Large Integrated Anti-Submarine Warfare Training (ASW)							
Acoustic	Joint Multi-Strike Group Exercise	Typically a 10-day Joint exercise, in which up to three carrier strike groups would conduct training exercises simultaneously.	10 days	ASW2, ASW3, ASW4, HF1, MF1, MF11, MF3, MF4, MF5, MF12, TORP1	Study Area; MIRC	1	4
Major Training Event – Medium Integrated ASW							
Acoustic	Joint Expeditionary Exercise	Typically a 10-day exercise that could include a Carrier Strike Group and Expeditionary Strike Group, Marine Expeditionary Units, Army Infantry Units, and Air Force aircraft together in a joint environment that includes planning and execution efforts as well as military training activities at sea, in the air, and ashore.	10 days	ASW2, ASW3, MF1, MF4, MF5, MF12	Study Area; Apra Harbor	1	7

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Medium Coordinated ASW							
Acoustic	Marine Air Ground Task Force Exercise (Amphibious) – Battalion	Typically a 10-day exercise that conducts over the horizon, ship to objective maneuver for the elements of the Expeditionary Strike Group and the Amphibious Marine Air Ground Task Force. The exercise utilizes all elements of the Marine Air Ground Task Force (Amphibious), conducting training activities ashore with logistic support of the Expeditionary Strike Group and conducting amphibious landings.	10 days	ASW3, MF1, MF4, MF12	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan; FDM	4	28
ASW							
Acoustic	Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter crews search for, detect, and track submarines	2–4 hours	MF4, MF5	Study Area > 3 NM from land; Transit Corridor	10	70
Acoustic	Torpedo Exercise – Helicopter (TORPEX – Helo)	Helicopter crews search for, detect, and track submarines. Recoverable air launched torpedoes are employed against submarine targets.	2–5 hours	MF4, MF5, TORP1	Study Area > 3 NM from land	4	28

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Acoustic	Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – Maritime Patrol Aircraft)	Maritime patrol aircraft crews search for, detect, and track submarines.	2–8 hours	MF5	Study Area > 3 NM from land	36	252
Acoustic	Torpedo Exercise – Maritime Patrol Aircraft (TORPEX – Maritime Patrol Aircraft)	Maritime patrol aircraft crews search for, detect, and track submarines. Recoverable air launched torpedoes are employed against submarine targets.	2–8 hours	MF5, TORP1	Study Area > 3 NM from land	4	28
Acoustic	Tracking Exercise –Surface (TRACKEX – Surface)	Surface ship crews search for, detect, and track submarines.	2–4 hours	ASW1, ASW3, MF1, MF11, MF12	Study Area > 3 NM from land	91	637
Acoustic	Torpedo Exercise – Surface (TORPEX – Surface)	Surface ship crews search for, detect, and track submarines. Exercise torpedoes are used during this event.	2–5 hours	ASW3, MF1, MF5, TORP1	Study Area > 3 NM from land	4	28
Acoustic	Tracking Exercise – Submarine (TRACKEX – Sub)	Submarine crews search for, detect, and track submarines.	8 hours	ASW4, HF1, HF3, MF3	Study Area > 3 NM from land; Transit Corridor	4	28

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Acoustic	Torpedo Exercise – Submarine (TORPEX – Sub)	Submarine crews search for, detect, and track submarines. Recoverable exercise torpedoes are used during this event.	8 hours	ASW4, HF1, MF3, TORP2	Study Area > 3 NM from land	6	42
Acoustic	Small Joint Coordinated ASW exercise (Multi-Sail/GUAMEX)	Typically, a 5-day exercise with multiple ships, aircraft and submarines integrating the use of their sensors, including sonobuoys, to search, detect, and track threat submarines.	5 days	ASW2, ASW3, ASW4, HF1, MF1, MF3, MF4, MF5, MF11, MF12	Study Area > 3 NM from land	2	14
Mine Warfare							
Acoustic	Civilian Port Defense	Maritime security personnel train to protect civilian ports and harbors against enemy efforts to interfere with access to those ports.	Multiple days	HF4, SAS2	MIRC, Mariana littorals, Inner and Outer Apra Harbor	1	7
Explosive	Mine Neutralization – Remotely Operated Vehicle Sonar (ASQ-235 [AQS-20], SLQ-48)	Ship, small boat, and helicopter crews locate and disable mines using remotely operated underwater vehicles	1–4 hours	E4	Study Area, Mariana littorals, and Outer Apra Harbor	4	28

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Acoustic	Mine Countermeasure Exercise – Surface Ship Sonar (SQQ-32, MCM)	Ship crews detect, locate, identify, and avoid mines while navigating restricted areas or channels, such as while entering or leaving port.	1–4 hours	HF4	Study Area, Apra Harbor	4	28
Acoustic	Mine Countermeasure Exercise – Towed Sonar (AQS-20)	Surface ship crews detect and avoid mines while navigating restricted areas or channels using towed active sonar systems.	1–4 hours	HF4	Study Area, Apra Harbor	4	28
Explosive	Mine Neutralization – Explosive Ordnance Disposal	Personnel disable threat mines using explosive charges.	Up to 4 hours	E5, E6	Agat Bay site, Piti, and Outer Apra Harbor	20	140
Acoustic	Submarine Mine Exercise	Submarine crews practice detecting mines in a designated area.	Varies	HF1	Study Area, Mariana Littorals, Inner/Outer Apra Harbor	1	7
Explosive	Underwater Demolition Qualification/ Certification	Navy divers conduct various levels of training and certification in placing underwater demolition charges.	Varies	E5, E6	Agat Bay site, Piti, and Outer Apra Harbor	45	315

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Surface Warfare (SW)							
Explosive	Bombing Exercise (Air-to-Surface)	Fixed-wing aircrews deliver bombs against stationary surface targets.	1 hour	E9, E10, E12	Study Area, Special Use Airspace	37	259
Explosive	Gunnery Exercise (GUNEX) (Air-to-Surface) – Medium-caliber	Fixed-wing and helicopter aircrews fire medium-caliber guns at surface targets.	1 hour	E1, E2	Study Area > 12 NM from land, Special Use Airspace	120	840
Explosive	GUNEX (Surface-to-Surface) Boat – Medium-caliber	Small boat crews fire medium-caliber guns at surface targets.	1 hour	E2	Study Area > 12 NM from land, Special Use Airspace	20	140
Explosive	GUNEX (Surface-to-Surface) Ship – Large-caliber	Surface ship crews fire large-caliber guns at surface targets.	Up to 3 hours	E5	Study Area > 12 NM from land, Special Use Airspace	170	1,176
Explosive	GUNEX (Surface-to-Surface) Ship – Small- and Medium-caliber	Surface ship crews fire medium and small-caliber guns at surface targets.	2–3 hours	E1	Study Area > 12 NM from land, Special Use Airspace	162	1,085

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Explosive	Maritime Security Operations	Helicopter, surface ship, and small boat crews conduct a suite of maritime security operations at sea, to include visit, board, search and seizure, maritime interdiction operations, force protection, and anti-piracy operations.	Up to 3 hours	E2	Study Area; MIRC	40	280
Explosive	Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing and helicopter aircrews fire air-to-surface missiles at surface targets.	2 hours	E6, E8, E10	Study Area > 12 NM from land, Special Use Airspace	10	70
Explosive	Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S] – Rocket)	Helicopter aircrews fire both precision-guided and unguided rockets at surface targets.	1 hour	E3	Study Area > 12 NM from land, Special Use Airspace	110	770
Explosive	Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against surface threats (ships or small boats) and engage them with missiles.	2–5 hours	E6, E10	Study Area > 50 NM from land, Special Use Airspace	19	133

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Explosive	Sinking Exercise	Aircraft, ship, and submarine crews deliberately sink a seaborne target, usually a decommissioned ship made environmentally safe for sinking according to U.S. Environmental Protection Agency standards, with a variety of ordnance.	4–8 hours, possibly over 1–2 days	E5, E8, E10, E11, E12, TORP2	Study Area > 50 NM from land and > 1,000 fathoms depth	1	4
Other Training Exercises							
Acoustic	Submarine Navigation	Submarine crews operate sonar for navigation and detection while transiting into and out of port during reduced visibility.	Up to 2 hours	HF1, MF3	Study Area, Apra Harbor, and Mariana littorals	8	56
Acoustic	Submarine Sonar Maintenance	Maintenance of submarine sonar and other system checks are conducted pierside or at sea.	Up to 1 hour	MF3	Study Area; Apra Harbor and Mariana littorals	86	602
Acoustic	Surface Ship Sonar Maintenance	Maintenance of surface ship sonar and other system checks are conducted pierside or at sea.	Up to 4 hours	MF1	Study Area; Apra Harbor and Mariana littorals	44	308

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Acoustic	Unmanned Underwater Vehicle Training	Units conduct training with unmanned underwater vehicles from a variety of platforms, including surface ships, small boats, and submarines.	Up to 24 hours	FLS2, M3, SAS2, SAS4	MIRC; Apra Harbor and Mariana littorals	64	448
Testing Activities							
ASW							
Acoustic; Explosive	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	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.	8 hours	ASW2, ASW5, E1, E3, MF5, MF6	Study Area > 3 NM from land	26	182
Acoustic	Anti-Submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. Test evaluates anti-submarine warfare systems onboard rotary-wing and fixed-wing aircraft and the ability to search for, detect, classify, localize, track, and attack a submarine or similar target.	2–6 flight hours	MF5, TORP1	Study Area > 3 NM from land	20	140

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Acoustic	Anti-Submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters and unmanned aerial systems) detect, localize, and prosecute submarines.	1–2 weeks, with 4–8 hours of active sonar use with intervals of non-activity in between.	ASW1, ASW2, ASW3, ASW5, MF12, MF4, MF5, TORP1	Mariana Island Range Complex	100	700
Acoustic	At-Sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment	From 4 hours to 11 days	HF1, HF6, M3, MF3, MF9	Study Area	3	21
Acoustic; Explosive	Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive and non-explosive torpedoes against artificial targets.	1–2 days during daylight hours	ASW3, HF1, HF6, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2, E8, E11	Mariana Island Range Complex	2	8
Acoustic	Torpedo (Non-explosive) Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels.	Up to 2 weeks	ASW3, ASW4, HF1, HF6, LF4, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2, TORP3	Mariana Island Range Complex	6	42

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Mine Warfare							
Acoustic; Explosive	Mine Countermeasure and Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines and mine-like objects.	1–10 days, with intermittent use of countermeasure/neutralization systems during this period	HF4, E4	MIRC; nearshore and littorals	3	21
SW							
Explosive	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.	2–4 flight-hours	E10	Study Area > 50 NM from land, Special Use Airspace	4	28

Table 1.5-1: Proposed Training and Testing Events that May Result in MMPA Takes of Marine Mammals within the MITT Study Area (continued)

Stressor Category	Activity	Description	Typical Duration of Event	Source Bin[1]	Location	Annual # of Events	7-Year # of Events
Vessel Evaluation							
Acoustic	Undersea Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance, weapons engagement, and communications systems. This tests ships' ability to detect, track, and engage undersea targets.	Up to 10 days	HF4, MF1, MF4, MF5, TORP1	MIRC	1	7

[1]Additional activities utilizing sources not listed in the Major Training Event and coordinated exercise bins above may occur during these exercises. All acoustic sources which may be used during training and testing activities have been accounted for in the modeling and analysis presented in this application and in the MITT Draft SEIS/OEIS.

1.5.2 SUMMARY OF ACOUSTIC AND EXPLOSIVE SOURCES ANALYZED FOR TRAINING AND TESTING

Source bins and numbers associated with Navy training and testing in the Study Area that were analyzed in this LOA request are provided in Table 1.5-2 for the acoustic source classes and hours and in Table 1.5-3 for explosive source classes and counts.

Table 1.5-2: Acoustic Source Class Bins Analyzed and Numbers Used during Training and Testing Activities

Source Class Category	*Bin*	*Description*	*Unit*	*Annual*	*7-year Total*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF4	LF sources equal to 180 dB and up to 200 dB	H	1	7
	LF5	LF sources less than 180 dB	H	10	65
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-60)	H	1,729	8,428
	MF1K	Kingfisher mode associated with MF1 sonars	H	3	21
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	189	1,061
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	172	1,089
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	2,024	10,683
	MF6	Active underwater sound signal devices (e.g., MK 84 SUS)	C	62	410
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	15	101
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	292	1,396
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	608	3,184
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	63	349
	HF3	Other hull-mounted submarine sonars (classified)	H	4	28
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	1,472	10,304
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	163	1,113
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB	H	192	1,344
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	C	538	3,556
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	3,024	14,683
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	268	1,516
	ASW5	MF sonobuoys with high duty cycles	H	50	350

Table 1.5-2: Acoustic Source Class Bins Analyzed and Numbers Used during Training and Testing Activities (continued)

Source Class Category	*Bin*	*Description*	*Unit*	*Annual*	*7-year Total*
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)	C	62	422
	TORP2	Heavyweight torpedo (e.g., MK 48)	C	40	268
	TORP3	Heavyweight torpedo test (e.g., MK 48)	C	6	42
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	4	28
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	17	115
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	HF SAS systems	H	449	3,140
	SAS4	MF to HF broadband mine countermeasure sonar	H	6	42

Notes: H= hours; C = count

Table 1.5-3: Explosive Source Class Bins Analyzed and Numbers Used during Training and Testing Activities

Bin	*Net Explosive Weight (lb.)*	*Example Explosive Source*	*Modeled Detonation Depths (ft.)*	*Annual*	*7-year Total*
E1	0.1–0.25	Medium-caliber projectiles	0.3, 60	512	3,584
E2	> 0.25–0.5	Anti-swimmer grenade	0.3	400	2,800
E3	> 0.5–2.5	57 mm projectile	0.3, 60	683	4,591
E4	> 2.5–5	Mine neutralization charge	33, 197	44	308
E5	> 5–10	5 in. projectiles	0.3, 10, 98	965	6,755
E6	> 10–20	15 lb. shaped charge	0.3, 98	29	203
E8	> 60–100	250 lb. bomb; Light weight torpedo	0.3, 150	134	932
E9	> 100–250	500 lb. bomb	0.3	110	770
E10	> 250–500	1,000 lb. bomb	0.3	69	483
E11	> 500–650	Heavy weight torpedo	150,300	3	15
E12	> 650–1,000	2,000 lb. bomb	0.3	48	336

Notes: (1) net explosive weight refers to the equivalent amount of TNT. The actual weight of a munition may be larger due to other components. (2) in. = inch(es), lb. = pound(s), ft. = feet

1.5.3 Vessel Movements

Navy policy (Chief of Naval Operations Instruction F3100.6J) is to report all whale strikes by Navy vessels. That information has been provided to NMFS on an annual basis. Vessel strike records from the Navy have been kept since 1995, and there have been no known Navy vessel strikes to marine mammals in the Study Area during training or testing activities.

Based on the absence of any Navy vessel strikes during training and testing in the Study Area and the general reduction in strike incidents Navy-wide since introduction of the Marine Species Awareness Training in 2006, and the future reduction in vessel use in comparison to the ongoing actions (see the MITT Draft SEIS/OEIS Section 3.4.2.4, Physical Disturbance and Strike Stressors), the Navy does not anticipate vessel strikes to marine mammals within the Study Area during training and testing activities.

1.5.4 Standard Operating Procedures

For training and testing to be effective, units must be able to safely use their sensors and weapon systems as they are intended to be used in military missions and combat operations and to their optimum capabilities. While standard operating procedures are designed for the safety of personnel and equipment and to ensure the success of training and testing activities, their implementation often yields benefits on environmental, socioeconomic, public health and safety, and cultural resources.

Navy standard operating procedures have been developed and refined over years of experience and are broadcast via numerous naval instructions and manuals, including, but not limited to the following materials:

- Ship, submarine, and aircraft safety manuals
- Ship, submarine, and aircraft standard operating manuals
- Fleet Area Control and Surveillance Facility range operating instructions
- Fleet exercise publications and instructions
- Naval Sea Systems Command test range safety and standard operating instructions
- Navy instrumented range operating procedures
- Naval shipyard sea trial agendas
- Research, development, test, and evaluation plans
- Naval gunfire safety instructions
- Navy planned maintenance system instructions and requirements
- Federal Aviation Administration regulations
- International Regulations for Preventing Collisions at Sea

Because standard operating procedures are essential to safety and mission success, the Navy considers them to be part of the proposed activities under the Proposed Action and has included them in the environmental analysis. Standard operating procedures that are recognized as having a benefit to marine mammals during training and testing activities are noted below:

- Vessel Safety
- Weapons Firing Procedures
- Target Deployment and Retrieval Safety
- Towed In-Water Device Procedures

Standard operating procedures differ from mitigation measures because mitigation is designed specifically for the purpose of avoiding or reducing environmental impacts, whereas standard operating procedures are designed to provide for safety and mission success. Information on mitigation measures is provided in Chapter 11 (Mitigation Measures) of this LOA request and is summarized below. Additional information on standard operating procedures is presented in Section 2.3.3 (Standard Operating Procedures) in the MITT Draft SEIS/OEIS.

1.5.5 Mitigation Measures

The Navy implements mitigation to avoid or reduce potential impacts from the Proposed Action on marine mammals during activities involving anti-submarine warfare, mine warfare, surface warfare, and other warfare mission areas. Mitigation measures for marine mammals are designed to effect the least practicable adverse impact on marine mammal species or stocks and their habitat, and have a negligible impact on marine mammal species and stocks (as required under the MMPA), and to ensure that the Proposed Action does not jeopardize the continued existence of endangered or threatened species (as required under the ESA). The Navy will implement mitigation for the training and testing activity categories, stressors, and geographic locations listed in Table 1.5-4 as part of the Proposed Action. See Chapter 11 (Mitigation Measures) for a complete presentation of the procedural mitigation and mitigation areas that will be implemented under the Proposed Action.

Table 1.5-4: Mitigation Categories

Chapter 11 (Mitigation Measures) Section	Applicable Stressor, Activity, or Location
Section 11.1 (Procedural Mitigation)	Environmental Awareness and Education
Section 11.1.1 (Acoustic Stressors)	Low-Frequency Active Sonar Mid-Frequency Active Sonar High-Frequency Active Sonar Weapons Firing Noise
Section 11.1.2 (Explosive Stressors)	Explosive Sonobuoys Explosive Torpedoes Explosive Medium- and Large-Caliber Projectiles Explosive Missiles and Rockets Explosive Bombs Sinking Exercises Explosive Mine Countermeasure and Neutralization Activities Explosive Mine Neutralization Activities Involving Navy Divers Maritime Security Operations – Anti-Swimmer Grenades
Section 11.1.3 (Physical Disturbance and Strike Stressors)	Vessel Movement Towed In-Water Devices Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions Non-Explosive Missiles and Rockets Non-Explosive Bombs and Mine Shapes
Section 11.2 (Mitigation Areas)	Geographic Mitigation Areas for Marine Mammals and Sea Turtles

2 Dates, Duration, and Specified Geographic Region

This request is for those training and testing activities that would be conducted in the MITT Study Area throughout the year from the end of 2020 through the end of 2027. The number of annual and 7-year occurrences of the different training and testing events can be found in the last columns of Tables 1.5-1–1.5-3. Also indicated is the location where the activity will occur within the Study Area. The Study Area is comprised of three components: (1) the MIRC, (2) additional areas on the high seas, and (3) a transit corridor between the MIRC and the HRC as depicted in Figure 1.1-1. The transit corridor is outside the geographic boundaries of the MIRC and represents a great-circle route across the high seas for Navy ships transiting between the MIRC and the HRC. The Proposed Action also includes various activities in Apra Harbor such as sonar maintenance and testing alongside Navy piers located in Inner Apra Harbor. Within the Study Area, a range complex is a designated set of specifically bounded geographic areas that encompasses a water component (above and below the surface), airspace, and may encompass a land component (such as at FDM) where training and testing activities also occur. The MIRC includes established operating areas (OPAREAs) and special use airspace, which may be further divided to provide safety and better control of the area and activities being conducted.

- **Airspace**
  - **Special Use Airspace**: Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8). Types of special use airspace common to 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, and some are shared with non-military agencies.
    - **Warning Areas**: Areas of defined dimensions, extending from 3 NM outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.
- **Sea and Undersea Space**
  - **Surface Danger Zones**: A danger zone is a defined water area used for hazardous military activities such as target practice, bombing, or rocket firing. They are established pursuant to statutory authority of the Secretary of the Army, administered by the Army Corps of Engineers, and may be closed to the public on a full-time or intermittent basis (33 CFR part 334).
  - **Restricted Areas**: A restricted area is a defined water area that prohibits or limits public access to the area. They generally provide security for Government property or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 CFR part 334).

2.1 Mariana Islands Training and Testing Range Complex

The MIRC includes the waters south of Guam to north of Pagan (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 1.1-1).

2.1.1 SPECIAL USE AIRSPACE

The MIRC includes approximately 40,000 NM^2 of special use airspace. This airspace is almost entirely over the ocean (except W13A) and includes warning areas, and restricted areas (R) (see the MITT Draft SEIS/OEIS, Figure 2.1-2 and Figure 2.1-3, for details).

Warning Areas (W)-517 and W-12 include approximately 11,800 NM^2 of special use airspace; W-11 (A/B) is approximately 10,500 NM^2 of special use airspace, and W-13 (A/B/C) is approximately 18,000 NM^2 of special use airspace.

The restricted area airspace over or near land areas within the MIRC includes approximately 2,463 NM^2 of special use airspace and restricted areas (R) 7201 and R7201A, which extends in a 12 NM radius around FDM.

2.1.2 SEA AND UNDERSEA SPACE

The MIRC includes the sea and undersea space from the ocean surface to the ocean floor. The MIRC also consists of designated sea and undersea space training areas, which include designated drop zones; underwater demolition and floating mine exclusion zones; danger zones associated with live-fire ranges; and training areas associated with military controlled beaches, harbors, and littoral areas.

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

In addition to the MIRC, the MITT Study Area includes the area to the north of the MIRC that is within the U.S. Exclusive Economic Zone of the CNMI and the areas to the west of the MIRC. The Study Area also includes a transit corridor, which is a great-circle route (i.e., the shortest distance) between the MIRC and the HRC. Although not part of any defined range complex, the transit corridor is important to the Navy in that it provides available air, sea, and undersea space where vessels and aircraft conduct training and testing while in transit. While in transit and along the corridor, vessels and aircraft would, at times, conduct basic and routine unit-level activities such as gunnery and sonar training as long as the training does not interfere with the primary objective of reaching their intended destination. Ships also conduct sonar maintenance, which includes active sonar transmissions.

2.2 PIERSIDE LOCATIONS

The Study Area includes pierside locations in the Apra Harbor Naval Complex where surface ship and submarine sonar maintenance and testing occur. Activities in Apra Harbor include channels and routes to and from the Navy port in the Apra Harbor Naval Complex, and associated wharves and facilities within the Navy port.

3 Species and Numbers of Marine Mammals

3.1 Species Known to Occur in the Study Area

Twenty-six cetacean marine mammal species are known to exist in the Study Area, including seven mysticetes (baleen whales) and 19 odontocetes (dolphins and toothed whales). The species expected to be present in the Study Area are provided in Table 3.1-1 and listed alphabetically within the two suborder groupings.

Table 3.1-1: Marine Mammals Occurrence within the MITT Study Area

Common Name	Scientific Name	Status		Occurrence*	
		MMPA	ESA	Mariana Islands	Transit Corridor
Mysticetes					
Blue whale	*Balaenoptera musculus*	D	E	Seasonal	Seasonal
Bryde's whale	*Balaenoptera edeni*	-	n/a	Regular	Regular
Fin whale	*Balaenoptera physalus*	D	E	Rare	Rare
Humpback whale	*Megaptera novaeangliae*	-[1]	E	Seasonal	Seasonal
Minke whale	*Balaenoptera acutorostrata*	-	n/a	Seasonal	Seasonal
Omura's whale	*Balaenoptera omurai*	-	n/a	Rare	Rare
Sei whale	*Balaenoptera borealis*	D	E	Seasonal	Seasonal
Odontocetes					
Blainville's beaked whale	*Mesoplodon densirostris*	-	n/a	Regular	Regular
Common bottlenose dolphin	*Tursiops truncatus*	-	n/a	Regular	Regular
Cuvier's beaked whale	*Ziphius cavirostris*	-	n/a	Regular	Regular
Dwarf sperm whale	*Kogia sima*	-	n/a	Regular	Regular
False killer whale	*Pseudorca crassidens*	-	n/a	Regular	Regular
Fraser's dolphin	*Lagenodelphis hosei*	-	n/a	Regular	Regular
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	-	n/a	Regular	Regular
Killer whale	*Orcinus orca*	-	n/a	Regular	Regular
Longman's beaked whale	*Indopacetus pacificus*	-	n/a	Regular	Regular
Melon-headed whale	*Peponocephala electra*	-	n/a	Regular	Regular
Pantropical spotted dolphin	*Stenella attenuata*	-	n/a	Regular	Regular
Pygmy killer whale	*Feresa attenuata*	-	n/a	Regular	Regular
Pygmy sperm whale	*Kogia breviceps*	-	n/a	Regular	Regular
Risso's dolphin	*Grampus griseus*	-	n/a	Regular	Regular
Rough-toothed dolphin	*Steno bredanensis*	-	n/a	Regular	Regular
Short-finned pilot whale	*Globicephala macrorhynchus*	-	n/a	Regular	Regular
Sperm whale	*Physeter macrocephalus*	D	E	Regular	Regular
Spinner dolphin	*Stenella longirostris*	-	n/a	Regular	Regular
Striped dolphin	*Stenella coeruleoalba*	-	n/a	Regular	Regular

[1] Humpback whales in the Mariana Islands have not been assigned a stock by the National Marine Fisheries Service in the Alaska or Pacific Stock Assessment Reports given they are not yet recognized in those reports as being present in U.S. territorial waters (Carretta et al., 2017c; Carretta et al., 2018; Muto et al., 2017b; Muto et al., 2018), but because individuals from the Western North Pacific Distinct Population Segment have been photographically identified in the MITT Study Area, the Navy assumes the humpback whales in the Mariana Islands are part of the Western North Pacific Stock.
Note: Status MMPA, D = depleted; ESA, E = endangered

The information presented in this LOA request incorporates data from the U.S. Pacific and the Alaska Marine Mammal Stock Assessments (Carretta et al., 2017c; Muto et al., 2017b), which cover some of those species present in the Study Area and incorporate the best available science, including monitoring data from Navy marine mammal research efforts. For those few species for which stock information exists for the Study Area, relevant data are included in the species-specific status and management summaries provided in Chapter 4 (Affected Species Status and Distribution).

3.2 Species Unlikely to Occur in the Study Area

Consistent with the analysis provided in the 2015 MITT Final EIS/OEIS and associated LOA, the species carried forward for analysis in this LOA request are those likely to be found in the Study Area based on the most recent sighting, survey, and habitat modeling data available. The analysis does not include species that may have once inhabited or transited the area, but have not been sighted in recent years (e.g., species that no longer occur in an area due to factors such as 19th-century commercial exploitation). These species include the North Pacific right whale (*Eubalaena japonica*), the western subpopulation of gray whale (*Eschrichtius robustus*), short-beaked common dolphin (*Delphinus delphis*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), northern elephant seal (*Mirounga angustirostris*), and dugong (*Dugong dugon*). Details regarding the reasons for these exclusions are explained in detail in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015b) and the MITT Draft SEIS/OEIS.

4 Affected Species Status and Distribution

The marine mammal species discussed in this section are those for which general regulations governing potential incidental takes of small numbers 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 MITT Draft SEIS/OEIS (U.S. Department of the Navy, 2018b). In addition, NMFS annually publishes stock assessment reports for all marine mammals in U.S. Exclusive Economic Zone waters, but for most marine mammal populations in the Study Area there have been no specific stocks assigned to those populations.

4.1 Mysticetes

4.1.1 Blue Whale (*Balaenoptera musculus*)

4.1.1.1 Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA throughout its range, but there is no designated critical habitat for this species. Although the designated Central North Pacific Stock of blue whales are present in winter in "lower latitudes in the western and central Pacific, including Hawaii," blue whales in the Study Area have not been assigned to a stock in either the Alaska or Pacific Stock Assessment Reports (SARs) (Carretta et al., 2017b; Muto et al., 2017a).

4.1.1.2 Geographic Range and Distribution

Blue whales inhabit all oceans and typically occur in both nearshore and deep oceanic waters. Blue whales belonging to the Central Pacific Stock feed in summer in the Pacific south of the Aleutian Islands and in the Gulf of Alaska, and then migrate to lower latitudes in the winter. There are no recent sighting records for blue whales in the Study Area (Fulling et al., 2011; Hill et al., 2017a; Uyeyama, 2014). Although rare, acoustic detections from passive monitoring devices deployed at Saipan and Tinian have recorded the presence of blue whales over short periods of time (a few days) (Oleson et al., 2015). However, since blue whale calls can travel up to 621 miles (mi.) (1,000 kilometers [km]), it is unknown whether the animals were actually within the Study Area. Blue whales would be most likely to occur in the Study Area during the winter and would be expected to be few in number.

4.1.1.3 Population and Abundance

Widespread whaling over the last century was believed to have decreased the global blue whale population to approximately 1 percent of its pre-whaling population size (Branch, 2007; Monnahan, 2013; Monnahan et al., 2014; Rocha et al., 2014; Širović et al., 2004). The most current information suggests that following the cessation of commercial whaling in 1971, the population in the North Pacific may have recovered and since the 1990s has been at a stable level despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Pacific Ocean (Campbell et al., 2015; Carretta et al., 2017b; Monnahan, 2013; Monnahan et al., 2014; Rockwood et al., 2017; Širović et al., 2015).

4.1.2 BRYDE'S WHALE (*BALAENOPTERA EDENI*)

4.1.2.1 Status and Management

The Bryde's whale is not listed under the ESA. There is currently no biological basis for defining separate stocks of Bryde's whales in the western Pacific (in the Mariana Islands) or central North Pacific (such as the waters around Hawaii) (Carretta et al., 2017b). NMFS recognizes two stocks of Bryde's whales in the Pacific with one for Hawaiian waters and the other for the Gulf of California and waters off California (Carretta et al., 2017b); none of the ranges described for these stocks include the Study Area.

4.1.2.2 Geographic Range and Distribution

Data suggest that winter and summer grounds partially overlap in the central North Pacific (Murase et al., 2015). Bryde's whales are distributed in the central North Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central North Pacific is about 20 degrees North (N) (Kishiro, 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer, but are not likely to move poleward of 40° N (Jefferson et al., 2015; Kishiro, 1996). Bryde's whale are expected to be present in the Study Area based on sighting records (Fulling et al., 2011; Hill et al., 2017a; Mobley, 2007; Oleson & Hill, 2010a; Uyeyama, 2014). Bryde's whales were detected in the Transit Corridor between the Study Area and Hawaii during a NMFS survey in January 2010 (Oleson & Hill, 2010a). Bryde's whales were also encountered off Rota during a small boat non-systematic survey in August–September 2015 (Hill et al., 2017a).

4.1.2.3 Population and Abundance

There are an estimated 233 (Coefficient of Variation [CV] = 0.45) Bryde's whales present in the portion of the Study Area[2] covered by the Mariana Islands Sea Turtle and Cetacean Survey research (Fulling et al., 2011), which is the best available science.

4.1.3 FIN WHALE (*BALAENOPTERA PHYSALUS*)

4.1.3.1 Status and Management

The fin whale is listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure of fin whales remains uncertain (Mizroch et al., 2009), and fin whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017b; Muto et al., 2017a). NMFS recognizes three stocks of fin whales in the North Pacific (Carretta et al., 2017b; Muto et al., 2017a), and none of the ranges described for these stocks include the Study Area.

4.1.3.2 Geographic Range and Distribution

Fin whales prefer temperate and polar waters; they are rarely seen in warm, tropical waters and are not expected south of 20°N latitude (Miyashita et al., 1996; Reeves et al., 2002). There are no sighting records for fin whales in the Study Area (Fulling et al., 2011; Hill et al., 2017a; Oleson et al., 2015; Uyeyama, 2014). Based on acoustic detections, fin whales are expected to be seasonally present in the Study Area although few in number. Acoustic detections from passive monitoring devices

[2] The Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) covered an area of approximately 301,300 km^2 (Fulling et al., 2011) within the larger MITT Study Area, which encompasses approximately 1,300,000 km^2 (see Chapter 2 for more details with regard to the MITT Study Area). The MISTCS abundance estimates reported by Fulling et al. thus represent the number of marine mammals predicted to be in approximately 24 percent of the MITT Study Area.

deployed at Saipan and Tinian have recorded the presence of fin whales over short (a few days) periods of time (Oleson et al., 2015), and fin whale vocalizations were detected in January 2010 in the Transit Corridor between Hawaii and Guam (Oleson & Hill, 2010a). Fin whales were not, however, detected in the Transit Corridor using the same equipment and methods in May 2010 (Oleson & Hill, 2010a).

4.1.3.3 Population and Abundance

There is no current abundance estimate available for fin whales in the Study Area (Carretta et al., 2017b; Muto et al., 2017a). There were approximately 50,000 reported fin whales killed during commercial whaling in the North Pacific from 1911 to 1985 (C. Allison, pers. comm. as provided in Mizroch et al. (2009), and it is assumed the population is still recovering.

4.1.4 HUMPBACK WHALE (*MEGAPTERA NOVAEANGLIAE*)

4.1.4.1 Status and Management

The humpback whales in the Study Area are indirectly addressed in the Alaska SAR, given that the historic range of humpbacks in the “Asia wintering area” includes the Mariana Islands. The observed presence of humpbacks in the Mariana Islands (Hill et al., 2016a; Hill et al., 2017a; Hill et al., 2018; Klinck et al., 2016a; Munger et al., 2014; National Marine Fisheries Service, 2018; Oleson et al., 2015; Uyeyama, 2014) are consistent with the Study Area as a plausible migratory destination for humpback whales from Alaska (Muto et al., 2017a).

Effective as of October 11, 2016, NMFS changed the status of all humpback whales from an endangered species to a specific status for each of 14 newly identified distinct population segments (DPSs) (81 Federal Register [FR] 62259). It is likely that humpback whales in the Mariana Islands are part of the endangered Western North Pacific DPS[3], based on the best available science (Bettridge et al., 2015; Calambokidis et al., 2008; Calambokidis et al., 2010; Carretta et al., 2017b; Hill et al., 2017b; Muto et al., 2017a; National Marine Fisheries Service, 2016a; National Oceanic and Atmospheric Administration, 2015b; Wade et al., 2016). Humpback whales from the winter range of the Western North Pacific DPS (including the Study Area) that feed in the summer off Russia and Alaska have been designated by NMFS as the Western North Pacific Stock (Muto et al., 2017a). As part of the Western North Pacific Stock, the population is considered depleted under the MMPA (Muto et al., 2017a). Critical habitat has not been designated for the Western North Pacific DPS.

4.1.4.2 Geographic Range and Distribution

Between 1948 and 1979, Soviet Union commercial whaling alone took 7,344 humpback whales from the North Pacific (Ilyashenko & Chapham, 2014). It is therefore likely that humpback whales in the western North Pacific are still recovering and will remain rare in parts of their former range. Researchers have reported that it is not clear whether humpback whales use the Mariana Islands as a winter breeding and

[3] There is reference to a “Second West Pacific DPS” in the latest NMFS humpback whale status report (Bettridge et al., 2015), although that terminology did not carry over into the rule establishing the 14 DPSs. Although the humpback whales in the Study Area may exactly fit the parameters of the intended “Second West Pacific DPS,” the Navy will assume humpback whales in the Study Area are part of the Western North Pacific DPS consistent with the determinations presented in 81 FR 62259 and the range for the Western North Pacific stock as presented in the Alaska Stock Assessment Report (Muto et al., 2017a).

calving area or as a corridor from one or more wintering areas when moving to summertime feeding area locations, which are also unknown (Hill et al., 2016a).

The Western North Pacific DPS designation is based on a known breeding group of individuals found off Okinawa and Ogasawara Islands (approximately 1,230 NM north of Guam) in Japan waters and in Philippine waters (approximately 1,350 NM west of Guam), as identified by photographic identification of individuals (Calambokidis et al., 2008; Calambokidis et al., 2010), in addition to an "unknown breeding group" from a location in the Western North Pacific that remains unidentified. Together humpback whales found off Okinawa, Ogasawara, the Philippines, and the unknown area were combined to form the Western North Pacific population (Bettridge et al., 2015). This corresponds to the historical range for the Western North Pacific that included an area extending from the South China Sea east through the Philippines, the Ryukyu Islands, Mariana Islands, and Marshall Islands and waters north to the arctic (Muto et al., 2017a; Rice, 1998). Navy aerial monitoring surveys occurring at FDM have documented the occasional presence of humpback whales, including mother-calf pairs and other adult individuals (Uyeyama, 2014). Small boat non-systematic surveys conducted in 2015 through 2017 as part of a series of Navy-funded monitoring surveys have recorded multiple mother-calf pairs, escort behavior, and competitive groups that are indicative of breeding and calving (Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018). A total of 35 individuals have been documented in the photo-identification catalog (Hill et al., 2018). Genetic and photographic data collected during these surveys have previously provided matches to individuals identified many years previously off the Ogasawara Islands (Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018). Based on a compendium of all opportunistic sightings through 2014, humpback whales have been sighted in the Study Area in the months of January through March (Uyeyama, 2014), male humpback songs have been recorded from December through April, and humpback whale sounds were infrequently detected at Tinian during June to October (Hill et al., 2017a; Klinck et al., 2016a; Munger et al., 2014; Oleson et al., 2015). Humpback whales were not, however, observed or acoustically detected in the Transit Corridor during a May 2010 survey, which is not unexpected given the time of year for that survey (Oleson & Hill, 2010a).

Humpback whales from the Western North Pacific, Hawaii, and Mexico DPSs overlap to some extent on feeding grounds off Alaska (Bettridge et al., 2015; Muto et al., 2017a; National Marine Fisheries Service, 2016b; Titova et al., 2017; Wade et al., 2016). Photographic identification data have also documented the presence of at least one whale seen multiple years off Ogasawara (Japan) later seen feeding off British Columbia (Darling et al., 1996), indicating there may be greater overlap of DPSs in the summer feeding areas than has been characterized in the SARs for Alaska and the Pacific (Carretta et al., 2017b; Muto et al., 2017a). Comparison of photographic identification data from Russian waters has found 35 individual whales that were also documented in Hawaii and 11 that were from the Mexican breeding grounds (Titova et al., 2017).

4.1.4.3 Population and Abundance

Based on photographic identifications off Okinawa and Ogasawara gathered previously and conclusions reached in 2008 (Calambokidis et al., 2008), the abundance of humpback whales in the Western North Pacific population was estimated to be approximately 1,000 individuals (Bettridge et al., 2015; Muto et al., 2017a). From that same data set, the growth rate of the Western North Pacific DPS was estimated to be 6.9 percent (Bettridge et al., 2015; Calambokidis et al., 2008). This can be viewed in context of the North Pacific population, which has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Bettridge et al., 2015; Muto et al., 2017a; Wade et al., 2016).The inclusion of more recent data from photographic identifications off Okinawa has documented the presence of at least 1,402 unique individuals in the Western North Pacific DPS (Kobayashi et al., 2016). Additional information from Navy-funded surveys and passive acoustic hydrophone recordings in the Mariana Islands has confirmed the presence of mother-calf pairs, non-calf whales, and singing males in the Study Area (Fulling et al., 2011; Hill et al., 2016a; Hill et al., 2018; Munger et al., 2014; Munger et al., 2015; Norris et al., 2012; Oleson & Hill, 2010a; Oleson et al., 2015; U.S. Department of the Navy, 2007; Uyeyama et al., 2012). The NMFS Alaska SAR provides a population estimate for humpbacks in Ogasawara Islands, Okinawa, and the Philippines of 1,107 animals, with a minimum population of 865, noting that these are likely to be an underestimate of the Western North Pacific Stock's true abundance (Muto et al., 2017a; Muto et al., 2018). Although not specific to the Study Area, the overall abundance of humpback whales in the North Pacific was recently estimated at 21,808 individuals (Carretta et al., 2017b), 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; Bettridge et al., 2015; Muto et al., 2017a; Muto et al., 2018; Wade et al., 2016).

4.1.5 MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*)

4.1.5.1 Status and Management

The minke whale is not listed as endangered under the ESA. The stock structure for minke whales remains uncertain in the Pacific, and minke whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017b; Muto et al., 2017a). NMFS recognizes three stocks of minke whales in the North Pacific: (1) the Hawaii Stock, (2) the California/Oregon/Washington Stock, and (3) the Alaska Stock (Carretta et al., 2017b; Muto et al., 2017a).

4.1.5.2 Geographic Range and Distribution

Surveys employing towed hydrophone arrays and sonobuoys, and long-term monitoring efforts using fixed passive acoustic recording devices have routinely detected the presence of minke whales in the Study Area (Klinck et al., 2016b; Norris et al., 2017; Oleson & Hill, 2010a; Oleson et al., 2015). Minke whales have not been visually detected in the Study Area during any known survey efforts within approximately the last decade (Fulling et al., 2011; Hill et al., 2011; Hill et al., 2013; Hill et al., 2014; Hill et al., 2015; Hill et al., 2017a; Mobley, 2007; Oleson & Hill, 2010a; Tetra Tech Inc., 2014; Uyeyama, 2014).

4.1.5.3 Population and Abundance

No estimates have been made for the number of minke whales in the North Pacific (Carretta et al., 2017b; Muto et al., 2017a). Acoustic data collected during a Navy-funded 2007 line-transect survey employing a towed hydrophone array in the Mariana Islands were used to estimate the abundance of calling minke whales (Norris et al., 2017). Abundance was estimated using two different methodologies, resulting in minimum estimates of 80 or 91 animals in the region (a density of 0.13 and 0.15 animals per 1,000 km^2, respectively; CV = 0.34) (Norris et al., 2017). Although this estimate is a minimum since it is based only on calling whales, this study provided the first abundance and density estimates for calling minke whales and the first minimum estimates of the true number of minke whales in the portion of the Mariana Islands covered by the 2007 survey (Fulling et al., 2011; Norris et al., 2017).

4.1.6 Omura's Whale (*Balaenoptera omurai*)

4.1.6.1 Status and Management

The Omura's whale is not listed under the ESA. Omura's whale is not mentioned in the Pacific or Alaska SARs (Carretta et al., 2017b; Muto et al., 2017a). There is no managed stock or population within U.S. waters pursuant to the MMPA, but the species is protected under that statute nonetheless, as are all marine mammals.

4.1.6.2 Geographic Range and Distribution

The species was first described in 2003 based on eight specimens taken by Japanese research whaling vessels in the Sea of Japan, the Solomon Sea, and the eastern Indian Ocean (Wada et al., 2003). Records of the species from Philippines shore-based whaling provide additional indication of a broad distribution that includes the western Pacific (Cerchio et al., 2015). Given the documented occurrence of the species, it is assumed the species may be present in the Study Area. Recent well-documented sightings have occurred in nearshore waters off Madagascar and off Sri Lanka, indicating in those cases a preference for relatively shallow water less than approximately 200 m in depth (Cerchio et al., 2015; de Vos, 2017).

4.1.6.3 Population and Abundance

There are no data available to estimate abundance for Omura's whale in the Study Area.

4.1.7 Sei Whale (*Balaenoptera borealis*)

4.1.7.1 Status and Management

The sei whale is listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure for sei whales is uncertain in the Pacific (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes three stocks of sei whales in the North Pacific: (1) the Hawaii Stock, (2) the California/Oregon/Washington Stock, and (3) the Alaska Stock (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017a; Muto et al., 2017b). The western Pacific and waters within the Study Area have not been addressed by NMFS, and sei whales in the Study Area have not been assigned to a stock (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017a; Muto et al., 2017b).

4.1.7.2 Geographic Range and Distribution

In a January–February survey in 1972, a single group of approximately 13 sei whales were sighted during a survey of the Mariana Islands and Ogasawara (Masaki, 1972). In the 2007 survey of the Mariana Islands (Fulling et al., 2011), a total of 16 sei whales were sighted in coverage of approximately 24 percent of the Study Area. Sei whale calls documented during the 2007 survey indicated a greater variability in the vocal repertoire of sei whales than documented elsewhere (Norris et al., 2014), which may have contributed to the lack of acoustic detections in the three-year record from 2010 to 2013 (Oleson et al., 2015). Sei whales were also visually detected in the Transit Corridor between the Study Area and Hawaii during a NMFS survey in January 2010 (Oleson & Hill, 2010a).

4.1.7.3 Population and Abundance

During a 2007 systematic survey covering approximately 24 percent of the Study Area, sei whales were sighted on 16 occasions with a resulting abundance estimate for the area covered of 166 individuals (CV = 0.49) (Fulling et al., 2011), which remains the current best available science.

4.2 ODONTOCETES

4.2.1 BLAINVILLE'S BEAKED WHALE (*MESOPLODON DENSIROSTRIS*)

4.2.1.1 Status and Management

The Blainville's beaked whale is not listed under the ESA. The stock structure for Blainville's beaked whales remains uncertain in the western Pacific, and Blainville's beaked whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes a single stock of Blainville's beaked whales in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.1.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the toothed whales within the *Mesoplodon* genus, occurring in temperate and tropical deep waters areas in all oceans (Jefferson et al., 2015; MacLeod, 2000; MacLeod & Mitchell, 2006). In Hawaii, some populations have been documented to be long-term residents to particular areas (Baird et al., 2009b; Baird, 2011; Baird et al., 2015; McSweeney et al., 2007). There were two *Mesoplodon* whale sightings during the 2007 survey in the Study Area, over the West Mariana Ridge, but they were not identified to the species level (Fulling et al., 2011). In total during Navy-funded 2010–2016 small boat surveys in the Mariana Islands, five *Mesoplodon* beaked whales were encountered on two occasions in a median depth of approximately 1,140 m and median approximate distance from shore of 15 km (Hill et al., 2013; Hill et al., 2017a). It could not be determined if these were Blainville's beaked whales or ginkgo-toothed beaked whales, both of which belong to the genus *Mesoplodon* and are believed to be present in the Study Area. Acoustic monitoring has indicated that Blainville's beaked whales occur regularly and year-round in the Study Area (Klinck et al., 2016b; Oleson et al., 2015; Tetra Tech Inc., 2014).

4.2.1.3 Population and Abundance

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

4.2.2 COMMON BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

4.2.2.1 Status and Management

The bottlenose dolphin is not listed under the ESA. The stock structure for bottlenose dolphin remains uncertain in the western Pacific and the Mariana Islands (Martien et al., 2014b), and bottlenose dolphins in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2017b; Carretta et al., 2017c). Other than small and resident Main Hawaiian island-associated populations of bottlenose dolphins, NMFS recognizes a single pelagic stock of bottlenose dolphin in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.2.2 Geographic Range and Distribution

Multiple fishery interactions with bottlenose dolphins in the western North Pacific (Miyashita, 1993b) indicated their presence beginning approximately 400 NM north of the Study Area. It is possible that bottlenose dolphins do not occur in great numbers in the Mariana Island chain, but they have been frequently sighted, although in small numbers. In the main Hawaiian Islands, data suggest that bottlenose dolphins exhibit site fidelity (Baird et al., 2009a; Baird et al., 2013c; 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, which would be similar to the Study Area.

Common bottlenose dolphins are generally found in coastal and continental shelf waters of tropical and temperate regions of the world and are known to occur in small enclosed bays or harbors (Martien et al., 2012; Rossman et al., 2015; Wells & Scott, 2009), but they have not been detected in any such enclosed water in the Study Area (such as Apra Harbor). During the 2007 survey of Mariana Islands, there were three sightings of bottlenose dolphins to the east of Saipan in deep waters near the Mariana Trench (Fulling et al., 2011). Bottlenose dolphins were not detected during the 2010 survey of the Mariana Islands and the Transit Corridor (Oleson & Hill, 2010a). In total during Navy-funded 2010–2016 small boat surveys in the Mariana Islands, 32 bottlenose dolphins were encountered on four occasions in a median depth of approximately 700 m and median approximate distance from shore of 7 km (Hill et al., 2017a). One of those occasions involved a mixed-species aggregation that included short-finned pilot whales and rough-toothed dolphins (Hill et al., 2011).

4.2.2.3 Population and Abundance

In some regions of the Pacific, "inshore" and "offshore" or pelagic species differ genetically and morphologically (Baird et al., 2009a; Baird et al., 2013c; Tezanos-Pinto et al., 2009), but this has not been demonstrated for the Mariana Islands (Martien et al., 2014b). A total of 4,610 photos taken during small boat surveys between 2011 and 2014 were analyzed to identify individual bottlenose dolphins. A total of 47 individuals were identified with 30 individuals (64 percent) re-encountered and the remaining 17 of those individuals (36 percent) encountered three or more times (Hill et al., 2017a). These re-encounters occurred between all islands and may be similar to the site fidelity present for some of the island-associated populations present in the Hawaiian Islands (Baird et al., 2009a). Genetic samples from 21 bottlenose dolphins encountered off Guam and Saipan between 2010 and 2014 suggest a history of hybridization with Fraser's dolphin (Martien et al., 2014b). The Marianas samples shared DNA haplotypes with individuals from the Philippines, South Korea, Taiwan, and the main Hawaiian Islands but precluded determination of any small populations associated with specific locations in the Mariana Islands similar to what has been found in Hawaii (Martien et al., 2014b).

A bottlenose dolphin abundance estimate of 31,700 animals was made for the area approximately 400 NM north of the Marianas (Miyashita, 1993b), which may possibly represent a stock of offshore bottlenose dolphins that occurs around the northern Mariana Islands region. There were three sightings of bottlenose dolphin during a 2007 systematic survey covering approximately 24 percent of the Study Area, resulting in an abundance estimate for the area covered of 122 animals (CV = 0.992) (Fulling et al., 2011).

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

4.2.3.1 Status and Management

The Cuvier's beaked whale is not listed under the ESA. The stock structure for Cuvier's beaked whales remains uncertain in the western Pacific and Cuvier's beaked whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017a; Muto et al., 2017b). With the exception of the U.S. West Coast, NMFS only recognizes a stock of Cuvier's beaked whale in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c) and in the "eastern North Pacific" and Alaskan waters (Muto et al., 2017a; Muto et al., 2017b), whose distribution does not extend to the Study Area.

4.2.3.2 Geographic Range and Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Ferguson et al., 2006a; Ferguson et al., 2006b; Jefferson et al., 2008; Pitman et al., 1988). 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) (Falcone et al., 2009; Jefferson et al., 2008). While there are indications of potential seasonal re-distribution of Cuvier's beaked whales and documented satellite tag movements in Southern California waters (Falcone & Schorr, 2014; Moretti, 2017; Schorr et al., 2014; Schorr et al., 2018), no such research findings are available from the Mariana Islands. 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 aerial surveys conducted in August 2007 covering 2,352 km of linear effort, 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 (the taxon that Cuvier's beaked whales belong to) was observed in deep water during the 2007 shipboard survey within the Study Area, but was not identified to the species level (Fulling et al., 2011). A single Cuvier's beaked whale was sighted and others acoustically detected during an August 2013 survey at Pagan Island (Tetra Tech Inc., 2014). A year's duration of acoustic monitoring at Saipan and at Tinian recorded vocalizing Cuvier's beaked whales (Oleson et al., 2015). These vocalizations were detected in all months having sufficient samples to detect their presence in the Study Area, suggesting there is no seasonal aspect to the Cuvier's beaked whale's distribution.

4.2.3.3 Population and Abundance

There are no abundance estimates for Cuvier's beaked whales in the Study Area.

4.2.4 DWARF SPERM WHALE (*KOGIA SIMA*)

4.2.4.1 Status and Management

The dwarf sperm whale is not listed under the ESA. The stock structure for dwarf sperm whales remains uncertain in the western Pacific, and dwarf sperm whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017c; Carretta et al., 2017d). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of dwarf sperm whale in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d).

4.2.4.2 Geographic Range and Distribution

Records of this species have been documented from the western Pacific (Taiwan and Japan) (Sylvestre, 1988; Wang et al., 2001; Wang & Yang, 2006), and there have been four known dwarf sperm whale strandings in the Mariana Islands (Trianni & Tenorio, 2012; Uyeyama, 2014).

There were no species of *Kogia* sighted during the 2007 shipboard survey within the Study Area, although this cryptic species is difficult to detect (Fulling et al., 2011). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered three dwarf sperm whales (Mobley, 2007). In total during Navy-funded 2010–2016 small boat surveys in the Mariana Islands, five dwarf sperm whales have been encountered on four occasions in a median depth of approximately 750 m and at a median distance of approximately 3 km from shore (Hill et al., 2017a).

4.2.4.3 Population and Abundance

There are no abundance estimates for dwarf sperm whales in the Study Area.

4.2.5 False Killer Whale (*Pseudorca crassidens*)

4.2.5.1 Status and Management

False killer whales in the Mariana Islands are not listed under the ESA. The stock structure for false killer whales remains uncertain in the western Pacific (Chivers et al., 2007; Martien et al., 2014a), and false killer whales in the Study Area have not been assigned to a stock in the current SAR for the Pacific (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes multiple stocks of false killer whale in the Pacific within the U.S. Exclusive Economic Zone in Hawaiian waters, at Palmyra Atoll, and waters around America Samoa (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.5.2 Geographic Range and Distribution

The false killer whale is an oceanic species, occurring in deep waters of the North Pacific (Miyashita et al., 1996; Wang et al., 2001) but also known to occur close to shore near oceanic islands (Baird, 2012). In Hawaii, false killer whales have been seen in groups of up to 100 over a wide range of depths and distance from shore (Baird et al., 2003; Baird et al., 2013a; Bradford et al., 2014; Bradford et al., 2015; Oleson et al., 2013). 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 & 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 within the Study Area, there were 10 false killer whale sightings in deep water offshore locations with group sizes ranging from 2 to 26 individuals (Fulling et al., 2011). During the 2010 NMFS survey, one sighting of a pod containing five false killer whales was made approximately midway between Guam and Hawaii in the Transit Corridor (Oleson & Hill, 2010a). In small boat surveys in the Study Area conducted between 2010 and 2016, false killer whales were encountered only on three occasions (Hill et al., 2014; Hill et al., 2017a). Three false killer whale strandings have been reported between 1963 and 2013, occurring in 2000, 2003, and 2007 (Trianni & Tenorio, 2012; Uyeyama, 2014).

4.2.5.3 Population and Abundance

There are estimated to be about 6,000 false killer whales in the North Pacific (starting approximately 50 NM of the Study Area from 25° N to 39° N latitude) based on fishery interaction data (Miyashita, 1993b). Based on sighting data from the 2007 survey covering approximately 24 percent of the Study Area, there were an estimated 637 (CV = 0.74) false killer whales in that portion of the Study Area (Fulling et al., 2011).

4.2.6 Fraser's Dolphin (*Lagenodelphis hosei*)

4.2.6.1 Status and Management

The Fraser's dolphin is not listed under the ESA. The stock structure for Fraser's dolphin remains uncertain in the western Pacific, and Fraser's dolphin in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes a single stock of Fraser's dolphin in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.6.2 Geographic Range and Distribution

Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar, 2009). 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 (Jefferson & Leatherwood, 1994). In Hawaiian waters, Fraser's dolphin was one of the most abundant species offshore, having large pod group sizes with an observed mean of 283 animals (Bradford et al., 2017).

4.2.6.3 Population and Abundance

There are no abundance estimates for Fraser's dolphin in the Study Area. Genetic samples from 21 bottlenose dolphins encountered off Guam and Saipan in 2007 suggests a history of hybridization with Fraser's dolphin (Martien et al., 2014b).

4.2.7 GINKGO-TOOTHED BEAKED WHALE (*MESOPLODON GINKGODENS*)

4.2.7.1 Status and Management

The Ginkgo-toothed beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* beaked whale species during visual surveys, ginkgo-toothed beaked whales are combined with all other *Mesoplodon* species that occur off the U.S. West Coast and are managed by NMFS as a species guild (Carretta et al., 2017b; Carretta et al., 2017c). The stock structure for ginkgo-toothed beaked whale remains uncertain in the western Pacific, and ginkgo-toothed beaked whales present in the Study Area or the remainder of the Pacific have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.7.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 200 m) and are only occasionally reported in waters over the continental shelf (Cañadas et al., 2002; Ferguson et al., 2006a; MacLeod & D'Amico, 2006; Pitman, 2009). Acoustic monitoring at sites around the North Pacific have encountered the "BWC type" beaked whale vocalizations, which are assumed to be produced by ginkgo-toothed beaked whales (Baumann-Pickering et al., 2012; Oleson et al., 2015). Strandings of ginkgo-toothed beaked whales are not common anywhere, but the largest number of records are from Japan (Baumann-Pickering et al., 2012); there have been no known strandings of the species in the Mariana Islands.

In total during Navy-funded 2010–2016 small boat surveys in the Mariana Islands, five *Mesoplodon* beaked whales have been encountered on two occasions in a median depth of approximately 1,140 m and median approximate distance from shore of 15 km (Hill et al., 2017a); it could not be determined if these were ginkgo-toothed beaked whales or Blainville's beaked whales, both of which are believed to be present in the Study Area.

A year of acoustic monitoring at Saipan and at Tinian recorded the BWC type beaked whale vocalizations assumed to be produced by ginkgo-toothed beaked whales (Oleson et al., 2015). These vocalizations were detected in all months having sufficient samples to detect their presence in the Study Area, suggesting there is no seasonal aspect to their distribution. This correlates with the findings reported from a previous acoustic monitoring site off Saipan where this same signal type was encountered during 24 percent of days sampled (Baumann-Pickering et al., 2012).

4.2.7.3 Population and Abundance

There are no abundance estimates for ginkgo-toothed beaked whale in the Study Area.

4.2.8 Killer Whale (*Orcinus orca*)

4.2.8.1 Status and Management

The stock structure for killer whales remains uncertain in the western Pacific, and killer whales present in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017a; Muto et al., 2017b). NMFS recognizes eight stocks of killer whales for the Pacific, but none of the identified ranges are within the Study Area (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017a; Muto et al., 2017b). Under the ESA, the Southern Resident DPS of killer whales is the only species listed as endangered, but those animals do not venture beyond the North American nearshore waters. Killer whales in the Study Area are not listed pursuant to the ESA.

4.2.8.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from inland and nearshore coastal areas, to the deep mid-ocean, and from equatorial regions to the polar pack ice zones of both hemispheres. Forney and Wade (2006) found that killer whale densities increased by one to two orders of magnitude from the tropics to the poles.

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) and the species has been reported in the tropical waters around Guam, Yap, and Palau (Rock, 1993). Between 1987 and 2017 in the Mariana Islands, killer whales in pods of three to five individuals were observed on only six occasions (Eldredge, 1991; Uyeyama, 2014). There was also a badly decomposed killer whale found stranded on Guam in August 1981 (Kami, 1982). There were no sightings of the species during a 2007 systematic line-transect survey (Fulling et al., 2011) or a 2010 survey within the Study Area (Oleson & Hill, 2010a). In May 2010, a group of approximately five killer whales, including one calf, were observed about 20 NM south of FDM (Uyeyama, 2014; Wenninger, 2010). The Navy-funded small boat surveys between 2010 and 2016 in the Mariana Islands did not encounter any killer whales (Hill et al., 2014; Hill et al., 2017a). Vocalizations from killer whales were detected on three occasions south of Guam by passive acoustic recorders aboard an underwater glider survey in 2014 (Klinck et al., 2016b).

4.2.8.3 Population and Abundance

There are no abundance estimates for killer whales in the Study Area.

4.2.9 Longman's Beaked Whale (*Indopacetus pacificus*)

4.2.9.1 Status and Management

The Longman's beaked whale is not listed under the ESA. Only one stock has been identified for the Pacific for the population present in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017b). The stock structure for Longman's beaked whale remains uncertain in the western Pacific, and the species in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.9.2 Geographic Range and Distribution

Longman's beaked whales are found in warm tropical waters, and most sightings occur in waters with sea surface temperatures warmer than 78 °F (26 °C) (Anderson et al., 2006; MacLeod et al., 2006; MacLeod & D'Amico, 2006). Based on systematic survey data collected from 1986 to 2005 in the eastern Pacific, all Longman's beaked whale sightings were south of 25° N (Hamilton et al., 2009). Sighting records of this species in the Indian Ocean showed that Longman's beaked whales are typically found in waters over deep bathymetric slopes reaching 200–2,000 m or greater (Anderson et al., 2006).

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 (Afsal et al., 2009; Dalebout et al., 2002; Dalebout et al., 2003; Moore, 1972). In the Pacific, records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico and Hawaii. Longman's beaked whales have not been observed or detected acoustically in the Study Area, although it is assumed they are present in the area. In Hawaii, there was a single sighting of approximately 18 Longman's beaked whales during a NMFS 2002 survey (Barlow, 2006) and during the follow-on 2010 survey, there were three sightings of Longman's beaked whales, with group sizes ranging from approximately 32 to 99 individuals (Bradford et al., 2017). It is assumed that Longman's beaked whales would have similar grouping behavior in the Study Area.

4.2.9.3 Population and Abundance

There are no abundance estimates for Longman's beaked whales in the Study Area.

4.2.10 MELON-HEADED WHALE (*PEPONOCEPHALA ELECTRA*)

4.2.10.1 Status and Management

The melon-headed whale is not listed under the ESA. The stock structure for melon-headed whales remains uncertain in the western Pacific, and melon-headed whales in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes two stocks of melon-headed whales in the Pacific associated with Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.10.2 Geographic Range and Distribution

Melon-headed whales are found worldwide in tropical and subtropical waters, but movement patterns for this species are poorly understood. It has been suggested that melon-headed whales near oceanic islands rest near shore during the day and feed in deeper waters at night (Brownell et al., 2009; Gannier, 2002; Woodworth et al., 2012). In surveys around the main Hawaiian Islands, melon-headed whales showed no clear pattern in depth use (Baird, 2013). Melon-headed whales are also known to enter shallow water areas on occasion, although these are generally characterized as animals being "out of habitat" or "mass strandings." Such out-of-habitat events, each involving a few hundred melon-headed whales, have occurred at Sasanhaya Bay, Rota (Jefferson et al., 2006), and in Hawaii (Fromm et al., 2006; Southall et al., 2006) on the same day in 2004, and similar numbers did so twice in the Philippines entering Manila Bay in February 2009 and the bay at Odiongan, Romblon in March 2009 (Aragones et al., 2010; Obusan et al., 2016). There was a live stranding of a melon-headed whale on the beach at Inarajan Bay, Guam in April 1980 (Donaldson, 1983; Kami, 1982), and four individuals at Orote in 2009 (Uyeyama, 2014).

There were two sightings of melon-headed whales during the 2007 survey within the Study Area, with group sizes of 80–109 individuals (Fulling et al., 2011). There was one sighting of approximately 53 individuals southeast of Guam and two mid-ocean sightings (pods sizes of 43 and 72) in the Transit Corridor portion of the Study Area during the large vessel Pacific Islands Fisheries Science Center survey (Oleson & Hill, 2010a). During small boat surveys in 2012 and 2014, melon-headed whales in large pods numbering between 85 and 325 individuals were sighted off Guam and Tinian/Saipan (HDR, 2012; Hill et al., 2014).

4.2.10.3 Population and Abundance

Based on sighting data from a systematic survey in 2007 covering approximately 24 percent of the Study Area, there were an estimated 2,455 (CV = 0.70) melon-headed whales in that portion of the Study Area (Fulling et al., 2011).

4.2.11 Pantropical Spotted Dolphin (*Stenella attenuata*)

4.2.11.1 Status and Management

The pantropical spotted dolphin is not listed under the ESA. The stock structure for pantropical spotted dolphin remains uncertain in the western Pacific, and pantropical spotted dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes a single pelagic stock and three Hawaiian Island associated stocks of pantropical spotted dolphin in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.11.2 Geographic Range and Distribution

Surveys in the Mariana Islands in 2007 encountered 17 groups of pantropical spotted dolphins ranging in size from 1 to 115 individuals (Fulling et al., 2011). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered a single pod of 30 pantropical spotted dolphins (Mobley, 2007). In total during the Navy-funded 2010–2016 small boat surveys in the Mariana Islands, pantropical spotted dolphins were encountered on 30 occasions in group sizes of 4–70 individuals at a median approximate distance from shore of 6 km (Hill et al., 2014; Hill et al., 2017a).

4.2.11.3 Population and Abundance

Based on sighting data from the 2007 systematic survey of the Mariana Islands covering approximately 24 percent of the Study Area, the estimated abundance for pantropical spotted dolphins in that portion of the Study Area is 12,981 (CV = 0.704) (Fulling et al., 2011).

4.2.12 Pygmy Killer Whale (*Feresa attenuata*)

4.2.12.1 Status and Management

The pygmy killer whale is not listed under the ESA. The stock structure for pygmy killer whale remains uncertain in the western Pacific, and pygmy killer whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.12.2 Geographic Range and Distribution

This species has been documented in the western Pacific (Taiwan and Japan) (Sylvestre, 1988; Wang et al., 2001; Wang & Yang, 2006). There was only one pygmy killer whale sighting of a group of six animals during the 2007 systematic survey within 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 between 2010 and 2016, there was a single pygmy killer whale sighting northeast of Saipan in 2011 and then single sightings in 2013 and 2014 off Guam; group sizes were from six to nine individuals (Hill et al., 2014; Hill et al., 2017a).

4.2.12.3 Population and Abundance

Based on a single sighting during the 2007 survey covering approximately 24 percent of the Study Area, pygmy killer whale abundance was estimated at 78 individuals (CV = 0.881) (Fulling et al., 2011).

4.2.13 Pygmy Sperm Whale (*Kogia breviceps*)

4.2.13.1 Status and Management

The pygmy sperm whale is not listed under the ESA. The stock structure for pygmy sperm whales remains uncertain in the western Pacific, and pygmy sperm whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of pygmy sperm whale in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.13.2 Geographic Range and Distribution

During marine mammal monitoring for Valiant Shield 2007, a group of three Kogia (dwarf or pygmy sperm whales) was observed about 8 NM east of Guam (Mobley, 2007). The stranding of a pygmy sperm whale in 1997 (Trianni & Tenorio, 2012), is the only other confirmed occurrence of this species in the Study Area.

4.2.13.3 Population and Abundance

There are no abundance estimates for pygmy sperm whale in the Study Area.

4.2.14 Risso's Dolphin (*Grampus griseus*)

4.2.14.1 Status and Management

The Risso's dolphin is not listed under the ESA. The stock structure for Risso's dolphin remains uncertain in the western Pacific, and Risso's dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of Risso's dolphins in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.14.2 Geographic Range and Distribution

Occurrence of this species is deep open ocean waters off Hawaii and in other locations in the Pacific (Au & Perryman, 1985; Bradford et al., 2017; Leatherwood et al., 1980; Miyashita et al., 1996; Wang et al., 2001). Fishery interaction data determined the species occurrence west of the International Date Line extended as far north as 40° N, but the southern extent of the range could not be determined (Miyashita, 1993a). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered a single pod of eight Risso's dolphins (Mobley, 2007). During the NMFS survey of 2010, there was a single Risso's dolphin sighting of three individuals approximately 60 NM north of FDM (Oleson & Hill, 2010a). The species has not been detected in any other surveys efforts in the Study Area (Fulling et al., 2011; Hill et al., 2014; Hill et al., 2017a). Vocalizations classified as Risso's dolphins were also detected south of Guam by passive acoustic recorders aboard an underwater glider survey in 2014 (Klinck et al., 2016b).

4.2.14.3 Population and Abundance

There are no abundance estimates for Risso's dolphin in the Study Area.

4.2.15 Rough-Toothed Dolphin (*Steno bredanensis*)

4.2.15.1 Status and Management

The rough-toothed dolphin is not listed under the ESA. The stock structure for rough-toothed dolphins remains uncertain in the western Pacific, and rough-toothed dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes a single stock of rough-toothed dolphins in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.15.2 Habitat and Geographic Range

Rough-toothed dolphins were sighted twice during a 2007 survey; once as nine individuals in a mixed group of short-finned pilot whales and bottlenose dolphins, and once in a pod of nine individuals with calves present (Fulling et al., 2011). A pod of eight rough-toothed dolphins was also sighted approximately 175 km south of Guam during a 2007 aerial survey (Mobley, 2007). Despite there being a broad offshore survey in 2010 (Oleson & Hill, 2010a) and annual small boat surveys conducted from 2010 to 2012 (Hill et al., 2011; Hill et al., 2013), rough-toothed dolphins were only re-encountered in 2013, and again in association with other odontocetes (bottlenose dolphins and spinner dolphins) (Hill et al., 2014). Four of the same photo-identified rough-toothed dolphins encountered in 2013 have been seen multiple times since in the same general location to the west of Saipan off Chalan Kanoa Reef (Hill et al., 2014; Hill et al., 2017a). One group of rough-toothed dolphins was sighted in 2014, but none were encountered in 2015, 2016, or 2017 (Hill et al., 2017a; Hill et al., 2018).

4.2.15.3 Population and Abundance

During the 2007 systematic line-transect survey covering approximately 24 percent of the Study Area, there was only one on-effort sighting of rough-toothed dolphin that was used to derive an abundance estimate of 166 animals for that portion of the Study Area (CV = 0.892) (Fulling et al., 2011). Given the very limited sample size (a single sighting), this estimate is considered highly uncertain. In July 2004, there was a sighting of an undetermined smaller number of rough-toothed dolphins mixed in with a school of an estimated 500–700 melon-headed whales off Rota in Sasanhayan Bay (Jefferson et al., 2006).

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

4.2.16.1 Status and Management

The short-finned pilot whale is not listed under the ESA. The stock structure for short-finned pilot whales remains uncertain in the western Pacific, and short-finned pilot whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). With the exception of the U.S. West Coast, NMFS recognizes a single stock of short-finned pilot whales in the Pacific in Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.16.2 Geographic Range and Distribution

In the 2007 survey in the Mariana Islands, short-finned pilot whales were encountered five times in groups ranging in size from 5 to 43 animals (Fulling et al., 2011). During the 2010 NMFS survey there was a single sighting of 23 short-finned pilot whales in the northern portion of the Study Area (Oleson & Hill, 2010a). Closer to the islands, there have been numerous incidental sightings of short-finned pilot whales occurring between 1977 and 2013 (Uyeyama, 2014). During the Navy-funded 2010–2016 small boat surveys in the Mariana Islands, short-finned pilot whale groups were encountered on 15 occasions in a median depth of approximately 700 m and median approximate distance from shore of 5 km (Hill et al., 2014; Hill et al., 2017a). Satellite tag locations from one short-finned pilot whale in 2016 appeared to indicate a position inside the mouth of Apra Harbor (Hill et al., 2017a). However, uncertainty due to the limited precision (error range) of even high-quality Argos satellite fixes, and in particular with regard to reduced longitudinal precision, given the Argos satellites are in polar orbits (Boyd & Brightsmith, 2013; Vincent et al., 2002), it should be considered uncertain if the animal was in Apra Harbor. Based on the locations from the 2013 to 2016 satellite tagged individuals in May–August timeframe, the combined data has suggested that the northwest side of Guam is a frequently used area for pilot whales during that time of the year (Hill et al., 2017a).

4.2.16.3 Population and Abundance

The estimated abundance for short-finned pilot whales in approximately 24 percent of the Study Area is 909 (CV = 0.677), based on sighting data from the 2007 systematic survey in the Mariana Islands (Fulling et al., 2011). Genetic samples taken during that survey found evidence of genetic differentiation for short-finned pilot whales between Mariana Islands, although they possess haplotypes also common in the South Pacific, North Atlantic, Indian Ocean, and off of southern Japan (Martien et al., 2014b).

4.2.17 SPERM WHALE (*PHYSETER MACROCEPHALUS*)

4.2.17.1 Status and Management

The sperm whale is listed as endangered under the ESA. The stock structure for sperm whales remains uncertain in the Pacific (Mesnick et al., 2011; Mizroch & Rice, 2013; National Marine Fisheries Service, 2015a), and sperm whales in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2017b; Carretta et al., 2017c). Except for waters off the U.S. West Coast, NMFS recognizes two stocks of sperm whales, one in the central Pacific (in Hawaiian waters) and one in the North Pacific (in Alaskan waters) (Carretta et al., 2017b; Carretta et al., 2017c; Muto et al., 2017a; Muto et al., 2017b).

4.2.17.2 Geographic Range and Distribution

Based on whaling data and discovery tag movement data for the North Pacific, it has been argued that the distribution of sperm whales encompasses the entire Pacific Ocean basin, with concentrations in the arctic and subtropical areas (Ilyashenko et al., 2014; Mizroch & Rice, 2013). The Study Area is south of the locations where the majority of sperm whales were encountered during whaling (Mizroch & Rice, 2013; Townsend, 1935), although during a 1972 survey of the Ogasawara and Mariana Island regions two large groups totaling 90 sperm whales were reported (Masaki, 1972). Sperm whales have been routinely sighted in the Study Area and detected in acoustic monitoring records. Acoustic recordings in August 2013 at Pagan Island indicated the presence of sperm whales within 20 NM of the island (Tetra Tech Inc., 2014). Although it has been reported that sperm whales are generally found far offshore in deep water (Mizroch & Rice, 2013), sightings in the Study Area have included animals close to shore in relatively shallow water as well as in areas near steep bathymetric relief (Fulling et al., 2011; Hill et al., 2017a; Uyeyama, 2014). A total of 23 sperm whale sightings and 93 acoustic encounters were made during the 2007 survey in water depths between approximately 400 and 1,000 m depth (Fulling et al., 2011; Yack et al., 2016). During the Navy-funded 2010–2016 small boat surveys in the Mariana Islands, six sperm whales were encountered on three occasions in a median depth of approximately 1,200 m and median approximate distance from shore of 12 km (Hill et al., 2017a). Vocalizations classified as sperm whales were also detected on 20 occasions to the east and south of Guam by passive acoustic recorders during an underwater glider survey in 2014 (Klinck et al., 2016b).

4.2.17.3 Population and Abundance

It is assumed the Pacific population is still recovering, given whaling by the Soviet Union from 1948 to 1979 in the North Pacific took 157,680 sperm whales (Ilyashenko et al., 2014). NMFS has reported that for the Pacific Ocean,[4] the population is estimated between 26,300 and 32,100 for the North Pacific and between 14,800 and 34,600 for the eastern tropical Pacific, while the population of the Hawaii Stock is estimated between 2,539 and 3,354 (National Marine Fisheries Service, 2015a). NMFS has not explicitly stated if the western North Pacific and the Mariana Islands are included in the range for the population of sperm whales considered the North Pacific Stock (Muto et al., 2017a; Muto et al., 2017b; National Marine Fisheries Service, 2015a), although that may be the most logical assignment for those animals in the Study Area. The most recent Alaska SAR provides that there is no current abundance data available for sperm whale of the North Pacific Stock (Muto et al., 2017a; Muto et al., 2017b).

During the 2007 systematic line-transect survey in the Mariana Islands, 11 on-effort sperm whale sightings were used to derive an abundance estimate of 705 animals (CV = 0.604) for approximately 24 percent of the Study Area (Fulling et al., 2011). Passive acoustic monitoring was also conducted during the 2007 survey, and 93 acoustic encounters from vocalizing sperm whales were used to develop a habitat-based density model for this species (Yack et al., 2016). The model provided spatially explicit density estimates for the Study Area, and daily model predictions indicated that sperm whale abundance varied temporally over the period of the 2007 survey (January 15 to April 10). Average Study Area abundance derived from the habitat model was similar to the line-transect estimate based on visual sightings; 700 animals (CV = 0.436) based on a model using sounds typically produced by mature males, females, and juveniles (i.e., "regular clicks"), and 637 animals (CV = 0.447) based on a model using both the regular clicks and "slow clicks" that are only produced by mature males (Yack et al., 2016).

4.2.18 Spinner Dolphin (*Stenella longirostris*)

4.2.18.1 Status and Management

The spinner dolphin is not listed under the ESA. The stock structure for spinner dolphins remains uncertain in the western Pacific, and spinner dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). NMFS recognizes seven stocks of island- or atoll-associated spinner dolphin populations in the Pacific in Hawaii and American Samoa waters (Carretta et al., 2017b; Carretta et al., 2017c), which are all at locations well to the east of the Study Area.

[4]The "Pacific Ocean" estimates provided did not address or otherwise specifically include the western Pacific Ocean that would include the Study Area.

4.2.18.2 Geographic Range and Distribution

Spinner dolphins traveling among the Mariana Islands chain are expected to occur throughout the Marianas, having been observed from Pagan in the north to Guam in the south (Fulling et al., 2011; Hill et al., 2017a; Jefferson et al., 2006; Oleson & Hill, 2010b; Tetra Tech Inc., 2014; Trianni & Kessler, 2002; Uyeyama, 2014; Vogt, 2008). 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; there have been no documented sightings within Apra Harbor (Amesbury et al., 2001; Eldredge, 1991).

During the Navy-funded 2010–2016 small boat surveys in the Mariana Islands, 129 spinner dolphins have been encountered on 15 occasions in a median depth of approximately 20 m and median approximate distance from shore of 1 km (Hill et al., 2017a). During a survey in August 2013 at Pagan Island, spinner dolphins calves and juveniles were encountered; although sighting rates were low relative to other island areas, re-sightings of four individual spinner dolphins on subsequent days were consistent with residency patterns (Tetra Tech Inc., 2014).

4.2.18.3 Population and Abundance

Spinner dolphins were sighted only once during the 2007 survey in the Mariana Islands (Fulling et al., 2011). Genetic samples (n = 93) from spinner dolphins encountered off Guam and Saipan in 2007 suggest the population has high haplotypic diversity similar to that observed in the Society Islands of French Polynesia and that spinner dolphins around the Mariana Islands are much less isolated than those around the Hawaiian Islands (Martien et al., 2014b). In the small boat portion of the NMFS 2010 survey of the Mariana Islands, eight spinner dolphin groups were detected around Guam in group sizes ranging from 22 to 85 individuals, and off Saipan/Tinian there were six encounters with groups ranging in size from 6 to 36 individuals (Oleson & Hill, 2010a). Between 2010 and 2016, Navy-funded small boat non-systematic surveys have documented 129 encounters with spinner dolphin groups (Hill et al., 2014; Hill et al., 2017a).

4.2.19 Striped Dolphin (*Stenella coeruleoalba*)

4.2.19.1 Status and Management

The striped dolphin is not listed under the ESA. The stock structure for striped dolphins remains uncertain in the western Pacific, and striped dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2017b; Carretta et al., 2017c). Other than along the U.S. West Coast, NMFS recognizes only a single stock of striped dolphins that is present within the 200-mile Exclusive Economic Zone defining Hawaiian waters (Carretta et al., 2017b; Carretta et al., 2017c).

4.2.19.2 Geographic Range and Distribution

Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au & Perryman, 1985; Reilly, 1990). The observed northern limits for the species are the Sea of Japan off Hokkaido, off Washington State in the eastern Pacific, or roughly along 40° N latitude across the western and central Pacific (Reeves et al., 2002).

Prior to the 2007 survey of the Study Area (Fulling et al., 2011), striped dolphins were only known to occur in the area from two strandings; one recorded in July 1985 (Eldredge, 1991, 2003) and a second in

1993 off Saipan (Trianni & Tenorio, 2012). However, striped dolphins were sighted throughout the Study Area during the 2007 survey covering approximately 24 percent of the Study Area (Fulling et al., 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group sizes ranged from 7 to 44 individuals, and several sightings included calves. In early April 2010, during an oceanographic survey of waters in Micronesia and the Commonwealth of the Northern Mariana Islands, there were two striped dolphin sightings (pod sizes of 6 and 12) in waters to the south of Guam (Oleson & Hill, 2010a). Striped dolphins have not been reported during more recent non-systematic surveys in the Study Area involving small boats operating close to shore (Hill et al., 2011; Hill et al., 2013; Hill et al., 2014; Hill et al., 2015; Hill et al., 2017a).

4.2.19.3 Population and Abundance

Based on the 2007 survey covering approximately 24 percent of the Study Area, there were an estimated 3,531 (CV = 0.54) striped dolphins in that portion of the Study Area (Fulling et al., 2011).

5 Type of Incidental Taking Authorization Requested

The Navy requests regulations and an LOA for the take of marine mammals incidental to proposed activities in the MITT Study Area for the period from 2020 through 2027. The term “take,” as defined in Section 3 (16 U.S.C. section 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 (Public Law 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. section 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 (Public Law 107-314). Military training and testing activities within the Study Area constitute military readiness activities as that term is defined in Public Law 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. section 1362(18)(B)(i) and (ii)].

Although the statutory definition of Level B harassment for military readiness activities requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. Many of the responses estimated using the Navy’s quantitative analysis are most likely to be moderate severity (e.g., alter migration path, alter locomotion, alter dive profiles, stop/alter nursing, stop/alter breeding, stop/alter feeding/foraging, stop/alter sheltering/resting, stop/alter vocal behavior if tied to foraging or social cohesion, avoid area near sound source). Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 6.4.2.1.1 (Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers – Behavioral Responses from Sonar and Other Transducers), the behavioral response functions used within the Navy’s quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences.

Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal's behavioral threshold for only a single exposure to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant versus non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that large numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from training and testing activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

The MITT Draft SEIS/OEIS considered all training and testing activities proposed to occur in the Study Area that have the potential to result in the MMPA-defined take of marine mammals. The Navy determined that the following three stressors could result in the incidental taking of marine mammals:

- Acoustics (sonar and other transducers)
- Explosives in water
- Physical disturbance and strikes (vessels)

Acoustic and explosive sources 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.

The quantitative analysis process used to estimate potential exposures to marine mammals resulting from acoustic and explosive stressors for the MITT Draft SEIS/OEIS and this request for an LOA is detailed in the technical report titled *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a). The Navy Acoustic Effects Model estimates acoustic and explosive effects without taking mitigation into account; therefore, the model overestimates predicted impacts on marine mammals within mitigation zones.

To account for procedural mitigation for marine species, the Navy conservatively quantifies the potential for mitigation to reduce model-estimated permanent threshold shift (PTS) to temporary threshold shift (TTS) for exposures to sonar and other transducers, and reduce model-estimated mortality to injury for exposures to explosives. For additional information on the quantitative analysis process and mitigation measures, refer to Chapter 6 (Take Estimates for Marine Mammals) and Chapter 11 (Mitigation Measures).

5.1 Incidental Take Request from Acoustic and Explosive Sources

A detailed analysis of effects due to marine mammal exposures to acoustic and explosive sources in the Study Area from Navy training and testing activities is presented in Chapter 6 (Take Estimates for Marine Mammals). Based on the quantitative analysis of acoustic and explosive sources described in Chapter 6 (Take Estimates for Marine Mammals), Table 5.1-1 summarizes the Navy's take request from training and testing activities annually (based on the maximum number of activities per 12-month period) and the summation over a 7-year period.

The7-year total impacts may be less than the sum total of each year, given that not all activities occur every year, some activities occur multiple times within a year, and some activities only occur a few times over the course of a 7-year period.

In summary, over the seven-year LOA period being requested, the Navy's quantitative analysis for acoustic and explosive sources in the MITT Study Area estimates zero mortalities to specific species (see Section 5.1.1 [Incidental Take Request from Acoustic and Explosive Sources for Training and Testing Activities] for details) and a total of 367 Level A exposures and 377,091 Level B exposures.

Table 5.1-1: Summary of Annual and 7-Year Take Request from Acoustic and Explosive Sources for MITT Training and Testing Activities

MMPA Category	*Source*	*Annual Authorization Sought**	*7-Year Authorization Sought**
Mortality	Acoustic & Explosive	None	None
Level A	Acoustic & Explosive	67	367
Level B	Acoustic & Explosive	61,345	377,091

*Species specific take numbers are shown in Table 5.1-2

5.1.1 Incidental Take Request from Acoustic and Explosive Sources for Training and Testing Activities

Chapter 6 (Take Estimates for Marine Mammals) contains detailed species-specific results of modeled potential exposures to acoustic and explosive sources from training and testing activities within the Study Area. Table 5.1-2 summarizes the Navy's take request (exposures which may lead to Level B and Level A harassment) for training and testing activities by species annually (based on the maximum number of activities per 12-month period) and the summation over a 7-year period. The 7-year total takes may be less than the annual totals times seven years, given that not all activities occur every year, some activities occur multiple times within a year, and some activities only occur a few times over the course of a 7-year period.

No mortalities are predicted by the analysis and are therefore not requested for these activities.

Table 5.1-2: Species-Specific Take Requests from Modeling Estimates of Acoustic and Explosive Effects for Training and Testing Activities

Species	*Annual*		*7-Year Total*[1]	
	Level B	*Level A*	*Level B*	*Level A*
Mysticetes				
Blue whale*	23	0	129	0
Bryde's whale	274	0	1,596	0
Fin whale*	22	0	130	0
Humpback whale*	442	0	2,574	0
Minke whale	88	0	521	0
Omura's whale	26	0	151	0
Sei whale*	143	0	829	0
Odontocetes				
Blainville's beaked whale	1,583	0	10,235	0
Bottlenose dolphin	125	0	766	0
Cuvier's beaked whale	604	0	3,942	0
Dwarf sperm whale	7,770	46	47,074	252
False killer whale	690	0	4,231	0
Fraser's dolphin	12,054	1	73,318	7
Ginkgo-toothed beaked whale	3,437	0	22,223	0
Killer whale	39	0	241	0
Longman's beaked whale	5,588	0	36,119	0
Melon-headed whale	2,554	0	15,555	0
Pantropical spotted dolphin	13,487	1	82,113	6
Pygmy killer whale	94	0	570	0
Pygmy sperm whale	3,116	19	18,868	102
Risso's dolphin	2,872	0	17,523	0
Rough-toothed dolphin	181	0	1,105	0
Short-finned pilot whale	1,048	0	6,431	0
Sperm whale*	195	0	1,134	0
Spinner dolphin	1,266	0	7,723	0
Striped dolphin	3,624	0	21,990	0

*Assumed to be ESA-listed distinct populations segments or species within the Study Area
[1]The 7-year totals may be less than the annual totals times seven, given that not all activities occur every year, some activities occur multiple times within a year, and some activities only occur a few times over the course of a 7-year period.

6 Take Estimates for Marine Mammals

6.1 ESTIMATED TAKE OF MARINE MAMMALS BY ACOUSTIC AND EXPLOSIVE 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, or reproductive condition of the various species of marine mammals predicted to be taken as a result of the proposed Navy training and testing. Twenty-six cetacean marine mammal species are known to exist in the Study Area (see details provided in the MITT Draft SEIS/OEIS, Section 3.4.1.1, General Background). 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.

Long recognized by the scientific community (Payne & Webb, 1971), and summarized by the National Academies of Science, is the fact that human-generated sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council, 2005). Assessing whether sounds may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sounds, and the effects that sounds may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003, 2005), there are many unknowns in assessing impacts, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Southall et al., 2007).

Furthermore, many other factors besides just the received level of sound may affect an animal's reaction, such as the animal's physical condition, prior experience with the sound, and proximity to the source of the sound. Although it is clear that sound can disturb marine mammals and alter their behaviors temporarily, there is currently an absence of observations or measurements that demonstrate that disturbance due to intermittent sound in the water will have long-term consequences for the animal or alter their behaviors to the point that they are abandoned or significantly altered over longer periods (i.e., greater than a few hours to a few days, dependent upon the species and stressor).

6.2 CONCEPTUAL FRAMEWORK FOR ASSESSING EFFECTS FROM SOUND-PRODUCING ACTIVITIES

A detailed discussion of the conceptual framework describing the potential effects from exposure to acoustic and explosive activities and the accompanying short-term costs to the animal (e.g., expended energy or missed feeding opportunity) can be found in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) of the MITT Draft SEIS/OEIS. It then outlines the conditions that may lead to long-term consequences for the individual if the animal cannot fully recover from the short-term costs and how these in turn may affect the population. This section provides a generalized description of potential outcomes for any marine animal exposed to acoustic and explosive stressors. Sections 6.4.1 (Background) and 6.5.1 (Background) provide background data specific to marine mammals based on best available science and follow this conceptual framework for acoustic and explosive stressors, respectively.

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 acoustic and explosive activities.

The categories of potential effects are detailed in the box below.

- ***Injury*** *- Injury to organs or tissues of an animal.*
- ***Hearing loss*** *- A noise-induced decrease in hearing sensitivity which can be either temporary or permanent and may be limited to a narrow frequency range of hearing.*
- ***Masking*** *- When the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise).*
- ***Physiological stress*** *- An adaptive process that helps an animal cope with changing conditions; however, too much stress can result in physiological problems.*
- ***Behavioral response*** *- A reaction ranging from very minor and brief changes in attentional focus, changes in biologically important behaviors, and avoidance of a sound source or area, to aggression or prolonged flight.*

Figure 6.2-1 is a flowchart that diagrams the process used to evaluate the potential effects to marine animals exposed to 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). Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only sound waves but also blast waves generated from explosive sources. Box A1, the Sound-Producing Activity, is the source of this stimuli and therefore the starting point in the analysis.

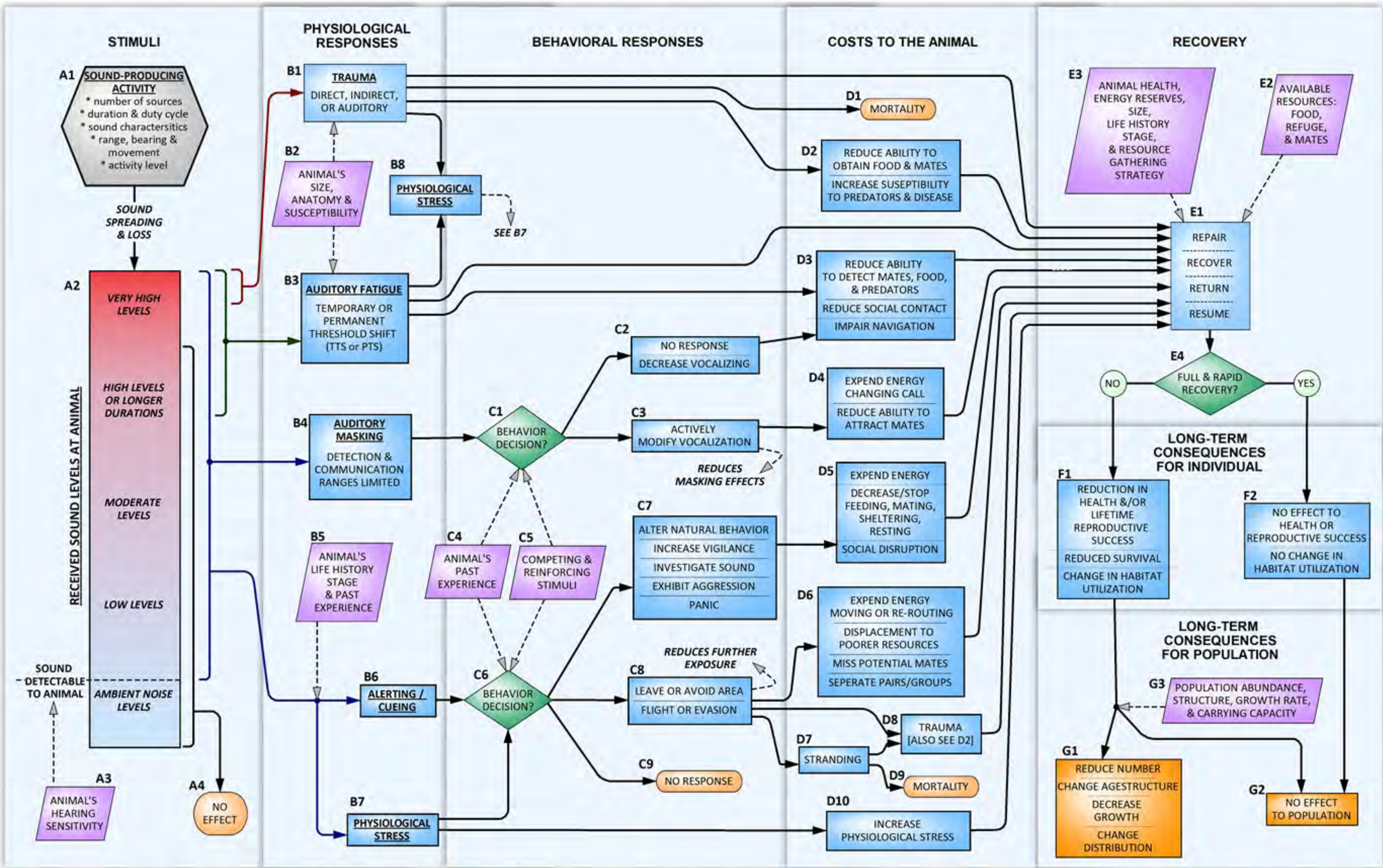


Figure 6.2-1: Flow Chart of the Evaluation Process of Sound-Producing Activities

6.3 Hearing and Vocalization

The typical terrestrial mammalian ear (which is ancestral to that of marine mammals) consists of an outer ear that collects and transfers sound to the tympanic membrane and then to the middle ear (Fay & Popper, 1994; Rosowski, 1994). The middle ear contains ossicles that amplify and transfer acoustic energy to the sensory cells (called hair cells) in the cochlea, which transforms acoustic energy into electrical neural impulses that are transferred by the auditory nerve to high levels in the brain (Møller, 2013). All marine mammals display some degree of modification to the terrestrial ear; however, there are differences in the hearing mechanisms of marine mammals with an amphibious ear versus those with a fully aquatic ear (Wartzok & Ketten, 1999). Marine mammals with an amphibious ear include the marine carnivores: pinnipeds, sea otters, and polar bears (Ghoul & Reichmuth, 2014; Owen & Bowles, 2011; Reichmuth et al., 2013). Outer ear adaptations in this group include external pinnae (ears) that are reduced or absent, and in the pinnipeds, cavernous tissue, muscle, and cartilaginous valves seal off water from entering the auditory canal when submerged (Wartzok & Ketten, 1999). Marine mammals with the fully aquatic ear (cetaceans and sirenians) use bone and fat channels in the head to conduct sound to the ear; while the auditory canal still exists in cetaceans and sirenians, it is narrow and sealed with wax and debris (Ketten, 1998).

The most accurate means of determining the hearing capabilities of marine mammal species are direct measures that assess the sensitivity of the auditory system (Nachtigall et al., 2000; Supin et al., 2001). Studies using these methods produce audiograms—plots describing hearing threshold (the quietest sound a listener can hear) as a function of frequency. Marine mammal audiograms, like those of terrestrial mammals, typically have a "U-shape," with a frequency region of best hearing sensitivity and a progressive decrease in sensitivity outside of the range of best hearing (Fay, 1988; Mooney et al., 2012; Nedwell et al., 2004; Reichmuth et al., 2013). The "gold standard" for producing audiograms is the use of behavioral (psychophysical) methods, where marine mammals are trained to respond to acoustic stimuli (Nachtigall et al., 2000). For species that are untrained for behavioral psychophysical procedures, those that are difficult to house under human care, or those in stranding rehabilitation and temporary capture contexts, auditory evoked potential methods are increasingly used to measure hearing sensitivity (e.g., Castellote et al., 2014; Finneran et al., 2009; Montie et al., 2011; Mulsow et al., 2011; Nachtigall et al., 2007; Nachtigall et al., 2008; Supin et al., 2001).

These auditory evoked potential methods, which measure electrical potentials generated by the auditory system in response to sound and do not require the extensive training of psychophysical methods, can provide an efficient estimate of behaviorally measured sensitivity (Finneran & Houser, 2006; Schlundt et al., 2007; Yuen et al., 2005). The thresholds provided by auditory evoked potential methods are, however, typically elevated above behaviorally measured thresholds, and auditory evoked potential methods are not appropriate for estimating hearing sensitivity at frequencies much lower than the region of best hearing sensitivity (Finneran, 2015; Finneran et al., 2016). For marine mammal species for which access is limited and therefore psychophysical or Auditory Evoked Potential testing is impractical (e.g., mysticete whales and rare species), some aspects of hearing can be estimated from anatomical structures, frequency content of vocalizations, and extrapolations from related species.

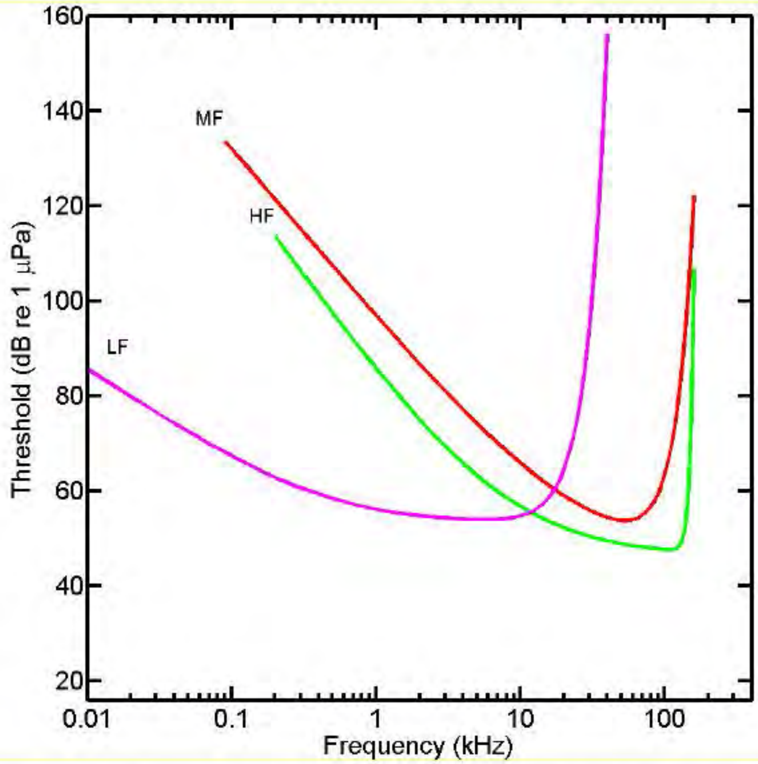
Direct measurements of hearing sensitivity exist for approximately 25 of the nearly 130 species of marine mammals. Table 6.3-1 summarizes hearing capabilities for marine mammal species in the Study Area.

Table 6.3-1: Species Within Marine Mammal Hearing Groups Likely Found in the Study Area

Hearing Group	*Species within the Study Area*
High-frequency cetaceans	Dwarf sperm whale
	Pygmy sperm whale
Mid-frequency cetaceans	Blainville's beaked whale
	Common bottlenose dolphin
	Cuvier's beaked whale
	False killer whale
	Fraser's dolphin
	Ginkgo-toothed beaked whale
	Killer whale
	Longman's beaked whale
	Melon-headed whale
	Pantropical spotted dolphin
	Pygmy killer whale
	Risso's dolphin
	Rough-toothed dolphin
	Short-finned pilot whale
	Sperm whale
	Spinner dolphin
	Striped dolphin
Low-frequency cetaceans	Blue whale
	Bryde's whale
	Fin whale
	Humpback whale
	Minke whale
	Omura's whale
	Sei whale

For this analysis, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency cetaceans (group HF: porpoises, Kogia spp.), mid-frequency cetaceans (group MF: delphinids, beaked whales, sperm whales), and low-frequency cetaceans (group LF: mysticetes). Note that the designations of high-, mid-, and low-frequency cetaceans are based on relative differences of sensitivity between groups, as opposed to conventions used to describe active sonar systems.

For these analyses, a single representative composite audiogram (Figure 6.3-1) was created for each functional hearing group using audiograms from published literature. For discussion of all marine mammal functional hearing groups and their derivation see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b). The mid-frequency cetacean composite audiogram is consistent with recently published behavioral audiograms of killer whales (Branstetter et al., 2017).



Source: Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) (U.S. Department of the Navy, 2017b)

Notes: For hearing in the water; LF = low frequency; MF = mid-frequency; HF = high frequency.

Figure 6.3-1: Composite Audiograms for Hearing Groups Likely Found in the Study Area

Similar to the diversity of hearing capabilities among species, the wide variety of acoustic signals used in marine mammal communication (including biosonar or echolocation) is reflective of the diverse ecological characteristics of cetacean and carnivore species (see Avens, 2003; Richardson et al., 1995). This makes a succinct summary difficult (see Richardson et al., 1995; Wartzok & Ketten, 1999 for thorough reviews); however, a division can be drawn between lower-frequency communication signals that are used by marine mammals in general, and the specific, high-frequency biosonar signals that are used by odontocetes to sense their environment.

Non-biosonar communication signals span a wide frequency range, primarily having energy up into the tens of kHz range. Of particular note are the very low-frequency calls of mysticete whales that range from tens of Hertz (Hz) to several kHz, and have source levels of 150–200 dB re 1 µPa (Cummings & Thompson, 1971; Edds-Walton, 1997; Širović et al., 2007; Stimpert et al., 2007; Wartzok & Ketten, 1999). These calls most likely serve social functions such as mate attraction, but may serve an orientation function as well (Green, 1994; Green et al., 1994; Richardson et al., 1995). Humpback whales are a notable exception within the mysticetes, with some calls exceeding 10 kHz (Zoidis et al., 2008).

Odontocete cetaceans use underwater communicative signals that, while not as low in frequency as those of many mysticetes, likely serve similar functions. The acoustic characteristics of these signals are quite diverse among species, but can be generally classified as having dominant energy at frequencies below 20 kHz (Richardson et al., 1995; Wartzok & Ketten, 1999).

Odontocete cetaceans generate short-duration (50–200 µs), specialized clicks used in biosonar with peak frequencies between 10 and 200 kHz to detect, localize, and characterize underwater objects such as prey (Au, 1993; Wartzok & Ketten, 1999). These clicks are often more intense than other communicative signals, with reported source levels as high as 229 dB re 1 µPa peak-to-peak (Au et al., 1974). The echolocation clicks of high-frequency cetaceans (e.g., porpoises) are narrower in bandwidth (i.e., the difference between the upper and lower frequencies in a sound) and higher in frequency than those of mid-frequency cetaceans (Madsen et al., 2005; Villadsgaard et al., 2007).

In general, frequency ranges of vocalization lie within the audible frequency range for an animal (i.e., animals vocalize within their audible frequency range); however, auditory frequency range and vocalization frequencies do not perfectly align. The frequency range of vocalization in a species can therefore be used to infer some characteristics of their auditory system; however, caution must be taken when considering vocalization frequencies alone in predicting the hearing capabilities of species for which no data exist (i.e., mysticetes). It is important to note that aspects of vocalization and hearing sensitivity are subject to evolutionary pressures that are not solely related to detecting communication signals. For example, hearing plays an important role in detecting threats (e.g., (Deecke et al., 2002)), and high-frequency hearing is advantageous to animals with small heads in that it facilitates sound localization based on differences in sound levels at each ear (Heffner & Heffner, 1992). This may be partially responsible for the difference in best hearing thresholds and dominant vocalization frequencies in some species of marine mammals (e.g., Steller sea lions, (Mulsow & Reichmuth, 2010)).

6.4 ACOUSTIC STRESSORS

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003, 2005), there are many unknowns in assessing impacts, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007). Many other factors besides just the received level of sound may affect an animal's reaction, such as the duration of the sound producing activity, the animal's physical condition, prior experience with the sound, activity at the time of exposure (e.g., feeding, traveling, resting), the context of the exposure (e.g., in a semi-enclosed bay vs open ocean), and proximity to the source of the sound.

The ways in which an acoustic exposure could result in immediate effects or long-term consequences for an animal are explained in the Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2). The following Background section discusses what is currently known about acoustic effects to marine mammals. These effects could hypothetically extend from physical injury or trauma to a behavioral or stress response that may or may not be detectable. Injury (physical trauma) can occur to organs or tissues of an animal (Section 6.4.1.1, Injury). Hearing loss (Section 6.4.1.2, Hearing Loss) is a noise-induced decrease in hearing sensitivity, which can be either temporary or permanent. Masking (Section 6.4.1.4, Masking) can occur when the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise). Physiological stress (Section 6.4.1.3, Physiological Stress) is an adaptive process that helps an animal cope with changing conditions, however too much stress can potentially result in additional physiological effects. Behavioral response (Section 6.4.1.5, Behavioral Reactions) ranges from brief distractions to avoidance of a sound source to prolonged flight. Extreme behavioral or physiological responses can lead to stranding (Section

6.4.1.5, Behavioral Reactions). Long-term consequences (Section 6.4.1.7, Long-Term Consequences) are those impacts, or accumulation of impacts, that can result in decreases in individual fitness or population changes. In order to avoid or reduce impacts to the maximum extent practicable, the Navy implements marine mammal mitigation measures during most Navy training and testing activities that generate acoustic stressors (see Chapter 11, Mitigation Measures).

6.4.1 BACKGROUND

6.4.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to exposure to pressure waves. Injury due to exposure to non-explosive acoustic stressors such as sonar is discussed below. The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on injury (i.e., physical trauma) and the framework used to analyze this potential impact.

Several mechanisms of acoustically induced tissue damage (non-auditory) have been proposed and are discussed below.

6.4.1.1.1 Injury due to Sonar-Induced Acoustic Resonance

An object exposed to its resonant frequency will tend to amplify its vibration at that frequency, a phenomenon called acoustic resonance. Acoustic resonance has been proposed as a mechanism by which a sonar or sources with similar operating characteristics could damage tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the potential for acoustic resonance to occur in marine mammals (National Oceanic and Atmospheric Administration, 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding. The conclusions of the group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding in 2000. The frequency at which resonance was predicted to occur in the animals' lungs was 50 Hz, well below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the unrealistic scenario in which air volumes would be undamped (unrestrained) by surrounding tissues and the amplitude of the resonant response would be greatest. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance would not occur under realistic conditions during training and testing activities, and this type of impact is not considered further in this analysis.

6.4.1.1.2 Nitrogen Decompression

Marine mammals are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al., 2012).

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses have been hypothesized to result in nitrogen off-gassing in super-saturated tissues, possibly to the point of deleterious vascular and tissue bubble formation (Hooker et al., 2012; Jepson et al., 2003; Saunders et al., 2008) with resulting symptoms similar to decompression sickness (also known as "the bends"). The process has been under debate in the scientific community (Hooker et al., 2012; Saunders et al., 2008), although analyses of by-caught and drowned animals have demonstrated that nitrogen bubble formation can occur in animals that no longer exchange gas with the lungs (drowned) and which are brought to the surface, where tissues become supersaturated with nitrogen due to the reduction in hydrostatic pressure (Bernaldo de Quiros et al., 2013b; Moore et al., 2009). Deep-diving whales, such as beaked whales, have been predicted to have higher nitrogen loads in body tissues for certain modeled changes in dive behavior, which might make them more susceptible to decompression (Fahlman et al., 2014b; Fernandez et al., 2005; Hooker et al., 2012; Jepson et al., 2003).

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was 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 (Fernandez et al., 2005; Jepson et al., 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer & Tyack, 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al., 2005; Jepson et al., 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Aguilar de Soto et al., 2006; Hooker et al., 2009; Hooker et al., 2012; Tyack et al., 2006; Zimmer & Tyack, 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (Fahlman et al., 2014b). To examine the potential for gas bubble formation, a bottlenose dolphin was trained to dive repetitively to depths shallower than lung collapse to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al., 2009). To estimate risk of decompression sickness, Kvadsheim et al. (2012) modeled gas exchange in the tissues of sperm, pilot, killer, and beaked whales based on actual dive behavior during exposure to sonar in the wild. Results indicated that venous supersaturation was within the normal range for these species, which have naturally high levels of nitrogen loading.

Still, little is known about respiratory physiology of deep-diving breath-hold animals. Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins, contributing to tissue gas loads. Researchers have also considered the role of carbon dioxide accumulation produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, may facilitate the formation of bubbles in nitrogen saturated tissues (Bernaldo de Quiros et al., 2012; Fahlman et al., 2014b). Garcia Parraga et al. (2018) suggest that diving marine mammals have physiological and anatomical adaptations to control gas uptake above the depth of lung collapse, favoring oxygen uptake while minimizing nitrogen uptake. Under the hypothesis of Garcia Parraga et al. (2018), elevated activity due to a strong evasive response could lead to increased uptake of nitrogen, resulting in an increased risk of nitrogen decompression.

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 (i.e., tissues that take longer to give off nitrogen, e.g., fat and bone lipid) to the point that they are supersaturated when the animals are at the surface (Fahlman et al., 2014b; Hooker et al., 2009; Saunders et al., 2008). The presence of osteonecrosis (bone death due to reduced blood flow) in deep diving sperm whales has been offered as evidence of chronic supersaturation (Moore & Early, 2004). 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 in these tissues has been demonstrated in marine mammals drowned at depth as fisheries bycatch and brought to the surface (Moore et al., 2009). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation might be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al., 2009).

A fat embolic syndrome (out-of-place fat particles, typically in the bloodstream) 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. Although rare, similar findings have been found in the Risso's dolphin, another deep-diving species, but with presumably non-anthropogenic causes (Fernandez et al., 2017).

Dennison et al. (2012) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the livers of two of the 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 could be tolerated since the majority of stranded dolphins released did not re-strand.

The appearance of extensive bubble and fat emboli in beaked whales was unique to a small number of strandings associated with certain high-intensity sonar events; the phenomenon has not been observed to the same degree in other stranded marine mammals, including other beaked whale strandings not associated with sonar use. It is uncertain as to whether there is some mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Nevertheless, based on the rarity of observations of bubble pathology, the potential for nitrogen decompression sickness, or "the bends", is considered discountable.

6.4.1.1.3 Acoustically Induced Bubble Formation due to Sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum & Mao, 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors, including the sound pressure level (SPL) 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 they become emboli or cause localized tissue trauma, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway & Howard, 1979). The dive patterns of some marine mammals (e.g., beaked whales) are predicted to induce greater supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pulses would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of supersaturated 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. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005) by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 µPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for marine mammals (Fahlman et al., 2009; Fahlman et al., 2014b; Houser et al., 2001; Saunders et al., 2008), and such high exposure level would only occur in very close proximity to the most powerful sonars. It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings.

There has been considerable disagreement among scientists as to the likelihood of this phenomenon (Evans & Miller, 2003; Piantadosi & Thalmann, 2004). Although it has been argued that traumas from beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al., 2005; Jepson et al., 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Bernaldo de Quiros et al., 2012; Bernaldo de Quiros et al., 2013a; Bernaldo de Quiros et al., 2013b; Dennison et al., 2012; Moore et al., 2009).

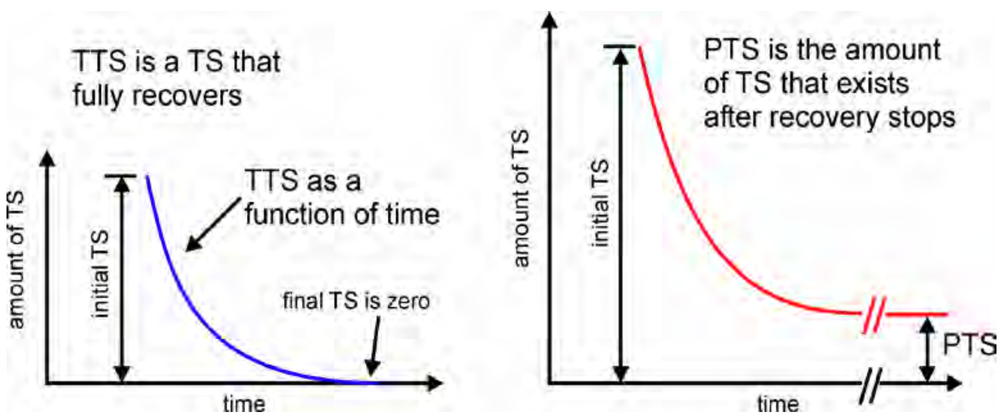
6.4.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative.

Hearing loss is typically quantified in terms of threshold shift (TS)—the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of TS measured usually decreases with increasing recovery time—the amount of time that has elapsed since a noise exposure. If the TS eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a TTS. If the TS does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining TS is called a PTS.

Figure 6.4-1 shows two hypothetical TSs: one that completely recovers, a TTS; and one that does not completely recover, leaving some PTS. By definition, TTS is a function of the recovery time, therefore recovery times are also taken into account. For example, a 20 dB TTS measured 24 hours post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only two minutes after exposure; if the TTS is 20 dB after 24 hours, the TTS measured after two minutes would likely be much higher. Conversely, if 20 dB of TTS was measured after two minutes, the TTS measured after 24 hours would likely be much smaller.

Studies have revealed that intense noise exposures may also cause auditory system injury that does not result in PTS (i.e., hearing thresholds return to normal after the exposure, but there is injury nonetheless). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure using electro-physiological methods, resulted in acute loss of nerve terminals and delayed degeneration of the cochlear nerve in mice. Lin et al. (2011) found a similar result in guinea pigs, that a TTS in auditory evoked potential of up to approximately 50 dB, measured 24 hours post-exposure, resulted in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury, since exposures producing high levels of TTS (40–50 dB measured 24 hours after exposure)—but no PTS—may result in auditory injury.



Notes: TTS = temporary threshold shift; TS = threshold shift; PTS = permanent threshold shift

Figure 6.4-1: Two Hypothetical Threshold Shifts

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). However, TTS and PTS are, by definition, mutually exclusive: an exposure that produces TTS cannot also produce PTS in the same individual; conversely, if an initial threshold shift only partially recovers, resulting in some amount of PTS, the difference between the initial TS and the PTS is not called TTS. As TTS increases, the likelihood that additional exposure SPL or duration would result in PTS or other injury also increases. Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS (i.e., although an exposure has been shown to produce only TTS, we assume that any additional exposure may result in some PTS or other injury). The specific upper limit of TTS is based on experimental data showing amounts of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury, we only need to know the upper limit for TTS before some PTS or injury is possible.

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40–50 dB may be induced without PTS, and that 40 dB is a precautionary upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al., 1965; Miller et al., 1963; Ward et al., 1958; Ward et al., 1959; Ward, 1960). It is reasonable to assume the same relationship would hold for marine mammals, since there are many similarities between the inner ears of marine and terrestrial mammals, and experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran et al., 2005a; Finneran, 2015; Ketten, 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately four minutes after exposure represent the limit of a non-injurious exposure (i.e., higher level exposures have the potential to cause auditory injury). Exposures sufficient to produce a TTS of 40 dB, measured approximately four minutes after exposure, therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS or other auditory injury, such as the delayed neural degeneration identified by Kujawa and Liberman (2009) and Lin et al. (2011) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in marine mammals (see Finneran, 2015). In these studies, hearing thresholds were measured in marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds was then used to determine the amount of TTS at various post-exposure times. The major findings from these studies include the following:

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological measures producing larger amounts of TTS compared to psychophysical measures (Finneran et al., 2007; Finneran, 2015).
- The amount of TTS varies with the hearing test frequency. As the exposure SPL increases, the frequency at which the maximum TTS occurs also increases (Kastelein et al., 2014b). For high-level exposures, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al., 2007; Mooney et al., 2009a; Nachtigall et al., 2004; Popov et al., 2011; Popov et al., 2013; Schlundt et al., 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range; i.e., narrowband exposures can produce broadband (greater than one octave) TTS.
- The amount of TTS increases with exposure SPL and duration, and is correlated with sound exposure level (SEL), especially if the range of exposure durations is relatively small (Kastak et al., 2007; Kastelein et al., 2014b; Popov et al., 2014). As the exposure duration increases, however, the relationship between TTS and SEL begins to break down. Specifically, duration has a more significant effect on TTS than would be predicted on the basis of SEL alone (Finneran et al., 2010a, 2010b; Kastak et al., 2005; Mooney et al., 2009a). This means if two exposures have the same SEL but different durations, the exposure with the longer duration (thus lower SPL) will tend to produce more TTS than the exposure with the higher SPL and shorter duration. In most acoustic impact assessments, the scenarios of interest involve shorter duration exposures than the marine mammal experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.
- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the

region of best sensitivity (Finneran & Schlundt, 2013). The onset of TTS—defined as the exposure level necessary to produce 6 dB of TTS (i.e., clearly above the typical variation in threshold measurements)—also varies with exposure frequency. At low frequencies onset-TTS exposure levels are higher compared to those in the region of best sensitivity.

- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al., 2010b; Kastelein et al., 2014d; Kastelein et al., 2015b; Mooney et al., 2009b). This means that TTS predictions based on the total, cumulative SEL will overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
  The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The 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) may require several days for recovery. Under many circumstances TTS recovers linearly with the logarithm of time (Finneran et al., 2010a, 2010b; Finneran & Schlundt, 2013; Kastelein et al., 2012a; Kastelein et al., 2012b; Kastelein et al., 2013a; Kastelein et al., 2014b; Kastelein et al., 2014c; Popov et al., 2011; Popov et al., 2013; Popov et al., 2014). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., 6 dB recovery per doubling of time).

Nachtigall et al. (2018) and Finneran (2018) describe the measurements of hearing sensitivity of multiple odontocete species (bottlenose dolphin, harbor porpoise, beluga, and false killer whale) when a relatively loud sound was preceded by a warning sound. These captive animals were shown to reduce hearing sensitivity when warned of an impending intense sound. Based on these experimental observations of captive animals, the authors suggest that wild animals may dampen their hearing during prolonged exposures or if conditioned to anticipate intense sounds. Finneran recommends further investigation of the mechanisms of hearing sensitivity reduction in order to understand the implications for interpretation of some existing temporary threshold shift data obtained from captive animals, notably for considering TTS due to short duration, unpredictable exposures. No modification of analysis of auditory impacts is currently suggested, as the Phase III auditory impact thresholds are based on best available data for both impulsive and non-impulsive exposures to marine mammals.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of man-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include some sonars and other transducers and impulsive sound sources such as air guns and impact pile driving.

6.4.1.2.1 Threshold Shift due to Sonar and Other Transducers

TTS in mid-frequency cetaceans exposed to non-impulsive sound has been investigated in multiple studies (Finneran et al., 2005b; Finneran et al., 2010a; Finneran & Schlundt, 2013; Mooney et al., 2009a; Mooney et al., 2009b; Nachtigall et al., 2003; Nachtigall et al., 2004; Popov et al., 2013; Popov et al., 2014; Schlundt et al., 2000) of two species, bottlenose dolphins and beluga whales. Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al., 2012b) and the finless porpoise (Neophocaena phocaenoides) (Popov et al., 2011). TTS from non-impulsive sounds has also been investigated in three pinniped species: harbor seal (Phoca vitulina), California sea lion (Zalophus californianus), and Northern elephant seal (Mirounga angustirostris) (e.g., Kastak et al., 2005; Kastelein et al., 2012a). These data are reviewed in detail in

Finneran (2015), as well as the Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) technical report (U.S. Department of the Navy, 2017b) and the major findings are summarized above.

6.4.1.3 Physiological Stress

The growing field of conservation physiology relies in part on the ability to monitor stress hormones in populations of animals, particularly those that are threatened or endangered. The ability to make predictions from stress hormones about impacts on individuals and populations exposed to various forms of stressors, natural and human-caused, relies on understanding the linkages between changes in stress hormones and resulting physiological impacts. At this time, the sound characteristics that correlate with specific stress responses in marine mammals are poorly understood, as are the ultimate consequences due to these changes. Navy-funded efforts are underway to try to improve our understanding and ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a). With respect to acoustically induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound [e.g., prior experience with a stressor may result in a reduced response due to habituation (Finneran & Branstetter, 2013; St. Aubin & Dierauf, 2001)]. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, the Navy assumes in its effect analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring toxins, lack of prey availability, and interactions with predators all contribute to the stress a marine mammal experiences (Atkinson et al., 2015). Breeding cycles, periods of fasting, social interactions with members of the same species, and molting (for pinnipeds) are also stressors, although they are natural components of an animal's life history. Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally (Fair et al., 2014; Meissner et al., 2015; Rolland et al., 2012). Anthropogenic stressors potentially include such things as fishery interactions, pollution, tourism, and ocean noise.

The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor (Moberg & Mench, 2000). The "fight or flight" response, an acute stress response, is characterized by the very rapid release of hormones that stimulate glucose release, increase heart rate, and increase oxygen consumption. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). The generalized stress response is classically characterized by the release of cortisol, a hormone that has many functions including elevation of blood sugar, suppression of the immune system, and alteration of the biochemical pathways that affect fat, protein, and carbohydrate metabolism. However, it is now known that the endocrine response (glandular secretions of hormones into the blood) to a stressor can extend to other hormones. For instance, thyroid hormones can also vary under the influence of certain stressors, particularly food deprivation. These types of responses typically occur on the order of minutes to days.

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. The endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al., 2015). For example, due to the necessity of breath-holding while diving and foraging at depth, the physiological role of the epinephrine and norepinephrine (the catecholamines) may have changed. Catecholamines increase during breath-hold diving in seals, co-occurring with a reduction in heart rate, peripheral vasoconstriction (constriction of blood vessels), and an increased reliance on anaerobic metabolism during extended dives (Hance et al., 1982; Hochachka et al., 1995; Hurford et al., 1996); the catecholamine increase is not associated with an increased heart rate, glycemic release, and increased oxygen consumption typical of terrestrial mammals. Other hormone functions may also be different, such as aldosterone, which has been speculated to not only contribute to electrolyte balance, but possibly also the maintenance of blood pressure during periods of vasoconstriction (Houser et al., 2011). In marine mammals, aldosterone is thought to play a particular role in stress mediation because of its pronounced increase in response to handling stress (St. Aubin & Dierauf, 2001; St. Aubin & Geraci, 1989).

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al., 1990b) but showed a small but statistically significant increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al., 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate a statistically significant elevation in aldosterone (Romano et al., 2004), albeit the increase was within the normal daily variation observed in this species (St. Aubin et al., 1996). Increases in heart rate were observed in bottlenose dolphins to which known calls of other dolphins were played, although no increase in heart rate was observed when background tank noise was played back (Miksis et al., 2001). Unfortunately, in this study, it cannot be determined whether the increase in heart rate was due to stress or an anticipation of being reunited with the dolphin to which the vocalization belonged. Similarly, a young beluga's heart rate was observed to increase during exposure to noise, with increases dependent upon the frequency band of noise and duration of exposure, and with a sharp decrease to normal or below normal levels upon cessation of the exposure (Lyamin et al., 2011). Spectral analysis of heart rate variability corroborated direct measures of heart rate (Bakhchina et al., 2017). This response might have been due in part to the conditions during testing, the young age of the animal, and the novelty of the exposure; a year later the exposure was repeated at a slightly higher received level and there was no heart rate response, indicating the beluga whale had potentially acclimated to the noise exposure. Kvadsheim et al. (2010) measured the heart rate of captive hooded seals during exposure to sonar signals, and found an increase in the heart rate of the seals during exposure periods vs. control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, Thompson et al. (1998) observed a rapid but short-lived decrease in heart rates in harbor and grey seals exposed to seismic air guns (cited in Gordon et al., 2003). Williams et al. (2017) monitored the heart rates of narwhals released from capture and found that a profound dive bradycardia persisted, even though exercise effort increased dramatically as part of their escape response following release. Thus, although some limited evidence suggests that tachycardia might occur as part of the acute stress response of animals that are at the surface, the dive bradycardia persists during diving and might be enhanced in response to an acute stressor (Williams et al., 2015).

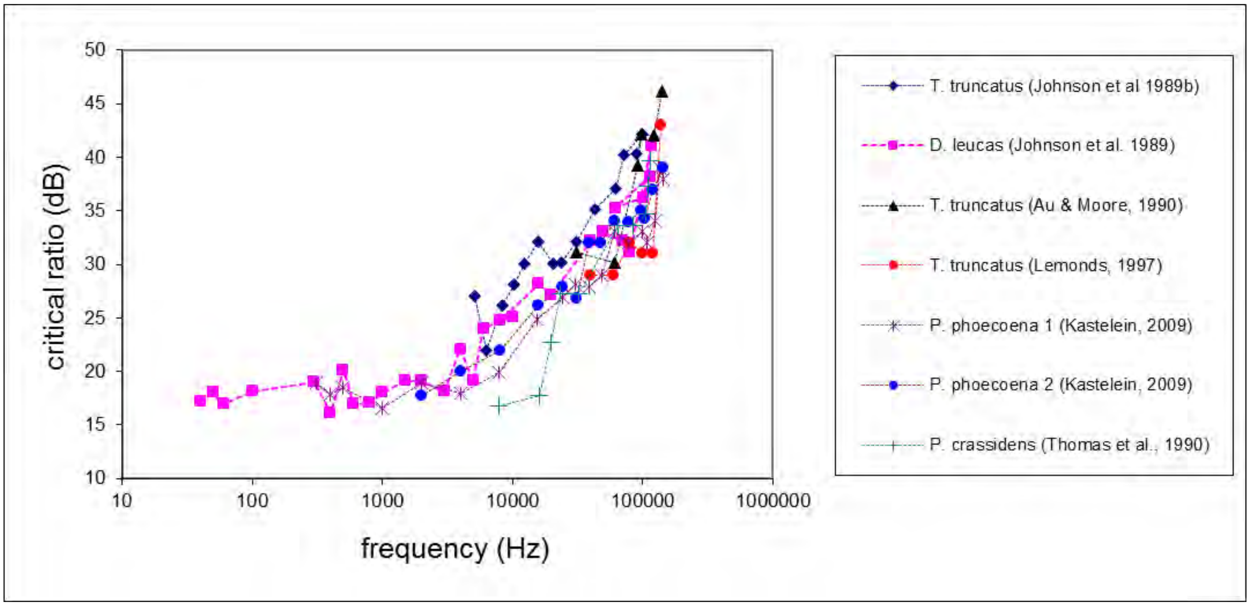
Whereas a limited amount of work has addressed the potential for acute sound exposures to produce a stress response, almost nothing is known about how chronic exposure to acoustic stressors affects stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly prohibited in the region where fecal collections were made and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al., 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (Bain, 2002; Erbe, 2002; Lusseau, 2006; Noren et al., 2009; Pirotta et al., 2015b; Read et al., 2014; Rolland et al., 2012; Williams et al., 2006; Williams et al., 2009; Williams et al., 2014a; Williams et al., 2014b). Most of these efforts focused primarily on estimates of metabolic costs associated with altered behavior or inferred consequences of boat presence and noise, but did not directly measure stress hormones. However, Ayres et al. (2012) investigated Southern Resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone measures that the lack of prey overshadowed any population-level physiological impacts on Southern Resident killer whales due to vessel traffic. Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise. Nevertheless, although the reduced presence of the ships themselves cannot be ruled out as potentially contributing to the reduction in fecal cortisol metabolites in North Atlantic right whales, the work of Rolland et al. (2012) represents the most provocative link between ocean noise and cortisol in cetaceans to date.

6.4.1.4 Masking

Masking occurs when one sound, distinguished as the “noise,” interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal (e.g., Lombard effect, or increasing amplitude or changing frequency) and behavior changes (e.g., cessation of foraging, leaving an area) to both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al., 2016).

Critical ratios are the lowest signal-to-noise ratio in which detection occurs (Finneran & Branstetter, 2013; Johnson et al., 1989; Southall et al., 2000). When expressed in dB, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 $\mu Pa^2/Hz$) from the signal level (in dB re 1 μPa) at threshold. Critical ratios have been measured for pinnipeds (Southall et al., 2000, 2003), odontocetes (Figure 6.4-2) (Au & Moore, 1990; Johnson et al., 1989; Kastelein & Wensveen, 2008; Lemonds et al., 2011; Thomas et al., 1990a), manatees (Gaspard et al., 2012), and sea otters (Ghoul & Reichmuth, 2014).

Critical ratios are directly related to the bandwidth of auditory filters and as a result, critical ratios increase as a function of signal frequency (Au & Moore, 1990; Lemonds et al., 2011). Higher-frequency noise is more effective at masking higher-frequency signals. Although critical ratios are typically estimated in controlled laboratory conditions using Gaussian (white) noise, critical ratios can vary considerably depending on the noise type (Branstetter et al., 2013; Trickey et al., 2010).



Source: from Finneran and Branstetter (2013)

Figure 6.4-2: Critical Ratios (in dB) Measured in Different Odontocetes Species

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 a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar de Soto et al. (2006) found that a 15 dB increase in background noise due to vessels led to a communication range of only 18 percent of its normal value for foraging beaked whales. This method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2016) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, noise-source location, distance relative to each other, and received level of the call.

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 and include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin & Parks, 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (Gordon et al., 2003; Holt et al., 2008; Holt et al., 2011; Lesage et al., 1999; McDonald et al., 2009; Rolland et al., 2012) as well as changes in the natural acoustic environment (Dunlop et al., 2014). Cholewiak et al. (2018) estimated communication space loss of baleen whales in Stellwagen National Sanctuary, assuming historical ambient noise levels were 10 dB lower than current measured levels of categories of vessel noise. Considering the combined exposure to all types of vessel noise, the authors estimated that right whale gun shot calls were the most robust with only about 5 percent loss of communication space, while fin and humpback whales (social sounds) lost 99 percent of communication space. Vocal changes can be temporary, or can be permanent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen & Parks, 2016) This shift in frequency was modeled, and it was found that it led to increased detection ranges between right whales; the frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 km to over 9 km (Tennessen & Parks, 2016). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al., 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may also move beyond vocal modifications (Dunlop et al., 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a different location to improve binaural cues (time or intensity differences between the ears due to a sound source's location relative to the animal's head), or going still to reduce noise associated with hydrodynamic flow. The structure of some noises (e.g., amplitude modulation) may also provide some release from masking through comodulation masking release (the difference in masking when a noise is broadband versus having the same bandwidth as the signal) (Branstetter & Finneran, 2008; Branstetter et al., 2013). Signal characteristics (e.g., whether the signal has harmonics, or is frequency modulated) may further enhance the detectability of a signal in noise (Cunningham et al., 2014).

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators (Allen et al., 2014; Cummings & Thompson, 1971; Curé et al., 2015; Fish & Vania, 1971), which may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and identification of predator cues are impeded. For example, sperm whales (Isojunno et al., 2016), long-finned pilot whales (Visser et al., 2016), and humpback whales (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks; these findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

6.4.1.4.1 Masking as a Result of Sonar and Other Transducers

Masking as a result of duty-cycled low-frequency or mid-frequency active sonar with relatively low duty cycles is unlikely for most cetacean and pinnipeds, as sonar tones occur over a relatively short duration and narrow bandwidth that does not overlap with vocalizations for most marine mammal species. While dolphin vocalizations can occur in the same bandwidth as mid-frequency active sonar, the duty cycle of most low-frequency and mid-frequency active sonars are low enough that delphinid whistles might be masked only a small percentage of the time they are whistling, and so masking by sonar would not likely have any short- or long-term consequences. Low-frequency active sonar could also overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, 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.

Newer high duty cycle or continuously active sonars also have more potential to mask vocalizations, particularly for delphinids and other mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, acoustic sources such as pingers that operate at higher repetition rates (e.g., 2–10 kHz with harmonics up to 19 kHz, 76 to77 pings per minute (Culik et al., 2001)), also operate at lower source levels. While the lower source levels of these systems limits the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high duty cycle systems operate overlaps the vocalization frequency of a number of mid-frequency cetaceans. Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g., killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g., vessel noise and low-frequency cetaceans), and will likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm & Slabbekoorn, 2005; Hotchkin & Parks, 2013) and behavioral impacts, such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al., 2003). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al., 2004; Parks et al., 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm & Slabbekoorn, 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm & Slabbekoorn, 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al., 2003).

6.4.1.5 Behavioral Reactions

As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) of the MITT Draft SEIS/OEIS, any stimulus in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels and sonar, but could also include the physical presence of a vessel or aircraft. However, these stimuli could also influence how or if a marine mammal responds to the presence of predators, prey, or conspecifics. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al., 2011). The distance from the sound source and whether it is 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 et al. (1995). Other reviews (Gomez et al., 2016; Nowacek et al., 2007; Southall et al., 2007) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated, and also examined the role of context.

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; Southall et al., 2016). Ellison et al. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context," as described, greatly influences the type of behavioral response exhibited by the animal (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b). Forney et al. (2017) also point out that an apparent lack of response (e.g., no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS, or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitable for foraging, resting, or socializing.

Behavioral reactions could result from a variety of sound sources, including impulsive sources such as explosives or non-impulsive sources such as sonar and other transducers (e.g., pingers). For some of these noise sources numerous studies exist (e.g., sonar), whereas for others the data are sparse (e.g., explosives), and surrogate sound sources must be relied upon to assess the potential for behavioral response. Similarly, there is data on the reactions of some species in different behavioral states, providing evidence on the importance of context in gauging a behavioral response. However, for most species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b).

6.4.1.5.1 Behavioral Reactions to Sonar and other Transducers

Sonar and other transducers can range in frequency from less than 1 kHz (e.g., low-frequency active sonar) to over 200 kHz (e.g., fish finders), with duty cycles that range from one ping per minute to an almost continuous sound. Although very-high-frequency sonars are out of the hearing range of most marine mammals, some of these sources may contain artifacts at lower frequencies that could be detected (Deng et al., 2014; Hastie et al., 2014). High duty cycle sonar systems operate at lower source levels, but with a more continuous sound output. These sources can be stationary or on a moving platform, and there can be more than one source present at a time. Guan et al. (2017) also found that sound levels in the mid-frequency sonar bandwidth remained elevated at least 5 dB above background levels for the first 7–15 seconds (within 2 km) after the emission of a sonar ping; depending on the length of the sonar ping and the inter-ping interval, this reverberation could increase cumulative SEL estimates during periods of active sonar. This variability in parameters associated with sonar and other transducers makes the estimation of behavioral responses to these sources difficult, with observed responses ranging from no apparent change in behavior to more severe responses that could lead to some costs to the animal. As discussed in this request for authorization in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities) and Section 6.4.1.5 (Behavioral

Reactions), responses may also occur in the presence of different contextual factors regardless of received level, including the proximity and number of vessels, the behavioral state and prior experience of an individual, and even characteristics of the signal itself or the propagation of the signal through the environment.

In order to explore this complex question, behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, United States (off Southern California), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to understand better their potential impacts. While controlling for as many variables as possible (e.g., the distance and movement of the source), these studies also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, distances of the sound source from the whales during behavioral response studies were always within 1–8 km. Some of these studies have suggested that ramping-up a source from a lower source level would act as a mitigation measure to protect against higher order (e.g., TTS or PTS) impacts of sonar; however, this practice may only be effective for more responsive animals, and for short durations (e.g., 5 minutes) of ramp up (von Benda-Beckmann et al., 2014; von Benda-Beckmann et al., 2016). Therefore, while these studies have provided the most information to date on behavioral responses of marine mammals to sonar, there are still many contextual factors to be teased apart, and determining what might produce a significant behavioral response is not a trivial task.

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos & Richlen, 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Martin et al., 2015; McCarthy et al., 2011; Mobley & Deakos, 2015; Moretti et al., 2014; Tyack et al., 2011). In addition, extensive aerial, visual, and passive acoustic monitoring have been conducted before, during, and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Farak et al., 2011; HDR, 2011; Norris et al., 2012; Smultea & Mobley, 2009; Smultea et al., 2009; Trickey et al., 2015; U.S. Department of the Navy, 2011b, 2013d, 2014a, 2015a). During all of these monitoring efforts, very few behavioral responses were observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event; e.g., Smultea et al., 2011). While passive acoustic studies are limited to detections of vocally active marine mammals, and visual studies are limited to what can be observed at the surface, these study types have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies. Furthermore, when visual and passive acoustic data collected during a training event are combined with ship movements and sonar use, and with tagged animal data when possible, they provide a unique and realistic scenario for analysis, as in Falcone et al. (2017), Manzano-Roth et al. (2016) or Baird et al. (2017b). In addition to these types of observational behavioral response studies, Harris & Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonars and other transducers beyond behavioral response-type studies or passive acoustic monitoring, including conducting controlled exposures on captive animals with scaled (smaller sized and deployed at closer proximity) sources, on wild animals with both scaled and real but directed sources, and predator playback studies, all of which will be discussed below.

The above behavioral response studies and observations have been conducted on a number of mysticete and odontocete species, which can be extrapolated to other similar species in these taxonomic groups. No field studies of pinniped behavioral responses to sonar have been conducted; however, there are several captive studies on some pinniped and odontocete species that can provide insight into how these animals may respond in the wild. The captive studies typically represent a more controlled approach, which allow researchers to better estimate the direct impact of the received level of sound leading to behavioral responses, and to potentially link behavioral to physiological responses. However, there are still contextual factors that must be acknowledged, including previous training to complete tasks and the presence of food rewards upon completion. There are no corresponding captive studies on mysticete whales, therefore some of the responses to higher level exposures must be extrapolated from odontocetes.

6.4.1.5.1.1 Mysticetes

The responses of mysticetes to sonar and other duty-cycled tonal sounds are highly dependent upon the characteristics of the signal, the behavioral state of the animal, the particular sensitivity and previous experience of an individual, and other contextual factors, including distance of the source, movement of the source, and the physical presence of vessels in addition to the sonar (Goldbogen et al., 2013; Harris et al., 2015; Martin et al., 2015; Sivle et al., 2015). Behavioral response studies have been conducted over a variety of contextual and behavioral states, helping to identify which contextual factors may lead to a response beyond just the received level of the sound. Observed reactions during behavioral response studies have not been consistent across individuals based on received sound levels alone, and likely were the result of complex interactions between these contextual factors.

Surface feeding blue whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 µPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (DeRuiter et al., 2017; Goldbogen et al., 2013; Sivle et al., 2015). Similarly, while the rates of foraging lunges decreased in humpback whales due to sonar exposure, there was variability in the response across individuals, with one animal ceasing to forage completely and another animal starting to forage during the exposure (Sivle et al., 2016). In addition, lunges decreased (although not significantly) during a no-sonar control vessel approach prior to the sonar exposure, and lunges decreased less during a second sonar approach than during the initial approach, possibly indicating some response to the vessel and some habituation to the sonar and vessel after repeated approaches. In the same experiment, most of the non-foraging humpback whales did not respond to any of the approaches (Sivle et al., 2016). These humpback whales also showed variable avoidance responses, as some animals avoided the sonar vessel during the first exposure but not the second, while others avoided the sonar during the second exposure, and only one avoided both. In addition, almost half of the animals that avoided the sonar vessel were foraging before the exposure; the animals that avoided the sonar vessel while not feeding responded at a slightly lower received level and greater distance than those that were feeding (Wensveen et al., 2017). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al., 2016). However, even when responses did occur the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al., 2013; Sivle et al., 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al., 2014). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives; in this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4500 Hz, was long in duration (lasting several minutes), and was purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al., 2004). Although the animals' received SPL was similar in the latter two studies (133–150 dB re 1 μPa^2s), the frequency, duration, and temporal pattern of signal presentation were different.

Humpback whales in another behavioral response experiment in Australia also responded to a 2 kHz tone stimulus by changing their course during migration to move more offshore and surfaced more frequently, but otherwise did not respond (Dunlop et al., 2013). Humpback whales in the Norwegian behavioral response study may have habituated slightly between the first and second sonar exposure (Sivle et al., 2015), and actually responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks. Several humpback whales have been observed during aerial or visual surveys during Navy training events involving sonar; no avoidance or other behavioral responses were ever noted, even when the whales were observed within 5 km of a vessel with active (or possibly active) sonar and maximum received levels were estimated to be between 135 and 161 dB re 1 µPa (Mobley & Milette, 2010; Mobley, 2011; Mobley & Pacini, 2012; Mobley et al., 2012; Smultea et al., 2009). In fact, one group of humpback whales approached a vessel with active sonar so closely that the sonar was shut down and the vessel slowed; the animals continued approaching and swam under the bow of the vessel (U.S. Department of the Navy, 2011a). Another group of humpback whales continued heading towards a vessel with active sonar as the vessel was moving away for almost 30 minutes, with an estimated median received level of 143 dB re 1 µPa. This group was observed producing surface active behaviors such as pec slaps, tail slaps and breaches; however, these are very common behaviors in competitive pods during the breeding season and were not considered to have occurred in response to the sonar (Mobley et al., 2012).

The strongest baleen whale response in any behavioral response study was observed in a minke whale in the 3S2 study, which responded at 146 dB re 1 µPa by strongly avoiding the sound source (Kvadsheim et al., 2017; Sivle et al., 2015). Although the minke whale increased its swim speed, directional movement and respiration rate, none of these were greater than rates observed in baseline behavior, and its dive behavior remained similar to baseline dives. A minke whale tagged in the Southern California BRS study also responded by increasing its directional movement, but maintained its speed and dive patterns, and so did not demonstrate as strong of a response(Kvadsheim et al., 2017). In addition, the 3S2 minke whale demonstrated some of the same avoidance behavior during the controlled ship approach with no sonar, indicating at least some of the response was to the vessel (Kvadsheim et al., 2017). Martin et al. (2015) found that the density of calling minke whales was reduced during periods of Navy training involving sonar relative to the periods before training, and increased again in the days after training was completed. The responses of individual whales could not be assessed, so in this case it is unknown whether the decrease in calling animals indicated that the animals left the range, or simply ceased calling. Similarly, minke whale detections made using Marine Acoustic Recording Instruments off Jacksonville, FL, were reduced or ceased altogether during periods of sonar use (Norris et al., 2012; U.S. Department of the Navy, 2013d), especially with an increased ping rate (Charif et al., 2015). Two minke whales also stranded in shallow water after the U.S. Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations, therefore no final conclusions were drawn on whether the sonar led to their stranding (Filadelfo et al., 2009a; Filadelfo et al., 2009b; U.S. Department of Commerce & U.S. Department of the Navy, 2001).

Baleen whales have also been exposed to lower frequency sonars, with the hypothesis that these whales may react more strongly to lower frequency sounds that overlap with their vocalization range. One series of studies was undertaken in 1997–1998 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. The frequency bands of the low-frequency sonars used were between 100 and 500 Hz, with received levels between 115 and 150 dB re 1 µPa, and the source was always stationary. Fin and blue whales were targeted on foraging grounds, singing humpback whales were exposed on breeding grounds, and gray whales were exposed during migratory behavior. These studies found only short-term responses to low-frequency sound by some fin and humpback whales, including changes in vocal activity and avoidance of the source vessel, while other fin, humpback, and blue whales did not respond at all. When the source was in the path of migrating gray whales they changed course up to 2 km to avoid the sound, but when the source was outside their path, little response was observed although received levels were similar (Clark & Fristrup, 2001; Croll et al., 2001; Fristrup et al., 2003; Miller et al., 2000; Nowacek et al., 2007). Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were also not found to affect dive times of humpback whales in Hawaiian waters (Frankel & Clark, 2000).

Opportunistic passive acoustic based studies have also detected behavioral responses to sonar, although definitive conclusions are harder to draw. 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, beginning at received levels of 110−120 dB re 1 µPa (Melcón et al., 2012); however, without visual observations it is unknown whether there was another factor that contributed to the reduction in foraging calls, such as the presence of conspecifics. In another example, Risch et al. (2012) determined that humpback whale song produced in the Stellwagen Bank National Marine Sanctuary was reduced, and since the timing was concurrent with an Ocean Acoustic Waveguide Remote Sensing experiment occurring 200 km away, they concluded that the reduced song was a result of the Ocean Acoustic Waveguide Remote Sensing. However, Gong et al. (2014) analyzed the same data set while also looking at the presence of herring in the region, and found that the singing humpbacks were actually located on nearby Georges Bank and not on Stellwagen, and that the song rate in their data did not change in response to Ocean Acoustic Waveguide Remote Sensing but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other transducers (e.g., the single minke whale), for the most part mysticete responses appear to be fairly moderate across all received levels. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the signal stopped. Mysticete responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would never be introduced in real Navy testing and training scenarios. While data are lacking on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al., 2004), suggesting that they are likely to have similar responses to high duty cycle sonars. Therefore, mysticete behavioral responses to Navy sonar will likely be a result of the animal's behavioral state and prior experience rather than external variables such as ship proximity; thus, if significant behavioral responses occur they will likely be short term. In fact, no significant behavioral responses such as panic, stranding or other severe reactions have been observed during monitoring of actual training exercises (Smultea et al., 2009; U.S. Department of the Navy, 2011b, 2014b; Watwood et al., 2012).

6.4.1.5.1.2 Odontocetes

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge et al., 2009; Defence Science and Technology Laboratory, 2007; Falcone et al., 2017; Henderson et al., 2015a; Henderson et al., 2015b; Henderson et al., 2016; Manzano-Roth et al., 2013; McCarthy et al., 2011; Moretti et al., 2009; Southall et al., 2011; Southall et al., 2012; Southall et al., 2013; Southall et al., 2014; Southall et al., 2015; Tyack et al., 2011). Through analyses of these behavioral response studies, a preliminary overarching effect of greater sensitivity to most anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al., 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, longer deep and shallow dive durations, and other unusual dive behavior (Boyd et al., 2008; Defence Science and Technology Laboratory, 2007; DeRuiter et al., 2013b; Miller et al., 2015; Southall et al., 2011; Stimpert et al., 2014; Tyack et al., 2011). A similar response was observed in a northern bottlenose whale, which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over seven hours (Miller et al., 2015). Responses occurred at received levels between 95 and 150 dB re 1 µPa; although all of these exposures occurred within 1–8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few km to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (DeRuiter et al., 2013b). Falcone et al. (2017) modeled deep and shallow dive durations, surface interval durations, and inter-deep dive intervals of Cuvier's beaked whales against predictor values that included helicopter-dipping, mid-power mid-frequency active sonar and hull-mounted, high-power mid-frequency active sonar along with other, non-mid-frequency active sonar predictors. They found both shallow and deep dive durations to increase as the proximity to both mid- and high-powered sources decreased, and found surface intervals and inter-deep dive intervals to also increase in the presence of both types of sonars, although surface intervals shortened during periods of no mid-frequency active sonar. The responses to the mid-power mid-frequency active sonar at closer ranges were comparable to the responses to the higher source level ship sonar, again highlighting the importance of proximity. This study also supports context as a response factor, as helicopter-dipping sonars are shorter duration and randomly located; consequently, they are more difficult for beaked whales to predict or track and therefore potentially more likely to cause a response, especially when they occur at closer distances (6 to 25 km in this study). Watwood et al. (2017) found that helicopter-dipping events occurred more frequently but with shorter durations than periods of hull-mounted sonar, and also found that the longer the duration of a sonar event, the greater reduction in detected Cuvier's beaked whale group dives. Therefore, when looking at the number of detected group dives, there was a greater reduction during periods of hull-mounted sonar than during helicopter-dipping sonar. Long-term tagging work has demonstrated that the longer duration dives considered a behavioral response by DeRuiter et al. (2013b) fell within the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Falcone et al., 2017; Schorr et al., 2014). However, the longer inter-deep dive intervals found by DeRuiter et al. (2013b), which were among the longest found by Schorr et al. (2014) and Falcone et al. (2017), could indicate a response to sonar. In addition, Williams et al. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in DeRuiter et al. (2013b), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams (2017) was higher.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge et al., 2009; Manzano-Roth et al., 2016; Manzano-Roth et al., 2013; McCarthy et al., 2011; Moretti et al., 2009; Tyack et al., 2011). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long-term consequences of the sonar activity. Similarly, photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone et al., 2009; Falcone & Schorr, 2014).

Beaked whales may respond similarly to shipboard echosounders, commonly used for navigation, fisheries, and scientific purposes, with frequencies ranging from 12 to 400 kHz and source levels up to 230 dB re 1 µPa but typically a very narrow beam (Cholewiak et al., 2017). During a scientific cetacean survey, an array of echosounders was used in a one-day-on, one-day-off paradigm. Beaked whale acoustic detections occurred predominantly (96 percent) when the echosounder was off, with only 4 detections occurring when it was on. Beaked whales were sighted fairly equally when the echosounder was on or off, but sightings were further from the ship when the echosounder was on (Cholewiak et al., 2017). These findings indicate that the beaked whales may be avoiding the area and may cease foraging near the echosounder.

Tyack et al. (2011) hypothesized that beaked whale responses to sonar may represent an anti-predator response. To test this idea, vocalizations of a potential predator—a killer whale—were also played back to a Blainville's beaked whale. This exposure resulted in a similar but more pronounced reaction than that elicited by sonar playback, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area (Allen et al., 2014; Tyack et al., 2011). This anti-predator hypothesis was also tested by playing back killer whale vocalizations to pilot whales, sperm whales, and even other killer whales, to determine responses by both potential prey and conspecifics (Miller et al., 2011; Miller, 2012). Results varied, from no response by killer whales to an increase in group size and attraction to the source in pilot whales (Cure et al., 2012).

While there has been a focus on beaked whale responses to sonar, other species have been studied during behavioral response studies as well, including pilot whales, killer whales, and sperm whales. Responses by these species have also included horizontal avoidance, changes in behavioral state, and changes in dive behavior (Antunes et al., 2014; Miller et al., 2011; Miller, 2012; Miller et al., 2014). Additionally, separation of a killer whale calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al., 2011). Received level thresholds at the onset of avoidance behavior were generally higher for pilot whales (mean 150 dB re 1µPa) and sperm whales (mean 140 dB re 1µPa) than killer whales (mean 129 dB re 1µPa) (Antunes et al., 2014; Miller, 2012; Miller et al., 2014). A close examination of the tag data from the Norwegian groups showed that responses seemed to be behaviorally or signal frequency mediated. For example, killer whales only changed their dive behavior when doing deep dives at the onset of 1−2 kHz sonar (sweeping across frequencies), but they did not change their dive behavior if they were deep diving during 6−7 kHz sonar (sweeping across frequencies). Nor did they change their dive behavior if they were conducting shallow dives at the onset of either type of sonar. Similarly, pilot whales and sperm whales performed normal deep dives during 6–7 kHz sonar, while during 1−2 kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al., 2012b). In addition, pilot whales were also more likely to respond to lower received levels when non-feeding than feeding during 6−7 kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during 1−2 kHz sonar exposures. Furthermore, pilot whales exposed to a 38 kHz downward-facing echosounder did not change their dive and foraging behavior during exposure periods, although the animals' heading variance increased and fewer deep dives were conducted (Quick et al., 2017). In contrast, killer whales were more likely to respond to either sonar type when non-feeding than when feeding (Harris et al., 2015). These results again demonstrate that the behavioral state of the animal mediates the likelihood of a behavioral response, as do the characteristics (e.g., frequency) of the sound source itself.

Other responses during behavioral response studies included the synchronization of pilot whale surfacings with sonar pulses during one exposure, possibly as a means of mitigating the sound (Wensveen et al., 2015), and mimicry of the sonar with whistles by pilot whales (Alves et al., 2014), false killer whales (DeRuiter et al., 2013b) and Risso's dolphins (Smultea et al., 2012). In contrast, in another study melon-headed whales had "minor transient silencing" (a brief, non-lasting period of silence) after each 6−7 kHz signal, and (in a different oceanographic region) pilot whales had no apparent response (DeRuiter et al., 2013a). The probability of detecting delphinid vocalizations (whistles, clicks, and buzzes) increased during periods of sonar relative to the period prior to sonar in a passive acoustic study using Marine Autonomous Recording Units in the Jacksonville Range Complex, while there was no impact of sonar to the probability of detecting sperm whale clicks (Charif et al., 2015; U.S. Department of the Navy, 2013b).

In addition, killer whale sighting data from the same region in Norway as the behavioral response study were used to compare the presence or absence of whales from other years against the period with sonar. The authors found a strong relationship between the presence of whales and the abundance of herring, and only a weak relationship between the whales and sonar activity (Kuningas et al., 2013). Baird et al. (2013b; 2014; Baird et al., 2017a) also tagged four shallow-diving odontocete species (rough-toothed dolphins, pilot whales, bottlenose dolphins, and false killer whales) in Hawaii off the Pacific Missile Range Facility before Navy training events. None of the tagged animals demonstrated a large-scale avoidance response to the sonar as they moved on or near the range, in some cases even traveling towards areas of higher noise levels, while estimated received SPLs varied from 130 to 168 dB re 1 µPa and distances from sonar sources ranged between 3.2 and 94.4 km. However, one pilot whale did have reduced dive rates (from 2.6 dives per hour before to 1.6 dives per hour during) and deeper dives (from a mean of 124 m to a mean of 268 m) during a period of sonar exposure. (Baird et al., 2016) also tagged four short-finned pilot whales from both the resident island-associated population and from the pelagic population. The core range for the pelagic population was over 20 times larger than for the pelagic population, leading (Baird et al., 2013b) to hypothesize that that likelihood of exposure to mid-frequency active sonar, and therefore the potential for response, would be very different between the two populations. These diverse examples demonstrate that responses can be varied, are often context- and behaviorally driven, and can be species and even exposure specific.

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to 220 dB re1 µPa (Bowles et al., 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington exhibited what were believed by some observers to be aberrant behaviors, during which time the USS Shoup was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the USS Shoup transmissions (Fromm, 2009; National Marine Fisheries Service, 2005; U.S. Department of the Navy, 2003) estimated a mean received SPL of approximately 169 dB re 1 µPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 µPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that “Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close” (National Oceanic and Atmospheric Administration Fisheries, 2014). Several odontocete species, including bottlenose dolphins, Risso’s dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and leaving the area, and at the highest received levels animals were not present in the area at all (Henderson et al., 2014). However, these observations were conducted from a vessel off-range, and so any observed responses could not be attributed to the sonar with any certainty. Research on sperm whales in the 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 & Schevill, 1975; Watkins et al., 1985). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bowride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (HDR, 2011; U.S. Department of the Navy, 2011a; Watwood et al., 2012). During small boat surveys near the Southern California Offshore Range in southern California, more dolphins were encountered in June compared to a similar survey conducted the previous November after seven days of mid-frequency sonar activity; it was not investigated if this change was due to the sonar activity or was a seasonal difference that was also observed in other years (Campbell et al., 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the MIRC, with the post-activity absence lasting longer than the mean dolphin absence of two days when sonar was not present (Munger et al., 2014; Munger et al., 2015).

Acoustic harassment devices and acoustic deterrent devices that transmit sound into the acoustic environment similar to Navy sonar, have been used to deter marine mammals from fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a 10 kHz tone and one with a broadband 30–160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and 40 percent for the tone, and while there was some gradual habituation after the first 2–4 exposures, longer-term exposures (over 28 days) showed no evidence of additional habituation. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins & Schevill, 1975). However, acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 µPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner & Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive or simulate a predator or are otherwise predictive of a threat are more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases net pingers may create a "dinner bell effect," where marine mammals have learned to associate the signal with the availability of prey (Jefferson & Curry, 1996; Schakner & Blumstein, 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales since these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta et al., 2008; Schakner & Blumstein, 2013). Similarly, a 12 kHz acoustic harassment device intended to scare seals was ineffective at deterring seals but effectively caused avoidance in harbor porpoises out to over 500 m from the source, highlighting different species- and device-specific responses (Mikkelsen et al., 2017). Additional behavioral studies have been conducted with captive harbor porpoises using 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). These studies have found that high-frequency sources with varied duration, interval, and sweep characteristics can prove to be effective deterrents for harbor porpoises (Kastelein et al., 2017). Van Beest et al. (2017) modeled the long-term, population-level impacts of fisheries bycatch, pinger deterrents, and time-area closures on a population of harbor porpoises. They found that when pingers were used alone (in the absence of gillnets or time-area closures), the animals were deterred from the area often enough to cause a population level reduction of 21 percent, greater even than the modeled level of current bycatch impacts. However, when the pingers were coupled with gillnets in the model, and time-area closures were also used (allowing a net- and pinger-free area for the porpoises to move into while foraging), the population only experienced a 0.8 percent decline even with current gillnet use levels. This demonstrates that, when used correctly, pingers can successfully deter porpoises from gillnets without leading to any negative impacts.

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to 3 kHz sonar-like tones between 115 and 185 dB re 1 µPa (Houser et al., 2013), and in another study bottlenose dolphins and beluga whales were presented with 1-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al., 2001; Finneran et al., 2003a; Finneran & Schlundt, 2004; Finneran et al., 2005b; Schlundt et al., 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location 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). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over 10 trials. In the TTS study bottlenose dolphins exposed to one-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa, 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 animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Behavioral responses to a variety of sound sources have been studied in harbor porpoises, including acoustic alarms (Kastelein et al., 2006; Kastelein et al., 2001), emissions for underwater data transmission (Kastelein et al., 2005), and tones, including 1–2 kHz and 6–7 kHz sweeps with and without harmonics (Kastelein et al., 2014d), and 25 kHz with and without sidebands (Kastelein et al., 2015c; Kastelein et al., 2015d). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1–2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6–7 kHz tonal at the same level (Kastelein et al., 2014d). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for 1–2 kHz and 6–7 kHz sweeps respectively when no harmonics were present, and decreased to 90 dB re 1 μPa for 1–2 kHz sweeps with harmonics present (Kastelein et al., 2014d). Harbor porpoises responded to seal scarers with broadband signals up to 44 kHz with a slight respiration response at 117 dB re 1 μPa and an avoidance response at 139 dB re 1 μPa, but another scarer with a fundamental (strongest) frequency of 18 kHz did not have an avoidance response until 151 dB re 1 μPa (Kastelein et al., 2014a). Exposure of the same acoustic pinger 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, although sample sizes in these studies was small so these could reflect individual differences as well. Additionally, Kastelein et al. (2018) exposed captive harbor porpoises to mid-frequency sonar to investigate reactions at varying duty cycles. Neither porpoise responded to the lower duty cycle, and only one of the porpoises responded to the high duty cycle at several levels. Both animals jumped more at the high duty cycle and highest received level. The investigators also indicated that there was no habituation or sensitization across the exposure periods. These received levels are similar to previous levels at which harbor porpoises have responded to sonar and do not change the current conclusions.

Behavioral responses by odontocetes to sonar and other transducers appear to range from no response at all to responses that could potentially lead to long-term consequences for individual animals (e.g., mother-calf separation). This is likely in part due to the fact that this taxonomic group is so broad and includes some of the most sensitive species (e.g., beaked whales and harbor porpoise) as well as some of the least sensitive species (e.g., bottlenose dolphins). This is also the only group for which both field behavioral response studies and captive controlled exposure experiments have been conducted, leading to the assessment of both contextually driven responses as well as dose-based responses. This wide range in both exposure situations and individual- and species-sensitivities makes reaching general conclusions difficult. However, it does appear as though exposures in close proximity, with multiple vessels that approach the animal, lead to higher-level responses in most odontocete species regardless of received level or behavioral state. In contrast, in more "real-world" exposure situations, with distant sources moving in variable directions, behavioral responses appear to be driven by behavioral state, individual experience or species-level sensitivities. These responses may also occur more in-line with received level such that the likelihood of a response would increase with increased received levels. However, these "real-world" responses are more likely to be short term, lasting the duration of the exposure or even shorter as the animal assesses the sound and (based on prior experience or contextual cues) determines a threat is unlikely. Therefore, while odontocete behavioral responses to Navy sonar will vary across species, populations, and individuals, they are not likely to lead to long-term consequences or population-level effects.

6.4.1.6 Stranding

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 & Lounsbury, 2005). When a marine mammal (alive or dead) 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 & Lounsbury, 2005; Perrin & Geraci, 2002). A stranding can also occur away from the shore if the animal is unable to cope in its present situation (e.g., disabled by a vessel strike, out of habitat) (Geraci & Lounsbury, 2005). Specifically, under U.S. law, a stranding 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 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. section 1421h).

Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, and aging (Bradshaw et al., 2006; Culik, 2004; Geraci et al., 1999; Geraci & Lounsbury, 2005; Huggins et al., 2015; National Research Council, 2006; Perrin & Geraci, 2002; Walker et al., 2005). Anthropogenic factors include pollution (Hall et al., 2006; Jepson et al., 2005), vessel strike (Geraci & Lounsbury, 2005; Laist et al., 2001), fisheries interactions (Read et al., 2006), entanglement (Baird & Gorgone, 2005; Saez et al., 2013), human activities (e.g., feeding, gunshot) (Geraci & Lounsbury, 2005; Dierauf & Gulland, 2001), and noise (Cox et al., 2006; National Research Council, 2003; Richardson et al., 1995). For some stranding events, environmental factors (e.g., ocean temperature and wind speed and geographic conditions) can be utilized in predictive models to aid in understanding why marine mammals strand in certain areas more than others (Berini et al., 2015). In most instances, even for the more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for strandings remains undetermined.

Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment, such as naval operations and seismic surveys. An in-depth discussion of strandings is in the Navy's *Technical Report on Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (U.S. Department of the Navy, 2017a).

Sonar use during exercises involving the U.S. Navy 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 (Cox et al., 2006; Fernandez, 2006; U.S. Department of the Navy, 2017a). These five mass strandings have resulted in about 40 known cetacean deaths, consisting mostly of beaked whales and with close linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a potential indirect cause of death of the marine mammals (Cox et al., 2006). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather have typically been attributed to natural or anthropogenic factors. The Navy has reviewed training requirements, standard operating procedures, and possible mitigation measures and implemented changes to reduce the potential for acoustic related strandings to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 11 (Mitigation Measures), which details all mitigation measures.

Multiple hypotheses regarding the relationship between non-impulsive sound exposure and stranding have been proposed. These range from direct impact of the sound on the physiology of the marine mammal, to behavioral reactions contributing to altered physiology (e.g., "gas and fat embolic syndrome" (Fernandez et al., 2005; Jepson et al., 2003; Jepson et al., 2005), to behaviors directly contributing to the stranding (e.g., beaching of fleeing animals). Unfortunately, without direct observation of not only the event but also the underlying process, and the potential for artefactual evidence (e.g., chronic condition, previous injury) to complicate conclusions from the post-mortem analyses of stranded animals (Cox et al., 2006), it has not been possible to determine with certainty the exact mechanism underlying these strandings.

Historically, stranding reporting and response efforts have been inconsistent, although they have improved considerably over the last 25 years. Although reporting forms have been standardized nationally, data collection methods, assessment methods, detail of reporting, and procedures vary by region and are not yet standardized across the United States. Conditions such as weather, time, location, and decomposition state may also affect the ability to thoroughly examine a specimen (Carretta et al., 2016b; Moore et al., 2013). Because of this, the current ability to interpret long-term trends in marine mammal stranding is limited. While the investigation of stranded animals provides insight into the types of threats marine mammal populations face, investigations are only conducted on a small fraction of the total number of strandings that occur, limiting our understanding of the causes of strandings (Carretta et al., 2016a; Carretta et al., 2017a; Helker et al., 2017). Although many marine mammals likely strand due to natural or anthropogenic causes, the majority of reported type of occurrences in marine mammal strandings in the Pacific include fisheries interactions, entanglement, vessel strike, and predation.

6.4.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate (see discussion in Section 6.2, Conceptual Framework for Assessing Effects from Sound-Producing Activities). Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual, or for very small populations, to the population as a whole (e.g., Hawaiian monk seals; however, short-term costs may be recouped during the life of an otherwise healthy individual). These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; 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. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). Mysticetes in the northeast tended to adjust to vessel traffic over a number a 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. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found 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.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. West Coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound, including the use of sonar by the U.S. Navy; however, new data has been published raising uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to 2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, 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. Individuals may move off the range for several days during and following a sonar event, but return within a few days (McCarthy et al., 2011; Tyack et al., 2011). Photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to seven years apart (Falcone et al., 2009; Falcone & Schorr, 2014). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates, and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard, however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of which was associated with her second calf, and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of km by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km south to Mexico and back again. Given that some beaked whales may routinely move hundreds of km as part of their normal pattern (Schorr et al., 2014), temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

Another approach to determining long-term consequences of anthropogenic noise exposure has been an attempt to link short-term effects to individuals from anthropogenic stressors with long-term consequences to populations using population models. 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. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and, ultimately, population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population, have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council 2005) proposes a conceptual model 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. In 2009, the U.S. Office of Naval Research set up a working group to transform the PCAD framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al., 2016a; Costa et al., 2016b; Harwood & King, 2014; Hatch et al., 2012; King et al., 2015; McHuron et al., 2018; New et al., 2013a; New et al., 2013b; New et al., 2014; Pirotta et al., 2018). Currently, the Population Consequences of Disturbance model provides a theoretical framework and identifies types of data that would be needed to assess population-level impacts using this process. The process is complicated and provides a foundation for the type of data that is needed, which is currently lacking for many marine mammal species. Relevant data needed for improving these analytical approaches for population-level consequences resulting from disturbances will continue to be collected during projects funded by the Navy's marine species monitoring program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance, can lead to markedly different impact results. For example, Costa (2016a) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was over 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Energetic costs were estimated for western gray whales that migrated to possible wintering grounds near China or to the Baja California wintering grounds of eastern gray whales versus the energetic costs of the shorter migration of eastern gray whales (Villegas-Amtmann et al., 2017). Researchers found that when the time spent on the breeding grounds was held constant for both populations, the energetic requirements for the western gray whales were estimated to be 11 percent and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance (Costa et al., 2016b).

Pirotta et al. (2018) modeled one reproductive cycle of a female North Pacific blue whale, starting with leaving the breeding grounds off Baja California to begin migrating north to feeding grounds off California, and ending with her return to the breeding grounds, giving birth, and lactating. They modeled this scenario with no disturbance and found 95 percent calf recruitment, under a "normal" environmental perturbation (El Niño-Southern Oscillation) there was a very small reduction in recruitment, and under an "unprecedented" environmental change, recruitment was reduced to 69 percent. An intense, localized anthropogenic disturbance was modeled (although the duration of the event was not provided); if the animals were not allowed to leave the area they did not forage and recruitment dropped to 63 percent. However, if animals could leave the area of the disturbance then there was almost no change to the recruitment rate. Finally, a weak but broader spatial disturbance, where foraging was reduced by 50 percent, caused only a small decrease in calf recruitment to 94 percent.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises, and, even under the worst-case scenarios, predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to two days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis et al. (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent reduction in population size over six years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy-dense prey and high-quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy dense prey or high quality habitat. Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions.

Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only a 0.4 percent population decline in the following year). McHuron et al. (2018) modeled the introduction of a generalized disturbance at different times throughout the breeding cycle of California sea lions, with the behavior response being an increase in the duration of a foraging trip by the female. Very short duration disturbances or responses led to little change, particularly if the disturbance was a single event, and changes in the timing of the event in the year had little effect. However, with even relatively short disturbances or mild responses, when a disturbance was modeled as recurring there were resulting reductions in population size and pup recruitment. Often, the effects weren't noticeable for several years, as the impacts on pup recruitment didn't affect the population until those pups were mature.

It should be noted that in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population-level effects.

The best assessment of long-term consequences from Navy training and testing activities will be to monitor the populations over time within the Study Area. A U.S. workshop on Marine Mammals and Sound (Fitch et al., 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed and implemented comprehensive monitoring plans since 2009 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 mitigation measures. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (Martin et al., 2017); preliminary results of this analysis at the Pacific Missile Range Facility off Kauai, Hawaii indicate no changes in detection rates for several species over the past decade, demonstrating that Navy activities may not be having long-term population-level impacts. This type of analysis can be expanded to the other Navy ranges, such as the MIRC. Continued analysis of this 15 -year dataset and additional monitoring efforts over time are necessary to fully understand the long-term consequences of exposure to military training and testing activities.

6.4.2 Impacts from Sonar and Other Transducer Stressors

Sonar and other transducers proposed for use could be used throughout the Study Area. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 1.4.1 (Acoustic Stressors).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 6.4.1.1 (Injury). Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is so unlikely as to be discountable under normal conditions and is therefore not considered further in this analysis.

The most probable impacts from exposure to sonar and other transducers are PTS, TTS, behavioral reactions, masking, and physiological stress (Sections 6.4.1.2, Hearing Loss; 6.4.1.3, Physiological Stress; and 6.4.1.5, Behavioral Reactions).

6.4.2.1 Methods for Analyzing Impacts from Sonars and Other Transducers

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be affected by sonars and other transducers used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on sea turtles and marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times that animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures.

The steps of this quantitative analysis are described in the MITT Draft SEIS/OEIS, Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts on Sea Turtles and Marine Mammals), which takes into account the following:

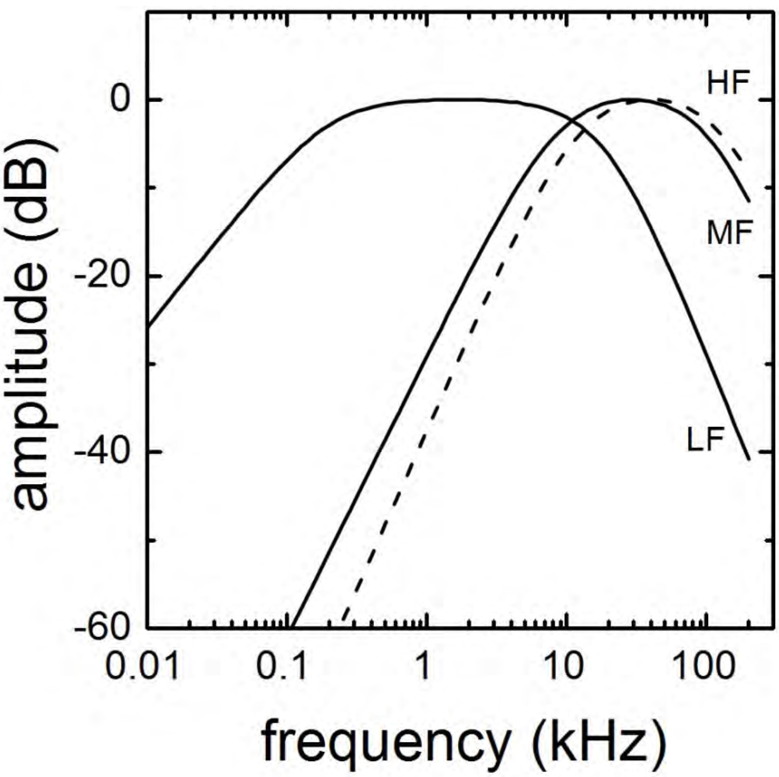
- criteria and thresholds used to predict impacts from sonar and other transducers (see below)
- the density and spatial distribution of marine mammals
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation when estimating the received sound level on the animals

A detailed explanation of this analysis is provided in the technical report titled *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a).

6.4.2.1.1 Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers

Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used (Figure 6.4-3). Auditory weighting functions are mathematical functions that adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges with less or no auditory sensitivity. They are based on a generic band pass filter and incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL. Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

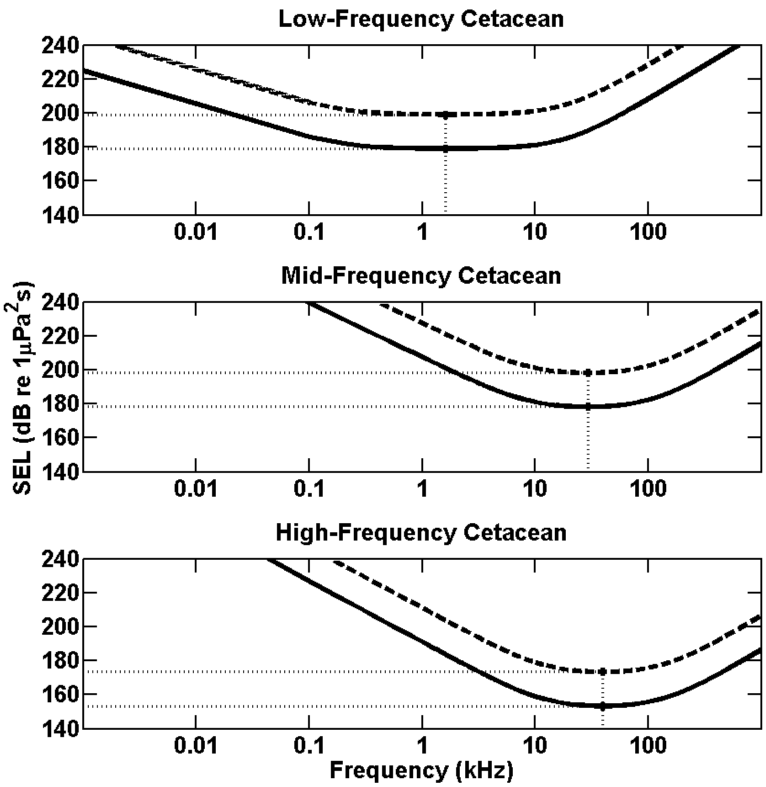


Notes: HF = High-Frequency Cetacean, LF = Low-Frequency Cetacean, and MF = Mid-Frequency Cetacean. For parameters used to generate the functions and more information on weighting function derivation see U.S. Department of the Navy (2017d).

Figure 6.4-3: Navy Weighting Functions for All Species Groups in the MITT Study Area

Hearing Loss from Sonar and Other Transducers

Defining the TTS and PTS exposure functions (Figure 6.4-4) requires identifying the weighted exposures necessary for TTS and PTS onset from sounds produced by sonar and other transducers. The criteria used to define threshold shifts from non-impulsive sources (e.g., sonar) determines TTS onset as the SEL necessary to induce 6 dB of threshold shift. A sound exposure level 20 dB above the onset of TTS is used in all hearing groups of marine mammals underwater to define the PTS threshold (Southall et al., 2007).



Note: The solid curve is the exposure function for TTS onset and the large dashed curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL threshold for TTS and PTS onset in the frequency range of best hearing.

Figure 6.4-4: TTS and PTS Exposure Functions for Sonar and Other Transducers

Behavioral Responses from Sonar and Other Transducers

Behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response to sonar and other transducers. See the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2017b) for detailed information on how the Behavioral Response Functions were derived. Developing the new behavioral criteria involved multiple steps. All peer-reviewed published behavioral response studies conducted both in the field and on captive animals were examined in order to understand the breadth of behavioral responses of marine mammals to sonar and other transducers.

The data from the behavioral studies were analyzed by looking for significant responses, or lack thereof, for each experimental session. The terms "significant response" or "significant behavioral response" are used in describing behavioral observations from field or captive animal research that may rise to the level of "harassment" for military readiness activities. Under the MMPA, for military readiness activities, such as Navy training and testing, behavioral "harassment" is: "any act that *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*." (16 U.S.C. section 1362(3)(18)(B).

The likelihood of injury due to disruption of normal behaviors would depend on many factors, such as the duration of the response, what the animal is being diverted from, and life history of the animal. Due to the nature of behavioral response research to date, it is not currently possible to ascertain the types of observed reactions that would lead to an abandonment or significant alteration of a natural behavior pattern. Therefore, the Navy has developed a methodology to estimate the possible significance of behavioral reactions and impacts on natural behavior patterns.

Behavioral response severity is described herein as "low," "moderate," or "high." These are derived from the Southall et al. (2007) severity scale. Low-severity responses are those behavioral responses that fall within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Low-severity responses include an orientation or startle response, change in respiration, change in heart rate, and change in group spacing or synchrony.

Moderate-severity responses could become significant if sustained over a longer duration. What constitutes a long-duration response is different for each situation and species, although it is likely dependent upon the magnitude of the response and species characteristics such as age, body size, feeding strategy, and behavioral state at the time of the exposure. In general, a response could be considered "long-duration" if it lasted for a few tens of minutes to a few hours, or enough time to significantly disrupt an animal's daily routine.

Moderate severity responses included

- alter migration path
- alter locomotion (speed, heading)
- alter dive profiles
- stop/alter nursing
- stop/alter breeding
- stop/alter feeding/foraging
- stop/alter sheltering/resting
- stop/alter vocal behavior if tied to foraging or social cohesion
- avoidance of area near sound source

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured, so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case. High-severity responses include those responses with immediate consequences (e.g., stranding, mother-calf separation), and were always considered significant behavioral reactions regardless of duration.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 6.4-5 through Figure 6.4-7). In most cases, these divisions are driven by taxonomic classifications (e.g., mysticetes, odontocetes). The Odontocete group combines most of the mid- and high-frequency cetaceans, without the beaked whales. These groups are combined as there are not enough data to separate them for behavioral responses.

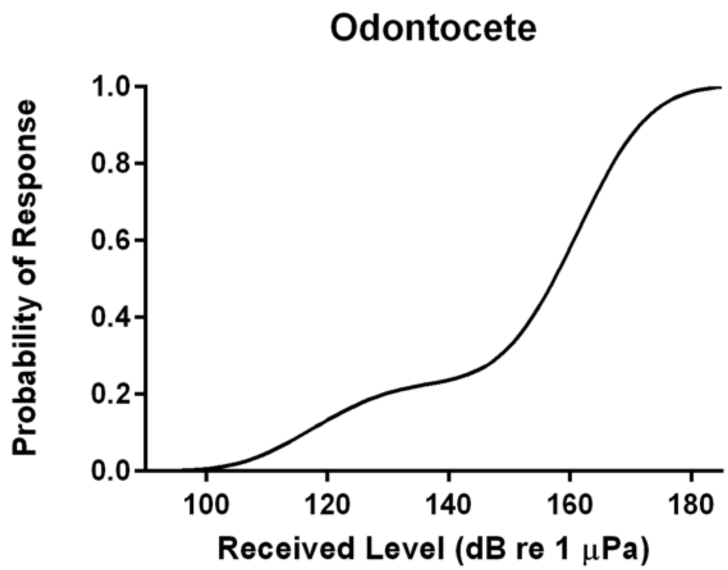


Figure 6.4-5: Behavioral Response Function for Odontocetes

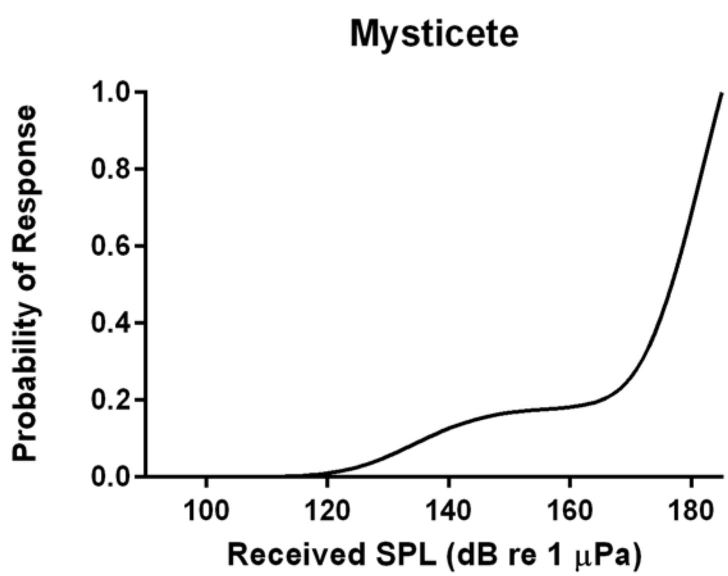


Figure 6.4-6: Behavioral Response Function for Mysticetes

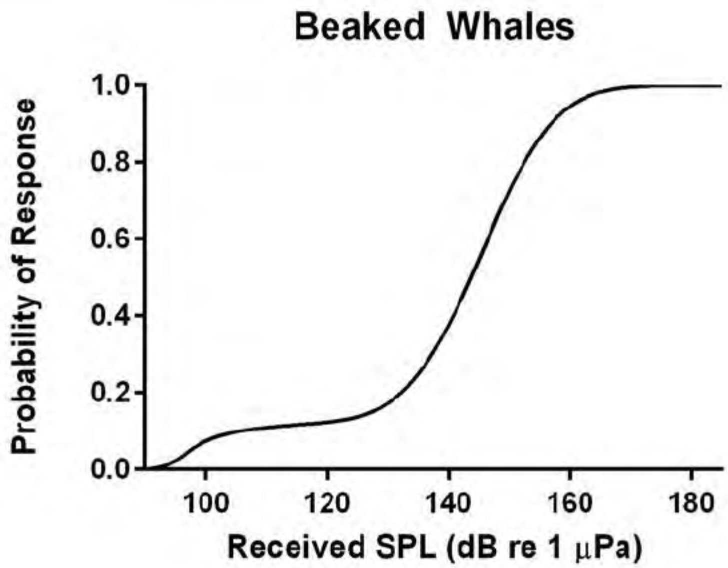


Figure 6.4-7: Behavioral Response Function for Beaked Whales

For all taxa, distances beyond which significant behavioral responses to sonar and other transducers are unlikely to occur, denoted as "cutoff distances," were defined based on existing data (Table 6.4-1). The distance between the animal and the sound source is a strong factor in determining that animal's potential reaction (e.g., DeRuiter et al., 2013b). For training and testing events that contain multiple platforms or tactical sonar sources that exceed 215 dB re 1 µPa @ 1 m, this cutoff distance is substantially increased (i.e., doubled) from values derived from the literature. The use of multiple platforms and intense sound sources are factors that probably increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances; therefore, the Navy will conservatively predict significant behavioral responses at further ranges for these more intense activities.

Table 6.4-1: Cutoff Distances for Moderate Source Level, Single Platform Training and Testing Events and for All Other Events with Multiple Platforms or Sonar with Source Levels at or Exceeding 215 dB re 1 µPa @ 1 m

Criteria Group	*Moderate SL/Single Platform Cutoff Distance*	*High SL/Multi-Platform Cutoff Distance*
Odontocetes	10 km	20 km
Mysticetes	10 km	20 km
Beaked Whales	25 km	50 km

6.4.2.1.2 Assessing the Severity of Behavioral Responses from Sonar

As discussed above, the terms "significant response" or "significant behavioral response" are used in describing behavioral reactions that may lead to an abandonment or significant alteration of a natural behavior pattern. Due to the limited amount of behavioral response research to date and relatively short durations of observation, it is not possible to ascertain the true significance of the majority of the observed reactions. When deriving the behavioral criteria, it was assumed that most reactions that lasted for the duration of the sound exposure or longer were significant, even though many of the exposures lasted for 30 minutes or less. Furthermore, the experimental designs used during many of the behavioral response studies were unlike Navy activities in many important ways. These differences include tagging subject animals, following subjects for sometimes hours before the exposure, vectoring towards the subjects after animals began to avoid the sound source, and making multiple close passes on focal groups. This makes the estimated behavioral impacts from Navy activities using the criteria derived from these experiments difficult to interpret. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b), the Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

The estimated behavioral reactions from the Navy's quantitative analysis are grouped into several categories based on the most powerful sonar source, the number of platforms, the duration, and geographic extent of each Navy activity attributed to the predicted impact. Activities that occur in often-used areas of the ocean require special consideration due to the potential for repeated activities in these areas.

Low-severity responses are within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Although the derivation of the Navy's behavioral criteria did not count low-severity responses as significant behavioral responses, in practice, some reactions estimated using the behavioral criteria are likely to be low severity (Figure 6.4-8).

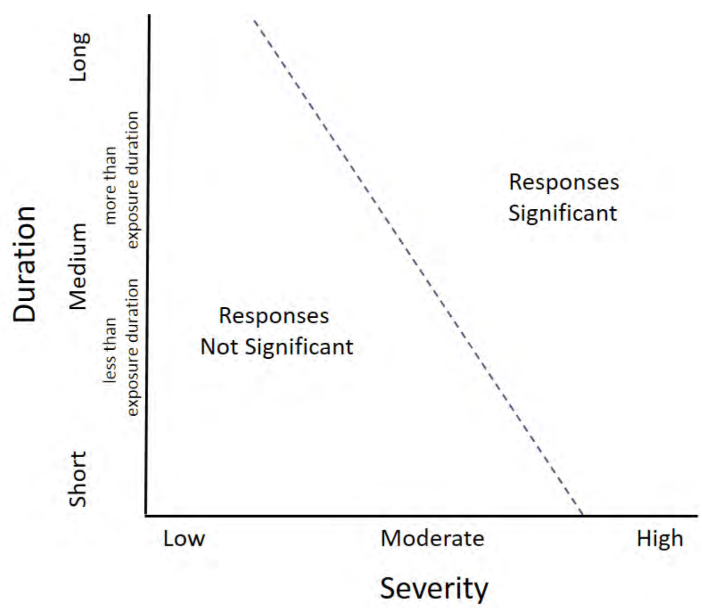


Figure 6.4-8: Relative Likelihood of a Response Being Significant Based on the Duration and Severity of Behavioral Reactions

High-severity responses are those with a higher potential for direct consequences to growth, survivability, or reproduction. Examples include prolonged separation of females and dependent offspring, panic, flight, stampede, or stranding. High-severity reactions would always be considered significant; however these types of reactions are probably rare under most conditions and may still not lead to direct consequences on survivability. For example, a separation of a killer whale mother-calf pair was observed once during a behavioral response study to an active sonar source (Miller et al., 2014), but the animals were rejoined as soon as the ship had passed. Therefore, although this was a severe response, it did not lead to a negative outcome. Five beaked whale strandings have also occurred associated with U.S. Navy active sonar use as discussed above (Section 6.4.1.6, Stranding), but the confluence of factors that contributed to those strandings is now better understood, and the avoidance of those factors has resulted in no known marine mammal strandings associated with U.S. Navy sonar activities for over a decade.

The Navy is unable to predict these high-severity responses for any activities since the probability of occurrence is apparently very low, although the Navy acknowledges that severe reactions could occasionally occur. In fact, no significant behavioral responses such as panic, stranding, or other severe reactions have been observed during monitoring of actual training or testing activities.

The responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate-severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As mentioned previously, the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate-severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sonar that may exceed an animal's behavioral threshold for only a single ping to several minutes. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b), the Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

6.4.2.1.3 The Navy's Acoustic Effects Model

The Navy's Acoustic Effects Model calculates sound energy propagation from sonar and other transducers during naval activities and the sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals distributed in the area around the modeled naval activity; each records its individual sound "dose." The model bases the distribution of animats over the Study Area on the density values in the Navy Marine Species Density Database and distributes animats in the water column proportional to the known time that species spend at varying depths.

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. The number of animats that exceed the thresholds for effects is tallied to provide an estimate of the number of marine mammals that could be affected.

Assumptions in the Navy model intentionally err on the side of overestimation when there are unknowns. Naval activities are modeled as though they would occur regardless of proximity to marine mammals (i.e., mitigation is not modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of procedural mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures.

The model estimates the impacts caused by individual training and testing exercises. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances that marine mammals may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances in which an effect threshold was exceeded over the course of a year, but it does not estimate the number of individual marine mammals that may be impacted over a year (i.e., some marine mammals could be impacted several times, while others would not experience any impact). A detailed explanation of the Navy's Acoustic Effects Model is provided in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a).

6.4.2.1.3.1 Accounting for Mitigation

The Navy will implement at-sea procedural mitigation measures to avoid or reduce potential impacts from active sonar (described in Chapter 11, Mitigation Measures). Procedural mitigation measures include a power down or shut down (i.e., power off) of applicable active sonar sources when a marine mammal is observed in a mitigation zone. The mitigation zones for active sonar activities were designed to avoid or reduce the potential for marine mammals to be exposed to levels of sound that could result in auditory injury (i.e., PTS) from active sonar to the maximum extent practicable. The mitigation zones for active sonar extend beyond the respective average ranges to auditory injury (including PTS). Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of procedural mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a).

In the quantitative analysis, consideration of mitigation measures means that, for activities that implement mitigation, some model-estimated PTS is considered mitigated to the level of TTS. The impact analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the range to PTS was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals within a mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. For example, based on small boat surveys between 2000 and 2012 in the Hawaiian Islands, pantropical spotted dolphins and striped dolphins were frequently observed leaping out of the water and Cuvier's beaked whales (Baird, 2013) and Blainville's beaked whales (HDR, 2012) were occasionally observed breaching. These behaviors are visible from a great distance and likely increase sighting distances and detections of these species. Environmental conditions under which the training or testing activity could take place are also considered such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

6.4.2.1.3.2 Marine Mammal Avoidance of Sonar and other Transducers

Because a marine mammal is assumed to initiate avoidance behavior after an initial startle reaction when exposed to relatively high-received levels of sound, a marine mammal could reduce its cumulative sound energy exposure over a sonar event with multiple pings (i.e., sound exposures). This would reduce risk of both PTS and TTS, although the quantitative analysis conservatively only considers the potential to reduce instances of PTS by accounting for marine mammals swimming away to avoid repeated high-level sound exposures. All reductions in PTS impacts from likely avoidance behaviors are instead considered TTS impacts.

6.4.2.2 Impact Ranges for Sonar and Other Transducers

The following section provides range to effects for sonar and other transducers to specific criteria determined using the Navy Acoustic Effects Model. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting acoustic impacts, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will be mitigated within applicable mitigation zones.

The ranges to the PTS threshold for exposures of 30 seconds are shown in Table 6.4-2 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 m per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to the maximum distance at which PTS is possible for each hearing group. For a SQS-53C (i.e., bin MF1) sonar transmitting for 30 seconds at 3 kHz and a source level of 235 dB re 1 μPa^2-s at 1 m, the average range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 181 m. PTS ranges for all other functional hearing groups, besides high-frequency cetaceans, are much shorter. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 and 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 m per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

For the other functional hearing groups in the Study Area (low-frequency cetaceans and mid-frequency cetaceans), 30-second average PTS zones are substantially shorter. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship; however, the close distances required make PTS exposure unlikely. For a Navy vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to suffer PTS.

Tables 6.4-3 through 6.4-7 below illustrate the range to TTS for one, 30, 60, and 120 seconds from five representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to add together, further increasing the range to onset-TTS.

Table 6.4-2: Range to Permanent Threshold Shift for Five Representative Sonar Systems

Hearing Group	*Approximate PTS (from 30 seconds) Ranges (meters)*[1]				
	Sonar bin HF4	*Sonar bin LF4L*	*Sonar bin MF1*	*Sonar bin MF4*	*Sonar bin MF5*
High-frequency cetaceans	29 (22–35)	0 (0–0)	181 (180–190)	30 (30–30)	9 (8–10)
Low-frequency cetaceans	0 (0–0)	0 (0–0)	65 (65–65)	15 (15–15)	0 (0–0)
Mid-frequency cetaceans	1 (0–1)	0 (0–0)	16 (16–16)	3 (3–3)	0 (0–0)

[1] PTS ranges extend from the sonar or other active acoustic sound source to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parenthesis.

Table 6.4-3: Ranges to Temporary Threshold Shift for Sonar Bin LF4L over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin LF4M			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Low-frequency cetaceans	3 (3–3)	4 (4–4)	6 (6–6)	9 (9–9)
Mid-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Table 6.4-4: Ranges to Temporary Threshold Shift for Sonar Bin MF1 over a Representative Range of Environments Within the Study Area

Hearing Group	Approximate TTS Ranges (meters)[1] Sonar Bin MF1			
	1 second	30 seconds	60 seconds	120 seconds
High-frequency cetaceans	3,181 (2,025–5,025)	3,181 (2,025–5,025)	5,298 (2,275–7,775)	6,436 (2,525–9,775)
Low-frequency cetaceans	898 (850–1,025)	898 (850–1,025)	1,271 (1,025–1,525)	1,867 (1,275–3,025)
Mid-frequency cetaceans	210 (200–210)	210 (200–210)	302 (300–310)	377 (370–390)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Note: Ranges for 1-second and 30-second periods are identical for Bin MF1 because this system nominally pings every 50 seconds; therefore, these periods encompass only a single ping.

Table 6.4-5: Ranges to Temporary Threshold Shift for Sonar Bin MF4 over a Representative Range of Environments Within the Study Area

Hearing Group	Approximate TTS Ranges (meters)[1] Sonar Bin MF4			
	1 second	30 seconds	60 seconds	120 seconds
High-frequency cetaceans	232 (220–260)	454 (420–600)	601 (575–875)	878 (800–1,525)
Low-frequency cetaceans	85 (85–90)	161 (160–170)	229 (220–250)	352 (330–410)
Mid-frequency cetaceans	22 (22–22)	35 (35–35)	50 (45–50)	70 (70–70)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Table 6.4-6: Ranges to Temporary Threshold Shift for Sonar Bin MF5 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF5			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	114 (110–130)	114 (110–130)	168 (150–200)	249 (210–290)
Low-frequency cetaceans	11 (10–12)	11 (10–12)	16 (16–17)	23 (23–24)
Mid-frequency cetaceans	5 (0–9)	5 (0–9)	12 (11–13)	18 (17–18)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

Table 6.4-7: Ranges to Temporary Threshold Shift for Sonar Bin HF4 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin HF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	155 (110–210)	259 (180–350)	344 (240–480)	445 (300–600)
Low-frequency cetaceans	1 (0–2)	2 (1–3)	4 (3–5)	7 (5–8)
Mid-frequency cetaceans	10 (7–12)	17 (12–21)	24 (17–30)	33 (25–40)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.

The range to received sound levels in 6 dB steps from five representative sonar bins and the percentage of animals that may exhibit a significant behavioral response under each behavioral response function (or step function in the case of the harbor porpoise) are shown in Table 6.4-8 through Table 6.4-12, respectively. See Section 6.4.2.1 (Methods for Analyzing Impacts from Sonars and Other Transducers) for details on the derivation and use of the behavioral response functions, thresholds, and the cutoff distances.

Table 6.4-8: Ranges to a Potentially Significant Behavioral Response for Sonar Bin LF4L over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 µPa²-s)	*Minimum Range (m) with Minimum and Maximum Values in Parenthesis*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Beaked Whales*
196	1 (1–1)	100%	100%	100%
190	3 (3–3)	100%	98%	100%
184	6 (6–6)	99%	88%	100%
178	12 (12–12)	97%	59%	100%
172	25 (25–25)	91%	30%	99%
166	51 (50–55)	78%	20%	97%
160	130 (130–160)	58%	18%	93%
154	272 (270–300)	40%	17%	83%
148	560 (550–675)	29%	16%	66%
142	1,048 (1,025–1,525)	25%	13%	45%
136	2,213 (1,525–4,525)	23%	9%	28%
130	4,550 (2,275–24,025)	20%	5%	18%
124	16,903 (4,025–66,275)	17%	2%	14%
118	43,256 (7,025–87,775)	12%	1%	12%
112	60,155 (7,775–100,000*)	6%	0%	11%
106	80,689 (8,775–100,000*)	3%	0%	11%
100	92,352 (9,025–100,000*)	1%	0%	8%

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, m = meters
* Indicates maximum range to which acoustic model was run, a distance of approximately 100 kilometers from the sound source. Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 6.4-1 for behavioral cut-off distances).

Table 6.4-9: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF1 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 μPa²-s)	*Minimum Range (m) with Minimum and Maximum Values in Parenthesis*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Beaked Whales*
196	106 (100–110)	100%	100%	100%
190	240 (240–250)	100%	98%	100%
184	501 (490–525)	99%	88%	100%
178	1,019 (975–1,025)	97%	59%	100%
172	3,275 (2,025–5,275)	91%	30%	99%
166	7,506 (2,525–11,025)	78%	20%	97%
160	15,261 (4,775–20,775)	58%	18%	93%
154	27,759 (5,525–36,525)	40%	17%	83%
148	43,166 (7,525–65,275)	29%	16%	66%
142	58,781 (8,525–73,525)	25%	13%	45%
136	71,561 (11,275–90,775)	23%	9%	28%
130	83,711 (13,025–100,000*)	20%	5%	18%
124	88,500 (23,525–100,000*)	17%	2%	14%
118	90,601 (27,025–100,000*)	12%	1%	12%
112	92,750 (27,025–100,000*)	6%	0%	11%
106	94,469 (27,025–100,000*)	3%	0%	11%
100	95,838 (27,025–100,000*)	1%	0%	8%

Notes: dB re 1 μPa = decibels referenced to 1 micropascal, m = meters
* Indicates maximum range to which acoustic model was run, a distance of approximately 100 kilometers from the sound source. Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 6.4-1 for behavioral cut-off distances).

Table 6.4-10: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF4 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 µPa²-s)	*Minimum Range (m) with Minimum and Maximum Values in Parenthesis*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Beaked Whales*
196	8 (8–8)	100%	100%	100%
190	17 (17–17)	100%	98%	100%
184	35 (35–35)	99%	88%	100%
178	70 (65–70)	97%	59%	100%
172	141 (140–150)	91%	30%	99%
166	354 (330–420)	78%	20%	97%
160	773 (725–1,275)	58%	18%	93%
154	1,489 (1,025–3,275)	40%	17%	83%
148	3,106 (1,775–6,775)	29%	16%	66%
142	8,982 (3,025–18,775)	25%	13%	45%
136	15,659 (3,775–31,025)	23%	9%	28%
130	25,228 (4,775–65,775)	20%	5%	18%
124	41,778 (5,525–73,275)	17%	2%	14%
118	51,832 (6,025–89,775)	12%	1%	12%
112	62,390 (6,025–100,000*)	6%	0%	11%
106	69,235 (6,775–100,000*)	3%	0%	11%
100	73,656 (7,025–100,000*)	1%	0%	8%

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, m = meters
*Indicates maximum range to which acoustic model was run, a distance of approximately 100 kilometers from the sound source.
Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 6.4-1 for behavioral cut-off distances).

Table 6.4-11: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF5 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 μPa²-s)	*Minimum Range (m) with Minimum and Maximum Values in Parenthesis*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Beaked Whales*
196	0 (0–0)	100%	100%	100%
190	1 (0–3)	100%	98%	100%
184	4 (0–7)	99%	88%	100%
178	14 (0–15)	97%	59%	100%
172	29 (0–30)	91%	30%	99%
166	58 (0–60)	78%	20%	97%
160	125 (0–150)	58%	18%	93%
154	284 (160–525)	40%	17%	83%
148	607 (450–1,025)	29%	16%	66%
142	1,213 (875–4,025)	25%	13%	45%
136	2,695 (1,275–7,025)	23%	9%	28%
130	6,301 (2,025–12,525)	20%	5%	18%
124	10,145 (3,025–19,525)	17%	2%	14%
118	14,359 (3,525–27,025)	12%	1%	12%
112	19,194 (3,525–37,275)	6%	0%	11%
106	24,153 (4,025–48,025)	3%	0%	11%
100	29,325 (5,025–57,775)	1%	0%	8%

Notes: dB re 1 μPa = decibels referenced to 1 micropascal, m= meters
Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 6.4-1 for behavioral cut-off distances).

Table 6.4-12: Ranges to a Potentially Significant Behavioral Response for Sonar Bin HF4 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 µPa²-s)	*Minimum Range (m) with Minimum and Maximum Values in Parenthesis*	*Probability of Behavioral Response*		
		Odontocetes	*Mysticetes*	*Beaked Whales*
196	3 (2–4)	100%	100%	100%
190	8 (6–10)	100%	98%	100%
184	16 (12–20)	99%	88%	100%
178	32 (24–40)	97%	59%	100%
172	63 (45–80)	91%	30%	99%
166	120 (75–160)	78%	20%	97%
160	225 (120–310)	58%	18%	93%
154	392 (180–550)	40%	17%	83%
148	642 (280–1,275)	29%	16%	66%
142	916 (420–1,775)	25%	13%	45%
136	1,359 (625–2,525)	23%	9%	28%
130	1,821 (950–3,275)	20%	5%	18%
124	2,567 (1,275–5,025)	17%	2%	14%
118	3,457 (1,775–6,025)	12%	1%	12%
112	4,269 (2,275–7,025)	6%	0%	11%
106	5,300 (3,025–8,025)	3%	0%	11%
100	6,254 (3,775–9,275)	1%	0%	8%

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, m=meters

6.4.2.3 Impacts from Sonar and Other Transducers Under the Proposed Action

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under the Proposed Action are described in Section 1.4.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Section 1.5 (Proposed Action) and Appendix A (Training and Testing Activities Descriptions) of the MITT Draft SEIS/OEIS. The major differences between the Action Alternatives for the purposes of analyzing impacts on marine mammals is that under the Proposed Action, for training and testing, the number of major training exercises would fluctuate annually. In addition, a portion of training requirements would be met synthetically. Training activities using sonar and other transducers could occur throughout the Study Area, although use would generally occur within 200 NM of shore or around inshore locations identified in Section 1.5 (Proposed Action).

Two Major Training Exercises would occur in the MITT Study Area: Joint Multi-Strike Group Exercise, which is a large integrated ASW event, and Joint Expeditionary Exercise, which is a medium integrated ASW event (Table 1.4-1). Both events are multi-day exercises that transition across large areas and involve multiple anti-submarine warfare assets. It is important to note that while these major training exercises focus on anti-submarine warfare activities, there are significant periods of time when active anti-submarine warfare sonars are not in use. Nevertheless, behavioral reactions attributable to these exercises are likely to be more significant than reactions that result from other smaller scale anti-submarine warfare activities because of the longer durations (i.e., multiple days) and larger scale (i.e., multiple sonar platforms) of major training exercises. Although these major training exercises typically progress through different locations in the Study Area as an event unfolds, it is possible that individual animals could be exposed multiple times over the course of the event.

Anti-submarine warfare activities also include unit-level training and integrated/coordinated ASW activities that use active sonar over shorter timeframes and with fewer sonar sources (Table 1.4-1, Table 1.5-1). In addition, active sonar is used when conducting surface ship and submarine sonar maintenance. Sonar maintenance activities involve the use of a single system in a limited manner; therefore, significant reactions to maintenance activities are less likely than with most other anti-submarine warfare activities. Furthermore, sonar maintenance activities typically occur either pierside or within entrances to harbors where higher levels of anthropogenic activity, including elevated noise levels, already exist. Unit-level training activities typically involve the use of a single vessel or aircraft and last for only a few hours over a small area of ocean. These unit-level training and maintenance activities are limited in scope and duration; therefore, significant behavioral reactions are less likely than with other anti-submarine warfare activities with greater intensity and duration. Unit-level training activities are more likely to occur close to homeports and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities. Coordinated exercises involve multiple assets and can last for several days, transiting across large areas of a range complex. Repeated exposures to some individual marine mammals are likely during coordinated exercises. However, due to the shorter duration and smaller footprint compared to major training exercises, impacts from these activities are less likely to be significant.

Anti-submarine warfare testing activities are typically similar to unit-level training. Vessel evaluation testing activities also use the same anti-submarine warfare sonars on ships and submarines. Testing activities that use anti-submarine warfare sonars typically occur in water deeper than approximately 200 m and therefore are outside of most nearshore habitats where productivity is typically higher (i.e., more food) and many marine mammals have higher abundances. Therefore, significant reactions to anti-submarine warfare and vessel evaluation testing activities are less likely than with larger anti-submarine warfare training activities discussed above. Anti-submarine warfare and vessel evaluation testing activities are more likely to occur close to homeports and testing facilities and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities. These testing activities are limited in scope and duration; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Mine warfare training activities typically involve a ship or helicopter using a mine-hunting sonar to locate mines. Most mine warfare sonar systems have a lower source level, higher-frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to mine warfare sonars. While individual animals could show short-term and minor responses to mine warfare sonar training activities, these reactions are very unlikely to lead to any costs or long-term consequences for individuals or populations.

Mine warfare testing activities typically involve a ship, helicopter, or unmanned vehicle testing a mine-hunting sonar system. Unmanned underwater vehicle testing also employs many of the same sonar systems as mine warfare testing and usually involves only a single sonar platform (i.e., unmanned underwater vehicle). Most of the sonar systems and other transducers used during these testing activities typically have a lower source level; higher-frequency; and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to these types of systems sonars. Animals are most likely to show short-term and minor-to-moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Other testing activities include testing of individual sonar systems and other transducers for performance and acoustic signature. Most sources used during these exercises have moderate source levels between 160 and 200 dB re 1 µPa @ 1 m and are used for a limited duration, up to a few hours in most cases. Significant reactions in marine mammals have not been reported due to exposure to the sonars and other transducers typically used in these activities. Animals are most likely to show short-term and minor-to-moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Surface warfare activities require limited use of sonar or other transducers as compared to other types of activities discussed above, typically limited to the sonar targeting system of a few torpedoes. The limited scope and duration of sonar use in these activities makes significant behavioral reactions less likely than with other activities that use anti-submarine warfare sonar systems and other transducers, which are discussed above.

6.4.2.3.1 Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from sonars and other transducers (Section 6.4.2.1, Methods for Analyzing Impacts from Sonars and Other Transducers) are discussed below. The numbers of potential impacts estimated for individual species and stocks of marine mammals from exposure to sonar for training and testing activities are shown in Appendix E (Estimated

Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors under Navy Training and Testing Activities) of the MITT Draft SEIS/OEIS and presented below in figures for each species of marine mammal with any estimated effects (e.g., Figure 6.4-11). The Activity Categories that are most likely to cause impacts and the most likely region in which impacts could occur are represented in the bar charts of each figure. There is a potential for impacts to occur anywhere within the Study Area where sound from sonar and the species overlap, although only Regions or Activity Categories where 0.5 percent of the impacts or greater are estimated to occur are graphically represented on the bar charts below. All (i.e., grand total) estimated impacts for that species are included in the bar plots, regardless of region or category.

Note that although the numbers of activities planned can vary from year-to-year, results are presented for a “maximum sonar use year.” The number of hours these sonars would be operated under the Proposed Action are described in Section 1.4.1 (Acoustic Stressors).

It is important to note when examining the results of the quantitative analysis that the behavioral response functions used to predict the numbers of reactions in this analysis are largely derived from several studies (Section 6.4.1.5, Behavioral Reactions). The best available science, including behavioral response studies, was used for deriving these criteria; however, many of the factors inherent in these studies that potentially increased the likelihood and severity of observed responses (e.g., close approaches by multiple vessels, tagging animals, and vectoring towards animals that have already begun avoiding the sound source) would not occur during Navy activities. Because the Navy purposely avoids approaching marine mammals, many of the behavioral responses estimated by the quantitative analysis are unlikely to occur or unlikely to rise to the severity observed during many of the behavioral response studies.

Although the statutory definition of Level B harassment for military readiness activities under the MMPA requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. Many of the responses estimated using the Navy’s quantitative analysis are most likely to be moderate severity. Moderate-severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 6.4.1.5 (Behavioral Reactions), the behavioral response functions used within the Navy’s quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy’s quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal’s behavioral threshold for only a single exposure to several minutes. It is likely that many of the estimated behavioral reactions within the Navy’s quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant versus non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that significant numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from military readiness activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

6.4.2.3.2 Mysticetes

Mysticetes may be exposed to sound from sonar and other transducers associated with training activities throughout the year. Most low- (less than 1 kHz) and mid- (1–10 kHz) frequency sonars and other transducers produce sounds that are likely to be within the hearing range of mysticetes (Section 6.3, Hearing and Vocalization). Some high-frequency sonars (greater than 10 kHz) also produce sounds that should be audible to mysticetes, although only smaller species of mysticetes such as minke whales are likely to be able to hear higher frequencies, presumably up to 30 kHz. Therefore, some high-frequency sonars and other transducers with frequency ranges between 10 and 30 kHz may also be audible to some mysticetes. If a sound is within an animal’s hearing range then behavioral reactions, physiological stress, masking, and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss is not likely to occur. Impact ranges for mysticetes are discussed under low-frequency cetaceans in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

A few behavioral reactions in mysticetes resulting from exposure to sonar could take place at distances of up to 20 km. Behavioral reactions, however, are much more likely within a few km of the sound source. As discussed above in Section 6.4.1.5 (Behavioral Reactions), the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that if mysticetes do respond they may react in a number of ways, depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise source is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, most behavioral reactions from mysticetes are likely to be short term and low to moderate severity.

Some mysticetes may avoid larger activities such as a major training exercise as it moves through an area, although these activities generally do not use the same training locations day after day during multi-day activities. Therefore, displaced animals could return quickly after the major training exercise finishes. It is unlikely that most mysticetes would encounter a major training exercise more than once per year. In the ocean, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period except around homeports and fixed instrumented ranges. Overall, a few behavioral reactions per year by a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that mysticetes most likely avoid sound sources at levels that would cause any hearing loss (i.e., TTS) (Section 6.4.1.5, Behavioral Reactions). Therefore, it is likely that the quantitative analysis overestimates PTS and TTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Mysticetes that do experience PTS or TTS from sonar sounds may have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable, and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that a mysticete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. Killer whales are a primary predator of mysticetes. Some hearing loss could make killer whale calls more difficult to detect at farther ranges until hearing recovers. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete’s ability to locate prey or rate of feeding. A single or even a few minor TTS (less than 20 dB of TTS) to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Research and observations of masking in marine mammals are discussed in Section 6.4.1.4 (Masking). Most anti-submarine warfare sonars and countermeasures use mid-frequency ranges and a few use low-frequency ranges. Most of these sonar signals are limited in the temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant masking in mysticetes. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). High-frequency (greater than 10 kHz) sonars fall outside of the best hearing and vocalization ranges of mysticetes (Section 6.3, Hearing and Vocalization). Furthermore, high frequencies (above 10 kHz) attenuate more rapidly in the water due to absorption than do lower frequency signals, thus producing only a small zone of potential masking. Masking in mysticetes due to exposure to high-frequency sonar is unlikely. Potential costs to mysticetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased. By contrast, hearing loss lasts beyond the exposure for a period. Nevertheless, mysticetes that do experience some masking for a short period from low- or mid-frequency sonar may have their ability to communicate with conspecifics reduced, especially at further ranges. However, larger mysticetes (e.g., blue whale, fin whale, sei whale) communicate at frequencies below those of mid-frequency sonar and even most low-frequency sonars. Mysticetes that communicate at higher frequencies (e.g., minke whale) may be affected by some short-term and intermittent masking. Sounds from mid-frequency sonar could mask killer whale vocalizations, making them more difficult to detect, especially at further ranges. It is unknown whether a masking would affect a mysticete’s ability to feed since it is unclear how or if mysticetes use sound for finding prey or feeding. A single or even a few short periods of masking, if it were to occur, to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

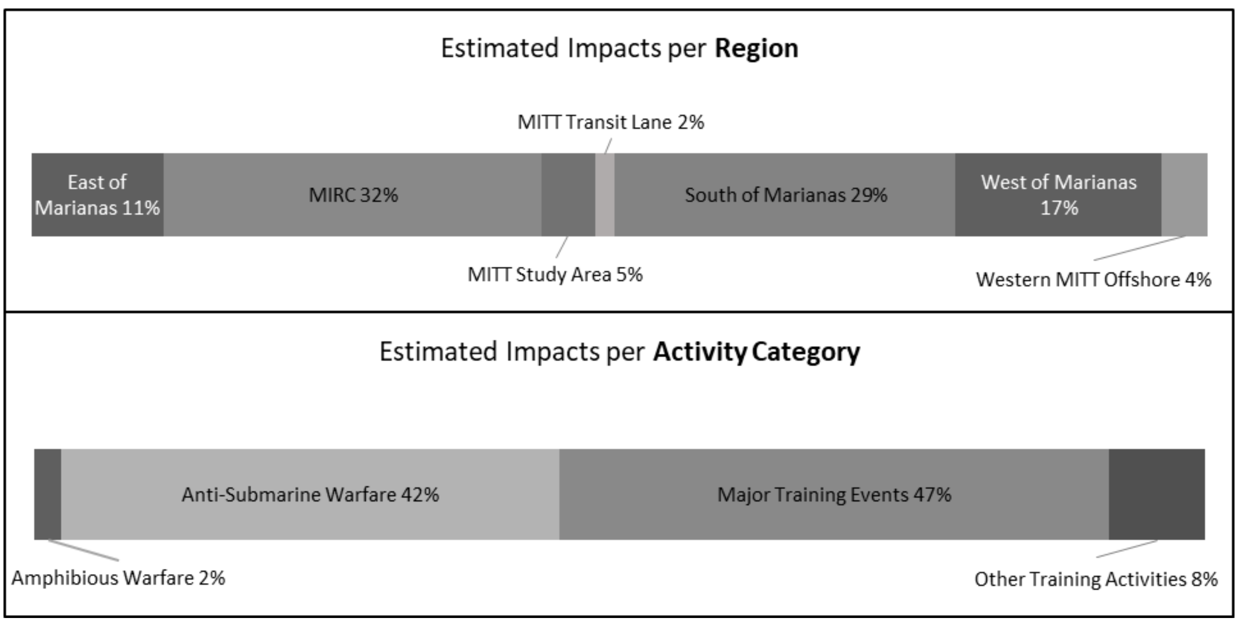
Many activities, such as submarine under ice certification and most mine-hunting exercises, use only high-frequency sonars that are not within mysticetes' hearing range; therefore, there were no predicted effects. Section 6.3 (Hearing and Vocalization) discusses low-frequency cetacean (i.e., mysticetes) hearing abilities.

6.4.2.3.2.1 Blue Whale (Endangered Species Act-Listed)

Blue whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-9 and Table 6.4-13). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of blue whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-9: Blue Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-13: Estimated Impacts on Individual Blue Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
4	20	0

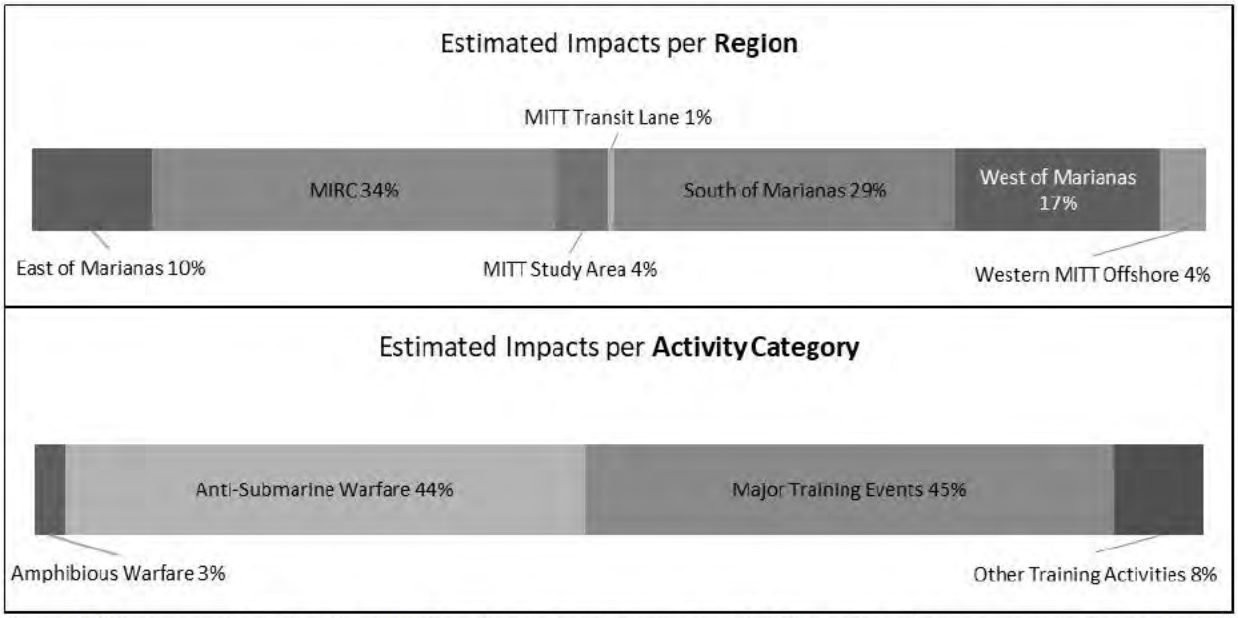
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.2 Bryde's Whale

Bryde's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-10 and Table 6.4-14). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Bryde's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-10: Bryde's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-14: Estimated Impacts on Individual Bryde's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
36	256	0

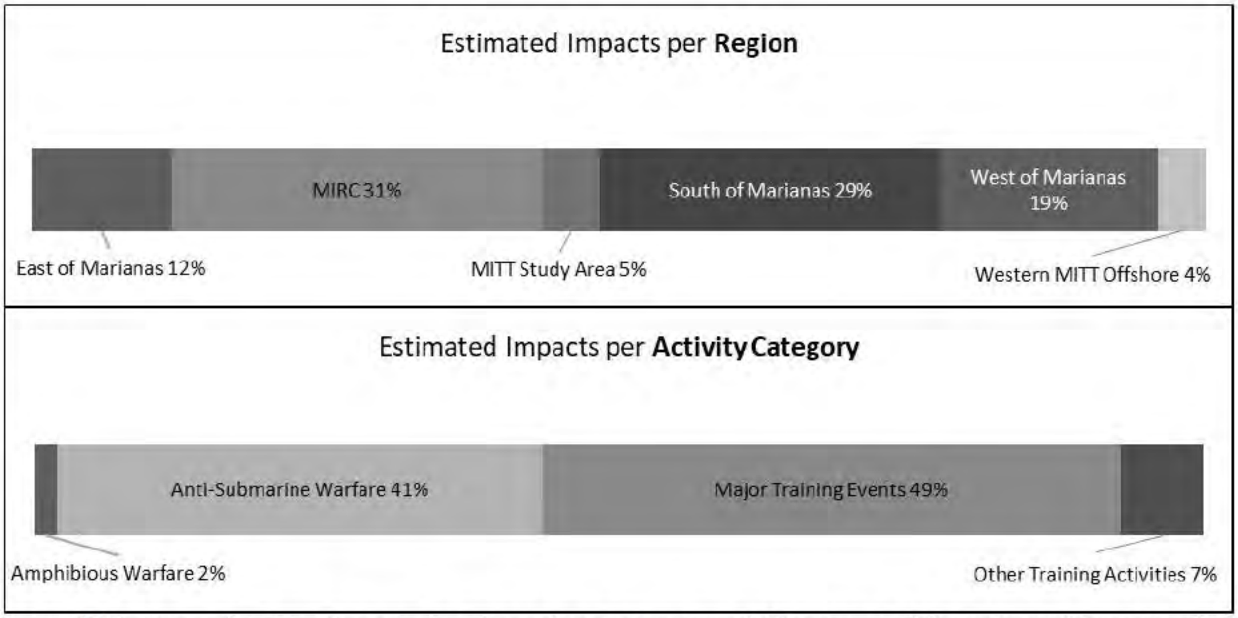
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.3 Fin Whale

Fin whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-11 and Table 6.4-15). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of fin whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-11: Fin Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-15: Estimated Impacts on Individual Fin Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
5	20	0

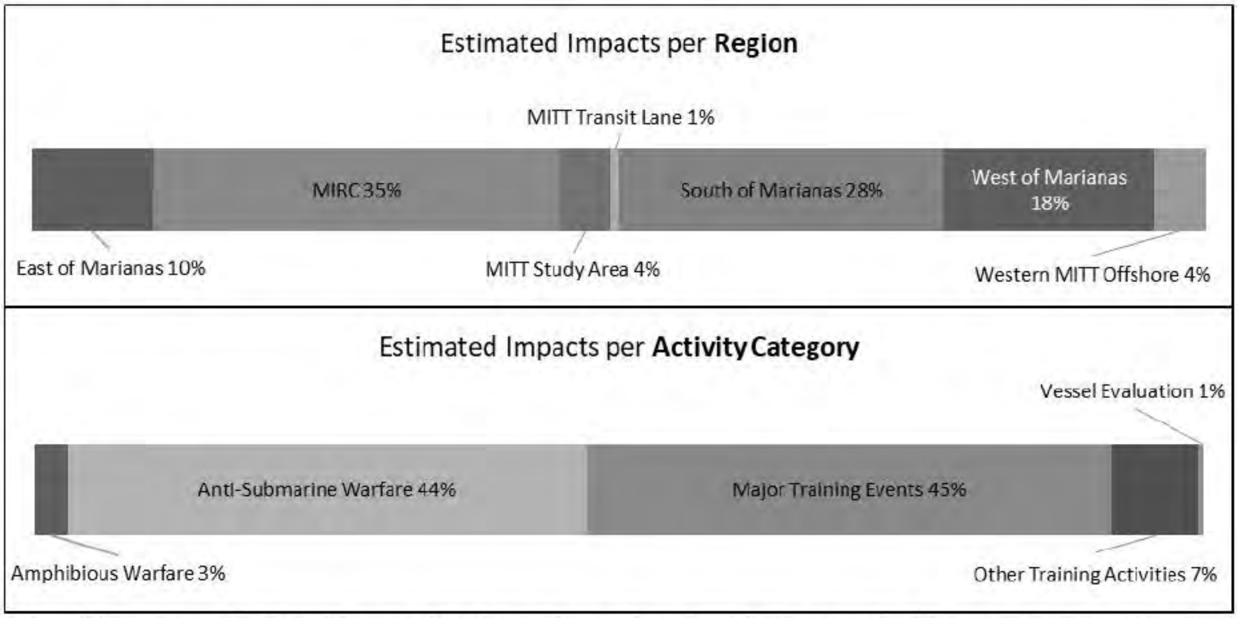
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.4 Humpback Whale

Humpback whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-12 and Table 6.4-16). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of humpback whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-12: Humpback Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-16: Estimated Impacts on Individual Humpback Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
51	419	0

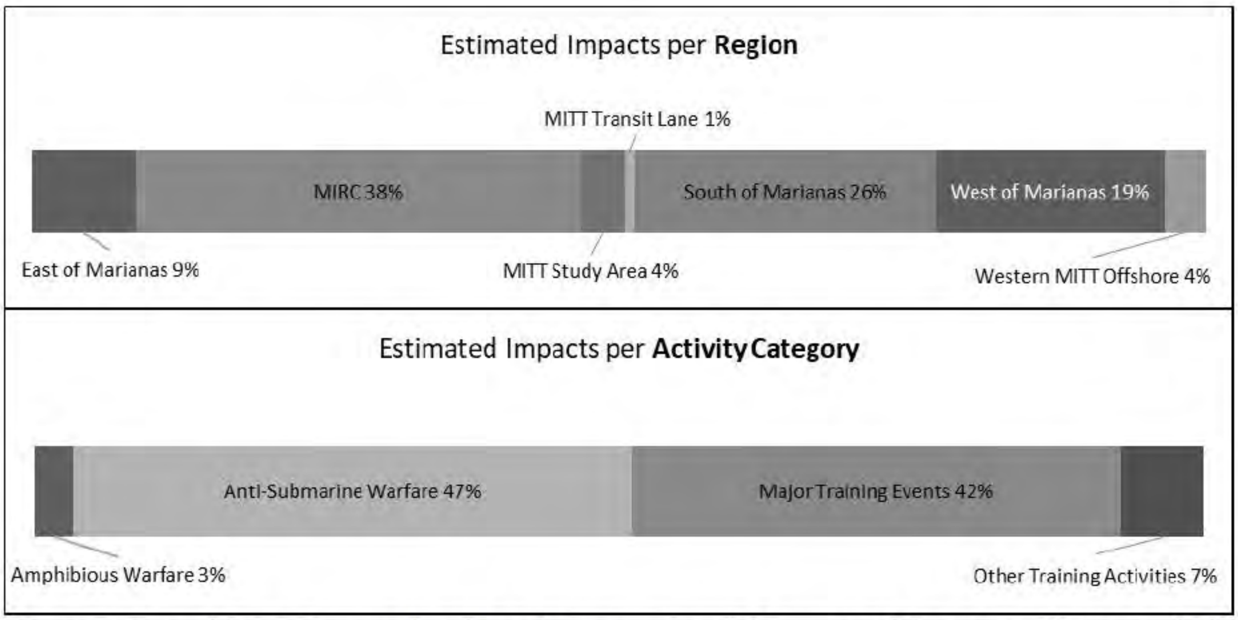
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.5 Minke Whale

Minke whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-13 and 6.4-17). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of minke whales incidental to those activities.



Notes: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-13: Minke Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-17: Estimated Impacts on Individual Minke Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
9	84	0

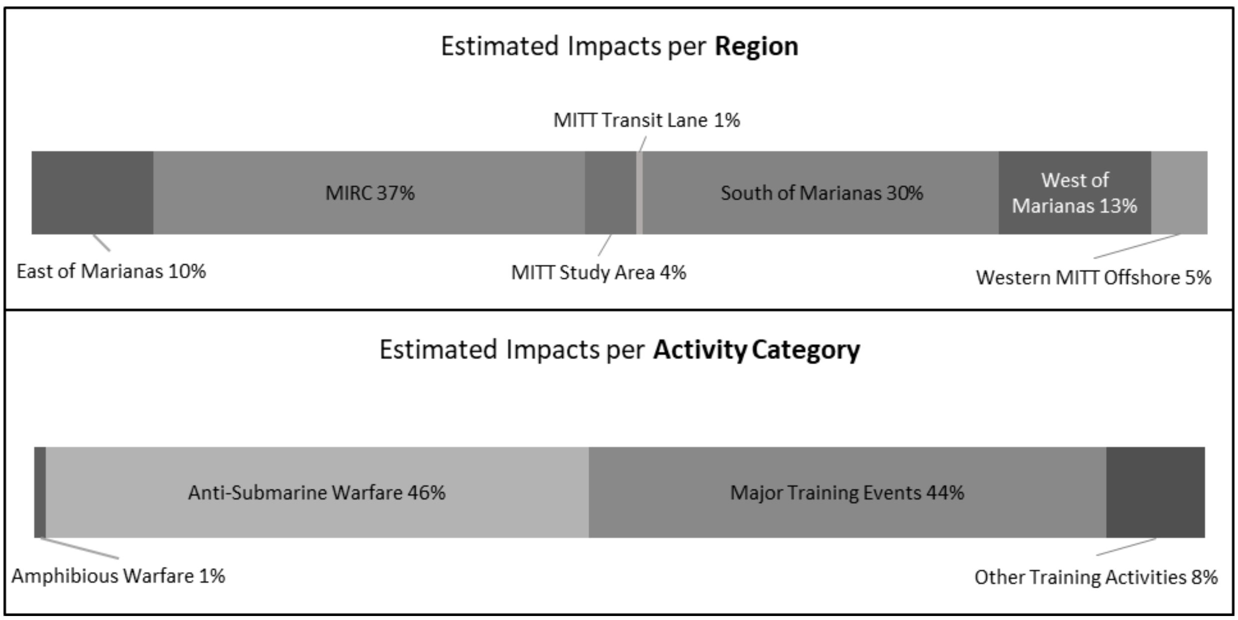
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.6 Omura's Whale

Omura's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-14 and Figure 6.4-18). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Omura's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-14: Omura's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-18: Estimated Impacts on Individual Omura's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3	25	0

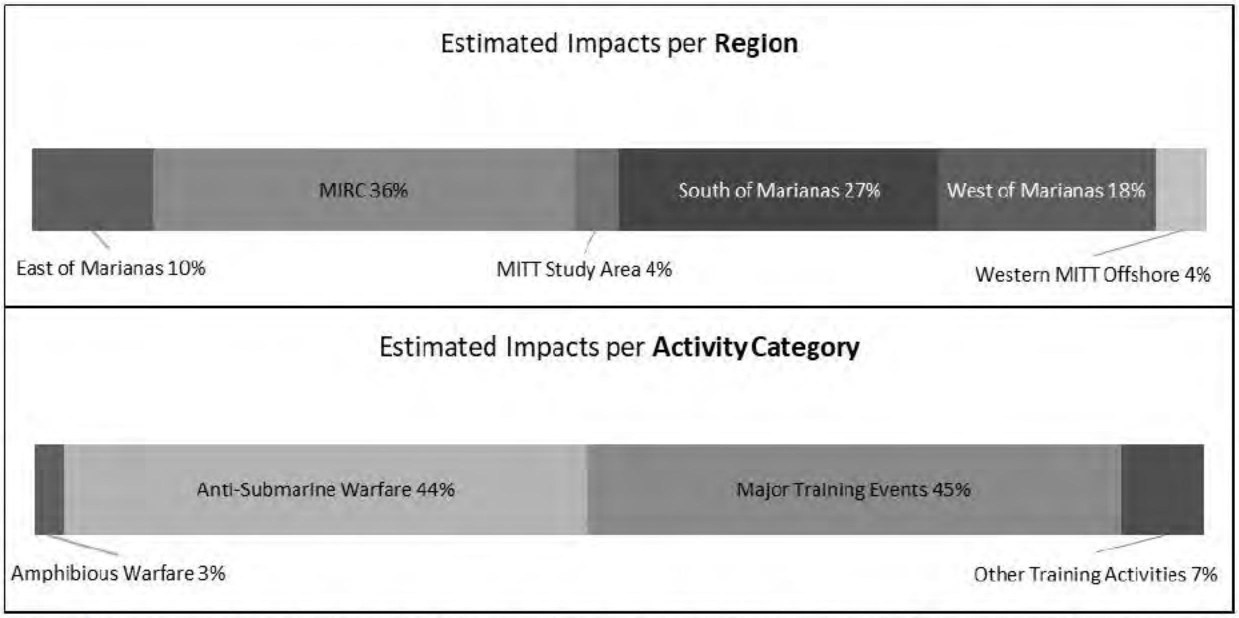
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.2.7 Sei Whale

Sei whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-15 and Table 6.4-19). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of sei whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-15: Sei Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-19: Estimated Impacts on Individual Sei Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
17	135	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3 Odontocetes

Odontocetes may be exposed to sound from sonar and other transducers associated with training and testing activities throughout the year. Low- (less than 1 kHz), mid- (1–10 kHz), high-frequency (10–100 kHz), and very high-frequency (100–200 kHz) sonars produce sounds that are likely to be within the audible range of odontocetes (see Section 6.3, Hearing and Vocalization). If a sound is within an animal's hearing range, then behavioral reactions, physiological stress, masking, and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss could not occur. Impact ranges for odontocetes are discussed under mid-frequency cetaceans in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

A few behavioral reactions in odontocetes (except beaked whales) resulting from exposure to sonar could take place at distances of up to 20 km. Beaked whales have demonstrated a high level of sensitivity to human-made noise and activity; therefore, the quantitative analysis assumes that some beaked whales could experience significant behavioral reactions at distances of up to 50 km from the sound source, respectively. Behavioral reactions, however, are much more likely within a few km of the sound source for most species of odontocetes, such as delphinids and sperm whales. Even for beaked whales, as discussed above in Section 6.4.2.1.2 (Assessing the Severity of Behavioral Responses from Sonar), the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions.

Research shows that if odontocetes do respond they may react in a number of ways, depending on the characteristics of the sound source and their experience with the sound source. Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, most behavioral reactions from odontocetes are likely to be short term and low-to-moderate severity.

Large odontocetes such as killer whales and pilot whales have been the subject of behavioral response studies (see Section 6.4.1.5, Behavioral Reactions). Based on these studies, a number of reactions could occur such as a short-term cessation of natural behavior, including feeding, avoidance of the sound source, or even attraction towards the sound source, as seen in pilot whales. Due to the factors involved in Navy training exercises versus the conditions under which pilot whales and killer whales were exposed during behavioral response studies, large odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few km. Most estimated impacts are due to anti-submarine warfare activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and sonar maintenance typically last for a matter of a few hours and involves a limited amount of sonar use, so significant responses would be less likely than with longer and more intense exercises (more sonar systems and vessels). Coordinated unit-level anti-submarine warfare exercises involve multiple sonar systems and can last for a period of days, making a significant response more likely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Small odontocetes have been the subject of behavioral response studies and observations in the field (see Section 6.4.1.5, Behavioral Reactions). Based on these studies, small odontocetes (dolphins) appear to be less sensitive to sound and human disturbance than other cetacean species. If reactions did occur, they could consist of a short-term behavioral response such as cessation of feeding, avoidance of the sound source, or even attraction towards the sound source. Small odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few km. Most estimated impacts are due to anti-submarine warfare activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and sonar maintenance typically last for a matter of a few hours and involve a limited amount of sonar use, so significant responses would be less likely than with longer and more intense exercises (more sonar systems and vessels). Coordinated unit-level anti-submarine warfare exercises involve multiple sonar systems and can last for a period of days, making a significant response more likely. Some bottlenose dolphin estimated impacts could also occur due to navigation and object avoidance (detection), since these activities typically occur entering and leaving Navy ports that overlap the distribution of coastal populations of this species. Navigation and object avoidance (detection) activities normally involve a single ship or submarine using a limited amount of sonar, therefore significant reactions are unlikely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Some odontocetes may avoid larger activities such as a major training exercise given training and testing events can be a source of noise and physical disturbance. Vessels and aircraft associated with training or testing activities are typically in transit during an event (they are not stationary) and do not use the same training locations day after day during multi-day activities. If an event otherwise focuses on a fixed location like an instrumented range, a sensitive species of odontocetes, such as beaked whales, may avoid the locus of the activity for the duration of the event. Section 6.4.1.5.1 (Behavioral Reactions to Sonar and Other Transducers) discusses these species' observed reactions to sonar and other transducers. If animals are displaced, they would likely return after the major training exercise subsides within an area, as seen during behavioral response studies in Blainville's beaked whales in the Bahamas (Tyack et al., 2011) and Hawaii (Henderson et al., 2016; Manzano-Roth et al., 2016; Manzano-Roth et al., 2013). Returning to the area would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual. It is unlikely that most individuals would encounter a major training exercise more than once per year due to where major training exercises are typically conducted. The use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period. However, a few behavioral reactions per year from a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that most odontocetes avoid sound sources at levels that would cause any temporary hearing loss (i.e., TTS) (see Section 6.4.1.2, Hearing Loss). TTS and even PTS is more likely for high-frequency cetaceans, such as Kogia whales (dwarf sperm whales and pygmy sperm whales), because hearing loss thresholds for these animals are lower than for all other marine mammals. These species have demonstrated a high level of sensitivity to human-made sound and activities and may avoid at further distances. This increased distance could avoid or minimize hearing loss for these species as well, especially as compared to the estimates from the quantitative analysis. Therefore, it is likely that the quantitative analysis overestimates TTS and PTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that an 130dontocetes had hearing loss, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of odontocetes. Some hearing loss could make killer whale calls more difficult to detect at further ranges until hearing recovers. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few tens of kHz for delphinids, beaked whales, and sperm whales, and above 100 kHz for Kogia whales. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be affected by threshold shift at lower frequencies and should not have any significant effect on an 130dontocetes's ability to locate prey or navigate, even in the short term. Therefore, a single or even a few minor TTS (less than 20 dB of TTS) to an individual 130dontocetes per year are unlikely to have any long-term consequences for that individual. Minor PTS in an individual could have no-to-minor long-term consequences for individuals.

Research and observations of masking in marine mammals are discussed in Section 6.4.1.4 (Masking). Many anti-submarine warfare sonars and countermeasures use low- and mid-frequency sonar. Most low- and mid-frequency sonar signals (i.e., sounds) are limited in their temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically much less than one-third octave). These factors reduce the likelihood of sources causing significant masking in odontocetes due to exposure to sonar used during anti-submarine warfare activities. Odontocetes may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of the sonar is narrow, limiting the likelihood of masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to odontocetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging, and the effect is over the moment the sound has ceased.

Nevertheless, odontocetes that do experience some masking from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations, making them more difficult to detect, especially at further ranges. As discussed above for TTS, odontocetes use echolocation to find prey and navigate. The echolocation clicks of odontocetes are above the frequencies of most sonar systems, especially those used during anti-submarine warfare. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be masked by sounds from sonars or other transducers. A single or even a few short periods of masking, if it were to occur, to an individual 131dontocetes per year are unlikely to have any long-term consequences for that individual.

Beaked Whales

Beaked whales within the Study Area include Blainville's beaked whale, Cuvier's beaked whale, Ginkgo-toothed beaked whale, and Longman's beaked whale.

As discussed above for odontocetes overall, the quantitative analysis overestimates hearing loss in marine mammals because behavioral response research has shown that most marine mammals are likely to avoid sound levels that could cause more than minor-to-moderate TTS (6–20 dB). Specifically for beaked whales, behavioral response research discussed below and in Section 6.4.1.5 (Behavioral Reactions) has demonstrated that beaked whales are sensitive to sound from sonars and usually avoid sound sources by 10 or more km. This distance is well beyond the ranges to TTS for mid-frequency cetaceans such as beaked whales. Therefore, any TTS predicted by the quantitative analysis is unlikely to occur in beaked whales.

Research and observations (Section 6.4.1.5, Behavioral Reactions) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source at levels ranging between 95 and 157 dB re 1 µPa (McCarthy et al., 2011).

Furthermore, in research done at the Navy's fixed tracking ranges in the Bahamas and Hawaii, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends (Manzano-Roth et al., 2013; Tyack et al., 2011). Populations of beaked whales and other odontocetes on Navy fixed ranges that have been operating for decades appear to be stable, and analysis is ongoing. Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of km, especially for prolonged periods (a few hours or more), since this is one of the most sensitive marine mammal groups to human-made sound of any species or group studied to date.

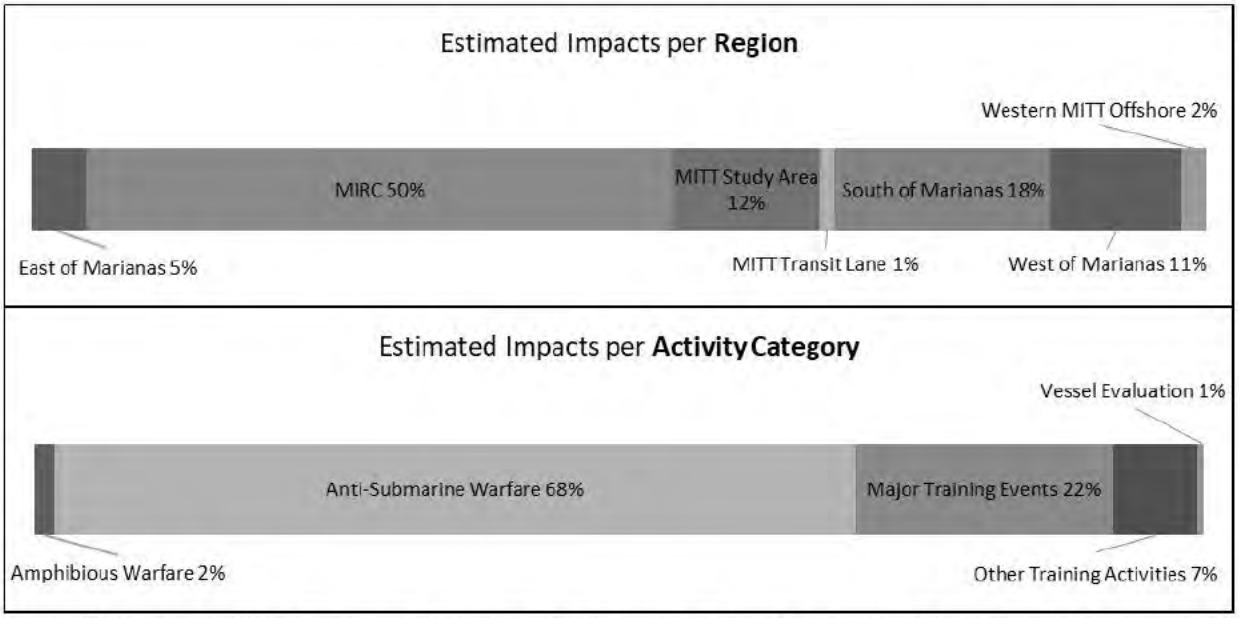
Based on the best available science, the Navy believes beaked whales that exhibit a significant behavioral reaction due to sonar and other transducers would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal link between sonar and stranding events, NMFS has stated in a letter to the Navy dated October 2006 that it "cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality." The Navy does not anticipate that marine mammal strandings or mortality would result from the operation of sonar during Navy exercises within the Study Area. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between Navy activities and a future stranding.

6.4.2.3.3.1 Blainville's Beaked Whale

Blainville's beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-16 and Table 6.4-20). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes and beaked whales above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Blainville's beaked whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-16: Blainville's Beaked Whales Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-20: Estimated Impacts on Individual Blainvilles's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,691	27	0

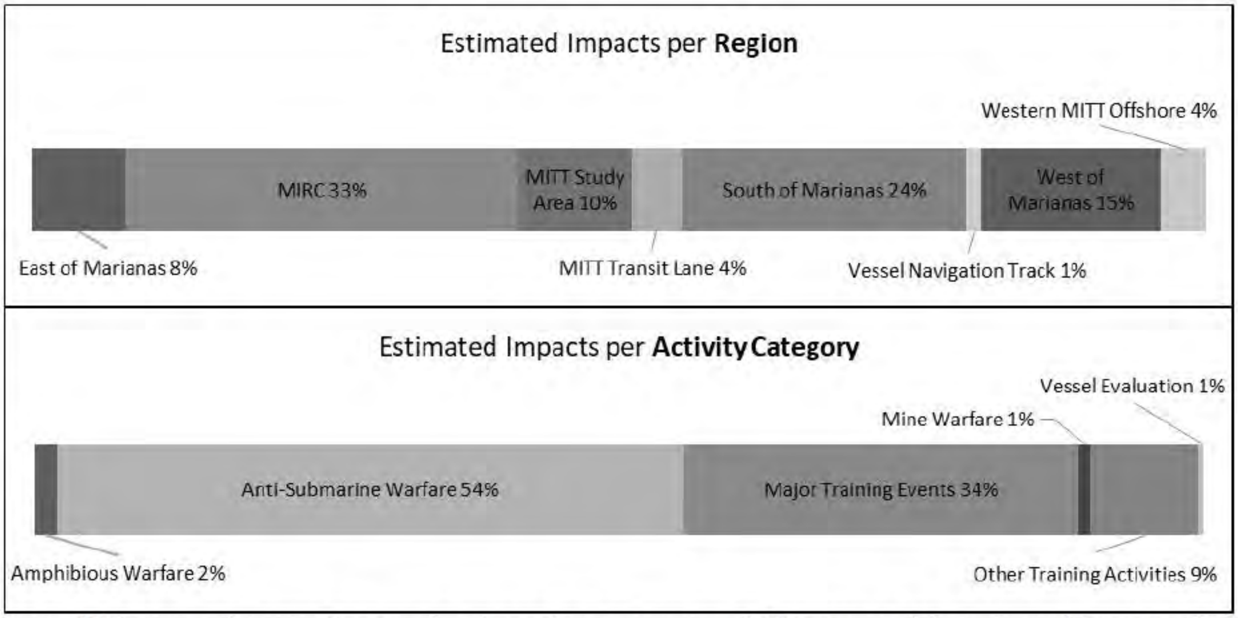
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.2 Common Bottlenose Dolphin

Common bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-17 and Table 6.4-21). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of common bottlenose dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-17: Common Bottlenose Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-21: Estimated Impacts on Individual Common Bottlenose Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
116	21	0

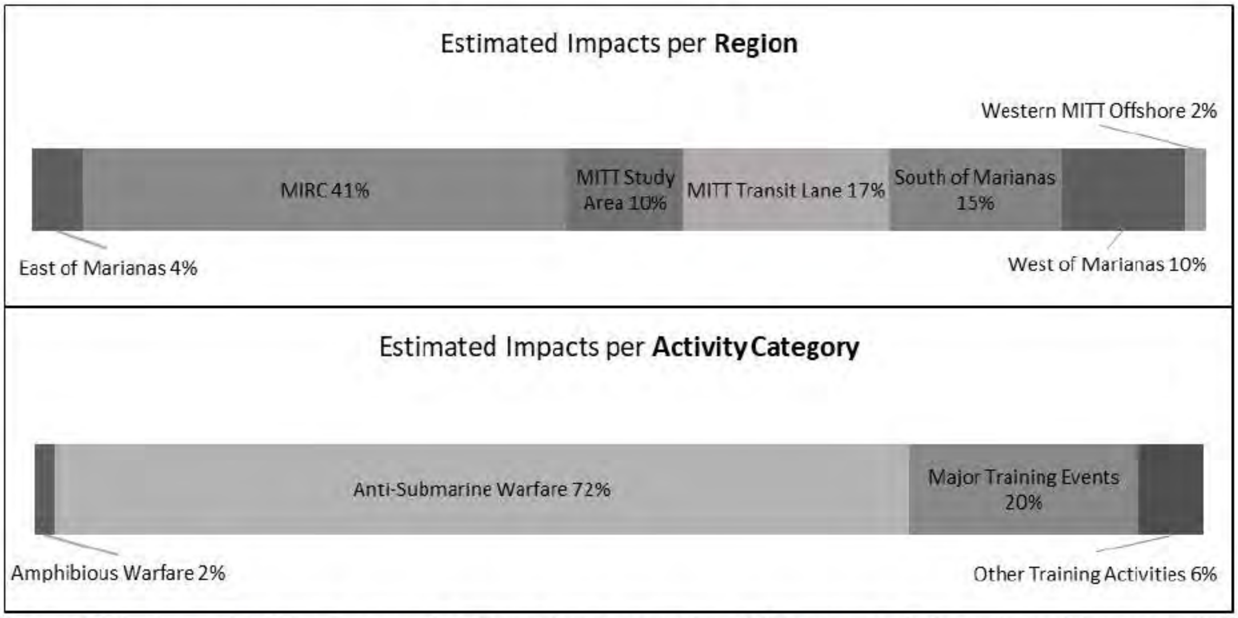
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.3 Cuvier's Beaked Whale

Cuvier's beaked whale may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-18 and Table 6.4-22). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes and beaked whales above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Cuvier's beaked whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-18: Cuvier's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-22: Estimated Impacts on Individual Cuvier's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
642	4	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

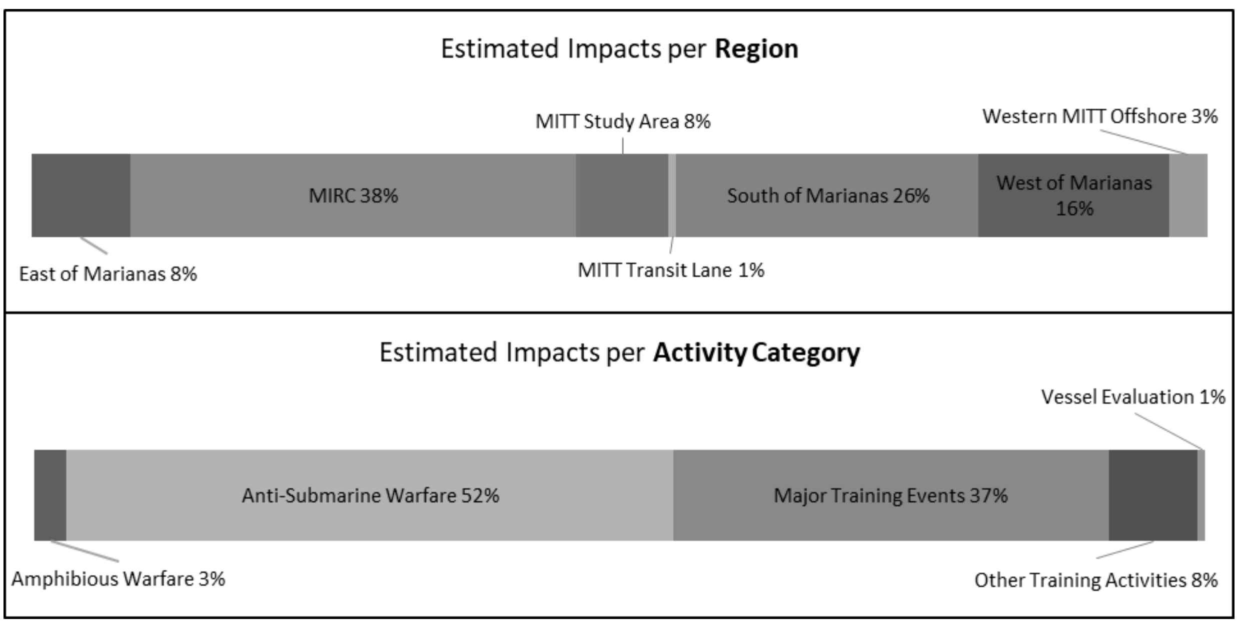
6.4.2.3.3.4 Dwarf Sperm Whale

Dwarf sperm whale may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS (Figure 6.4-19 and Table 6.4-23). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Kogia whales rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of dwarf sperm whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-19: Dwarf Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-23: Estimated Impacts on Individual Dwarf Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,289	70,46	29

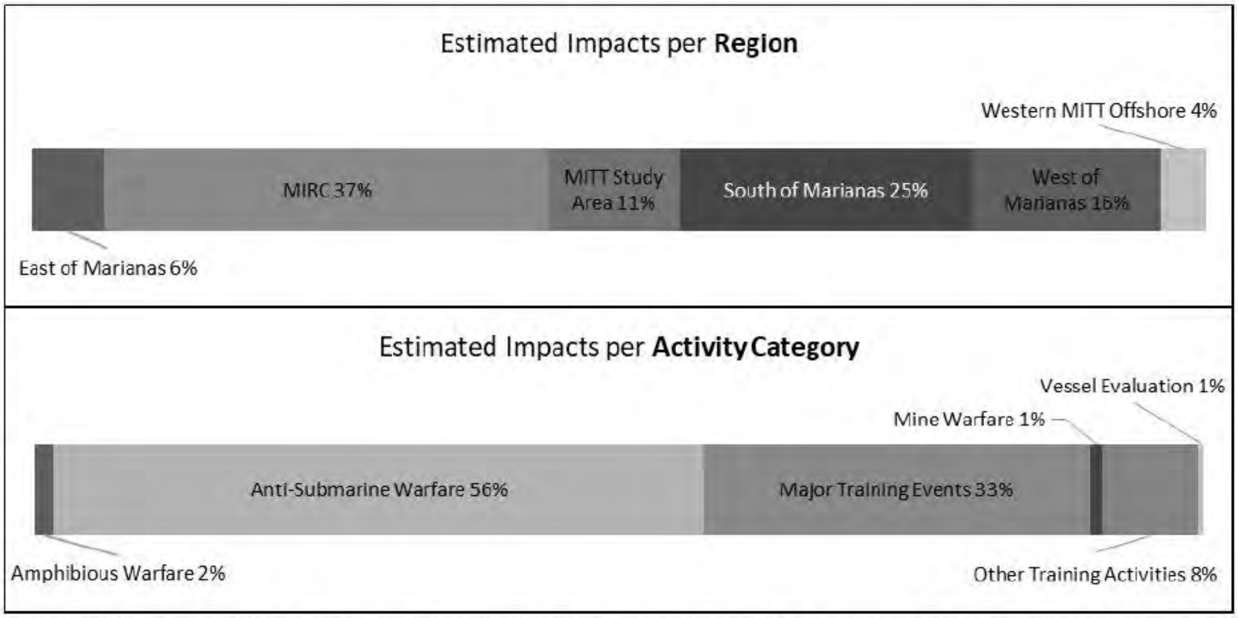
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.5 False Killer Whale

False killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-20 and Table 6.4-24). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of false killer whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-20: False Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-24: Estimated Impacts on Individual False Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
641	121	0

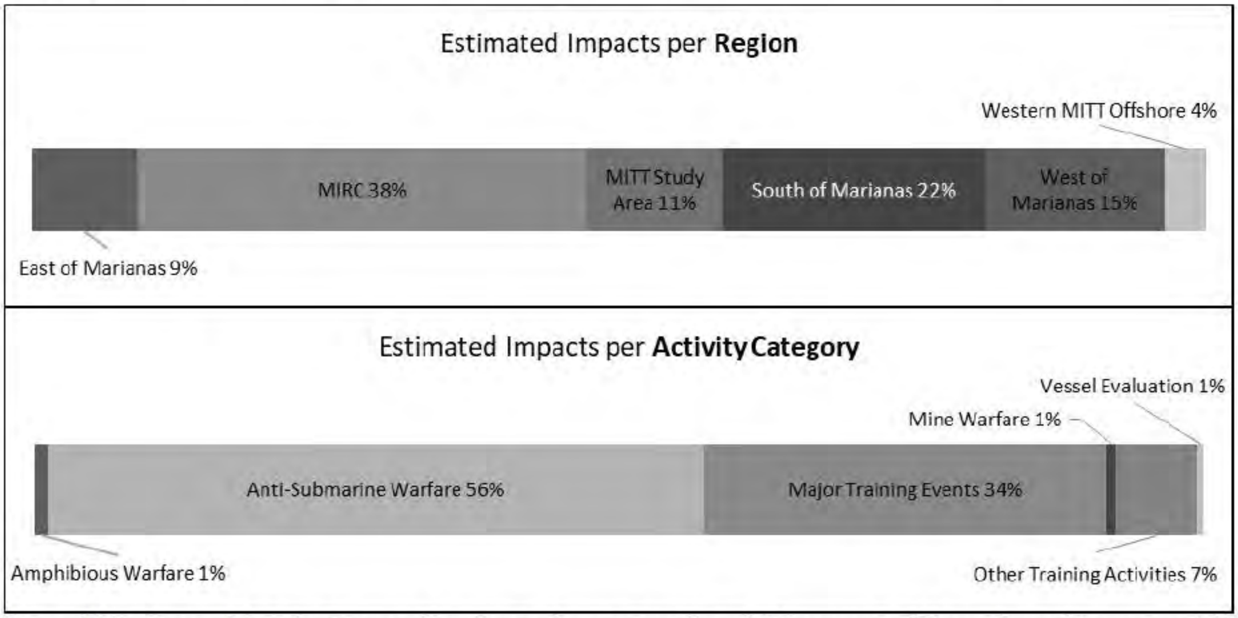
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.6 Fraser's Dolphin

Fraser's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-21 and Table 6.4-25). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Fraser's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-21: Fraser's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-25: Estimated Impacts on Individual Fraser's Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
11,322	1,947	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

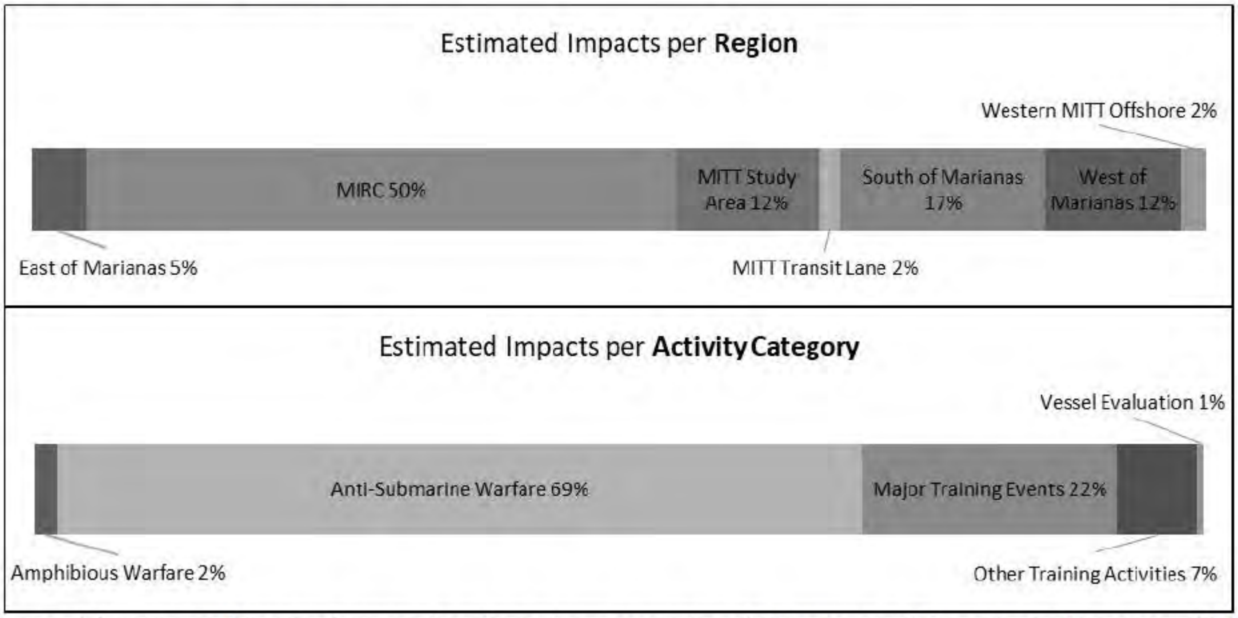
6.4.2.3.3.7 Ginkgo-Toothed Beaked Whale

Ginkgo-toothed beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-22 and Table 6.4-26). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes and beaked whales above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs

or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Ginkgo-toothed beaked whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-22: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-26: Estimated Impacts on Individual Ginkgo-Toothed Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3,659	65	0

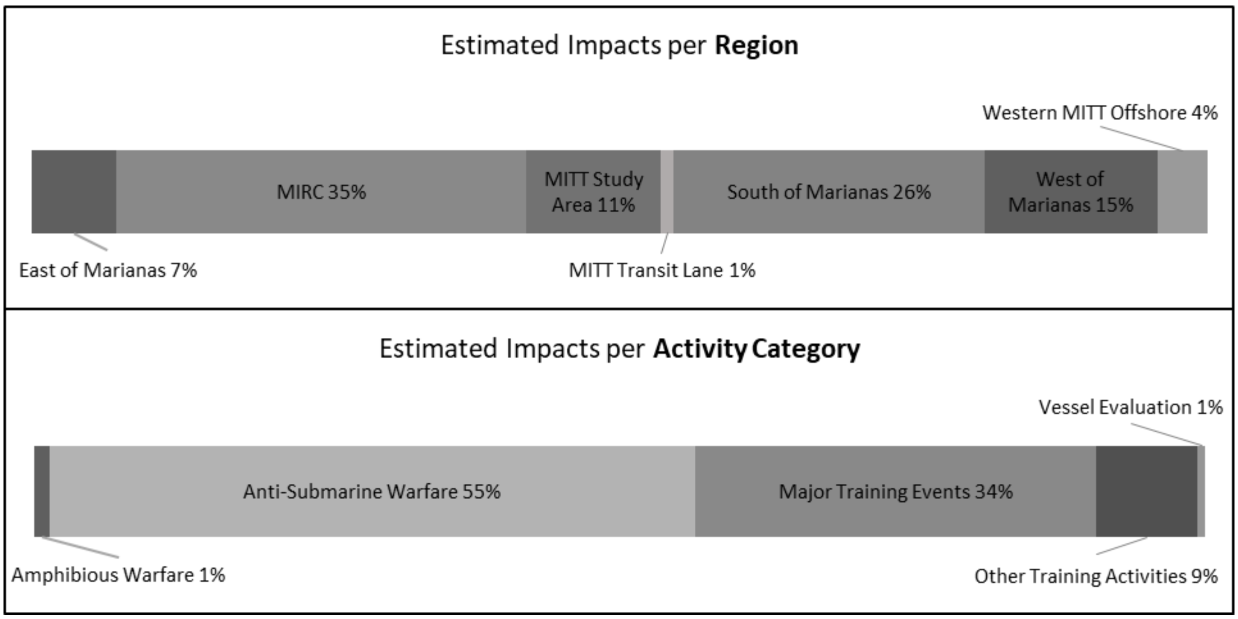
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.8 Killer Whale

Killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-23 and Table 6.4-27). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of killer whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-23: Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-27: Estimated Impacts on Individual Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
36	8	0

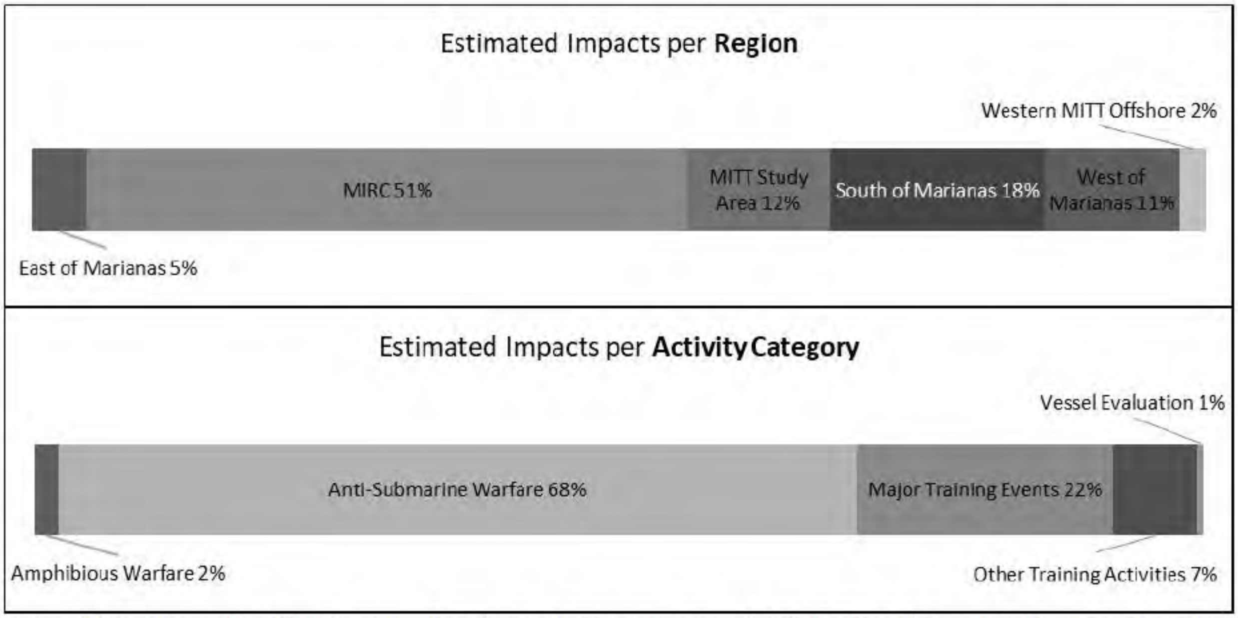
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.9 Longman's Beaked Whale

Longman's beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-24 and Table 6.4-28). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes and beaked whales above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Longman's beaked whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-24: Longman's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-28: Estimated Impacts on Individual Longman's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
5,958	106	0

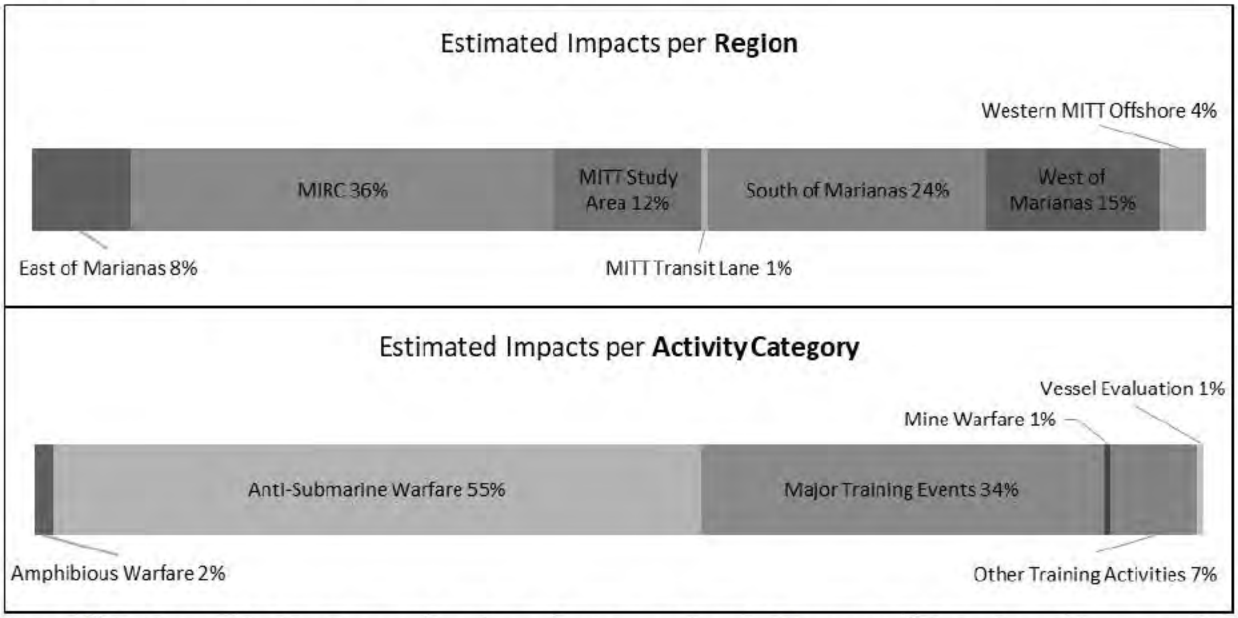
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.10 Melon-headed Whale

Melon-headed whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-25 and Table 6.4-29). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of melon-headed whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-25: Melon-Headed Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-29: Estimated Impacts on Individual Melon-Headed Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,305	508	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

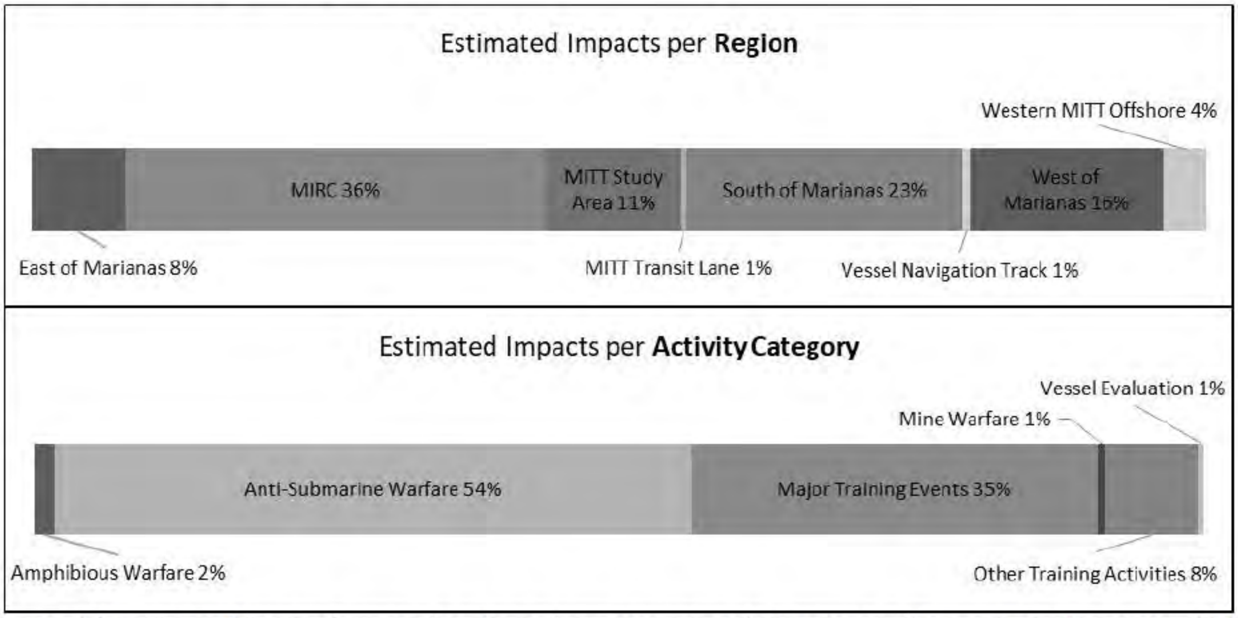
6.4.2.3.3.11 Pantropical Spotted Dolphin

Pantropical spotted dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-26 and Table 6.4-30). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences

for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-26: Pantropical Spotted Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-30: Estimated Impacts on Individual Pantropical Spotted Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
12,074	2,815	0

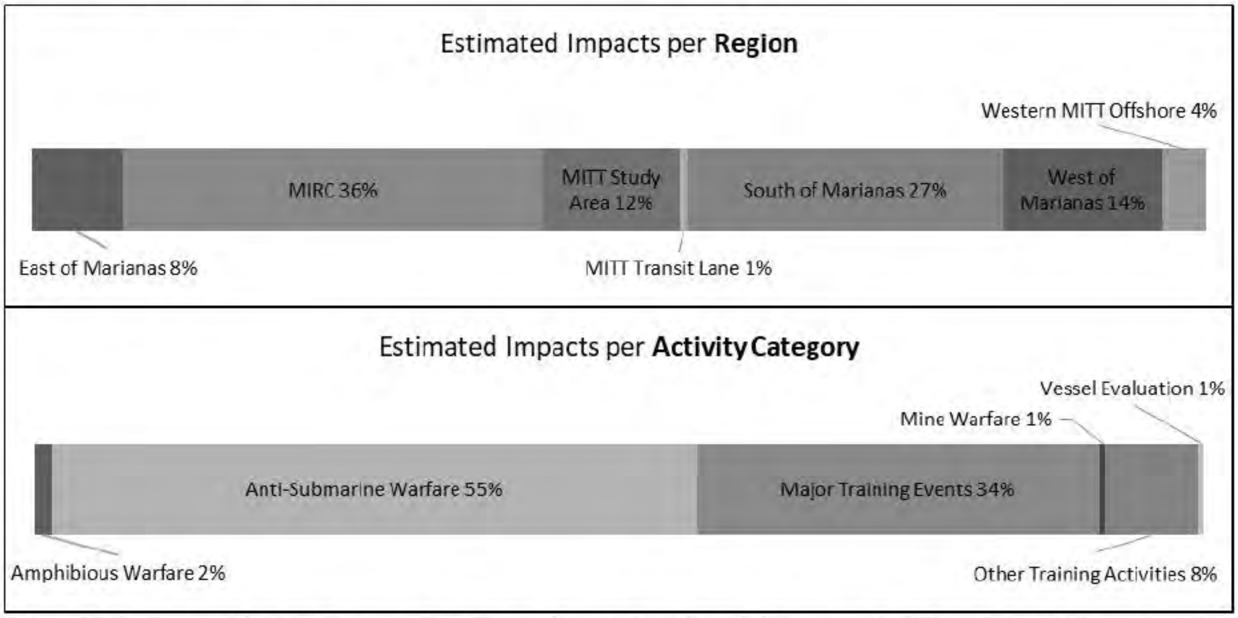
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.12 Pygmy Killer Whale

Pygmy killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-27 and Table 6.4-31). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of pygmy killer whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-27: Pygmy Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-31: Estimated Impacts on Individual Pygmy Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
87	17	0

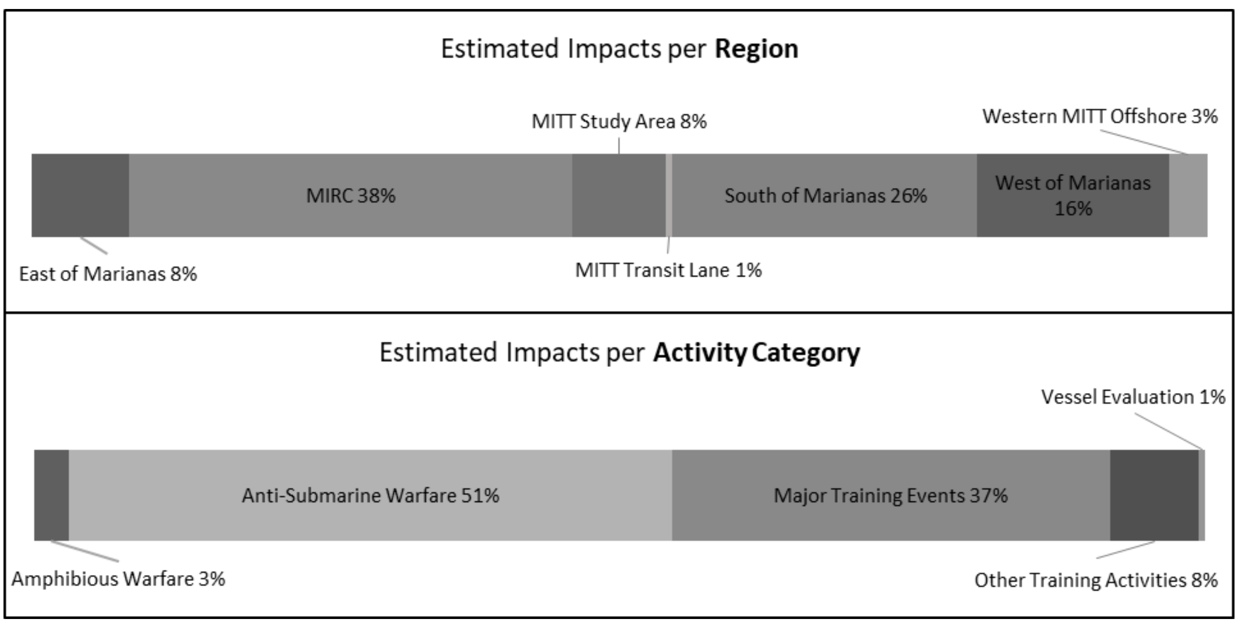
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.13 Pygmy Sperm Whale

Pygmy sperm whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions, TTS and PTS (Figure 6.4-28 and Table 6.4-32). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers). TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Kogia whales rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of pygmy sperm whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-28: Pygmy Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-32: Estimated Impacts on Individual Pygmy Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
508	2,840	11

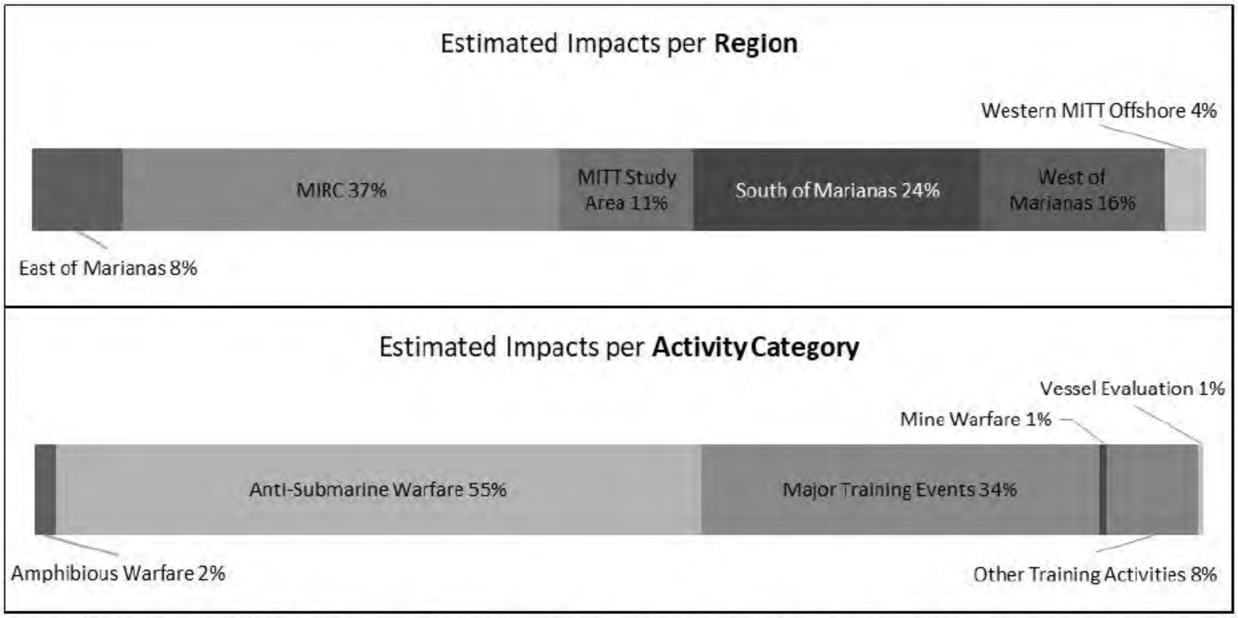
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.14 Risso's Dolphin

Risso's dolphin may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-29 and Table 6.4-33). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of Risso's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-29: Risso's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-33: Estimated Impacts on Individual Risso's Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,649	519	0

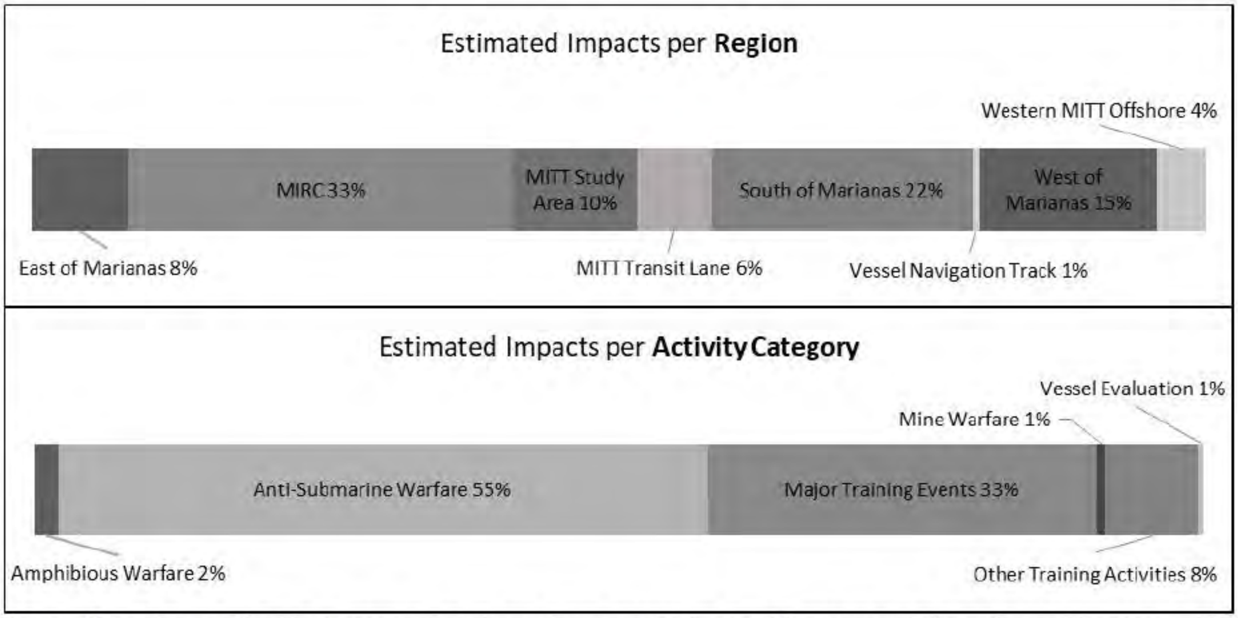
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.15 Rough-Toothed Dolphin

Rough-toothed dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-30 and Table 6.4-34). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of rough-toothed dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-30: Rough-Toothed Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-34: Estimated Impacts on Individual Rough-Toothed Dolphin Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
161	36	0

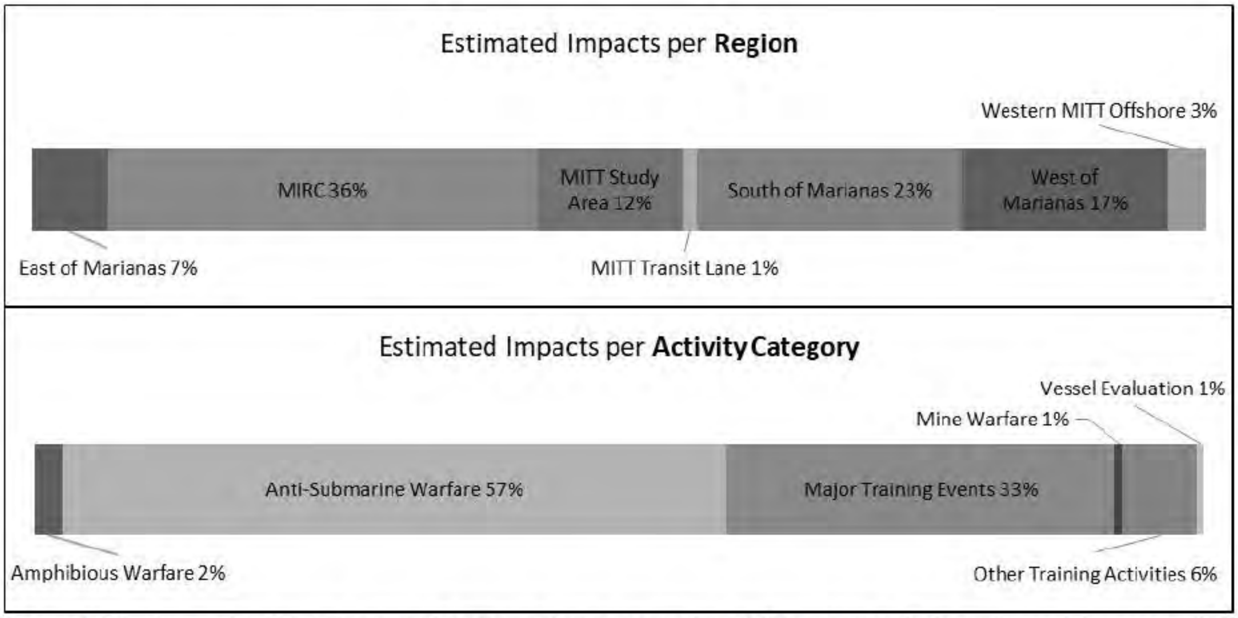
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.16 Short-Finned Pilot Whale

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-31 and Table 6.4-35). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of short-finned pilot whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-31: Short-Finned Pilot Whales Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-35: Estimated Impacts on Individual Short-Finned Pilot Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
986	176	0

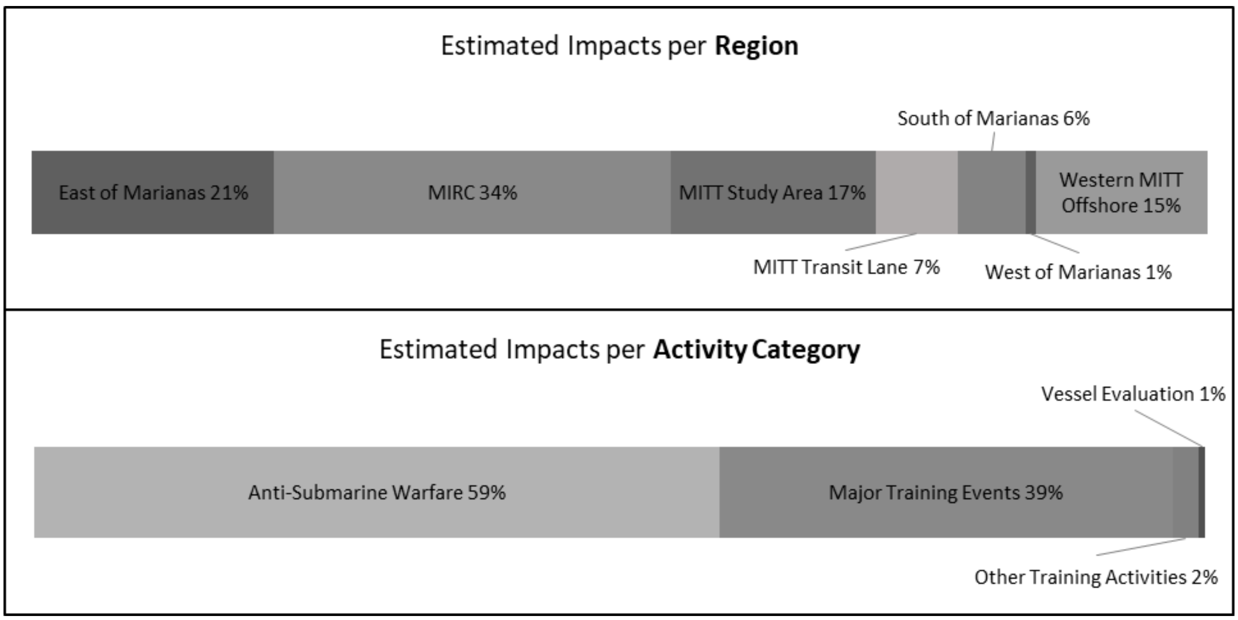
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.17 Sperm Whale

Sperm whales may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-32 and Table 6.4-36). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of sperm whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-32: Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-36: Estimated Impacts on Individual Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
192	11	0

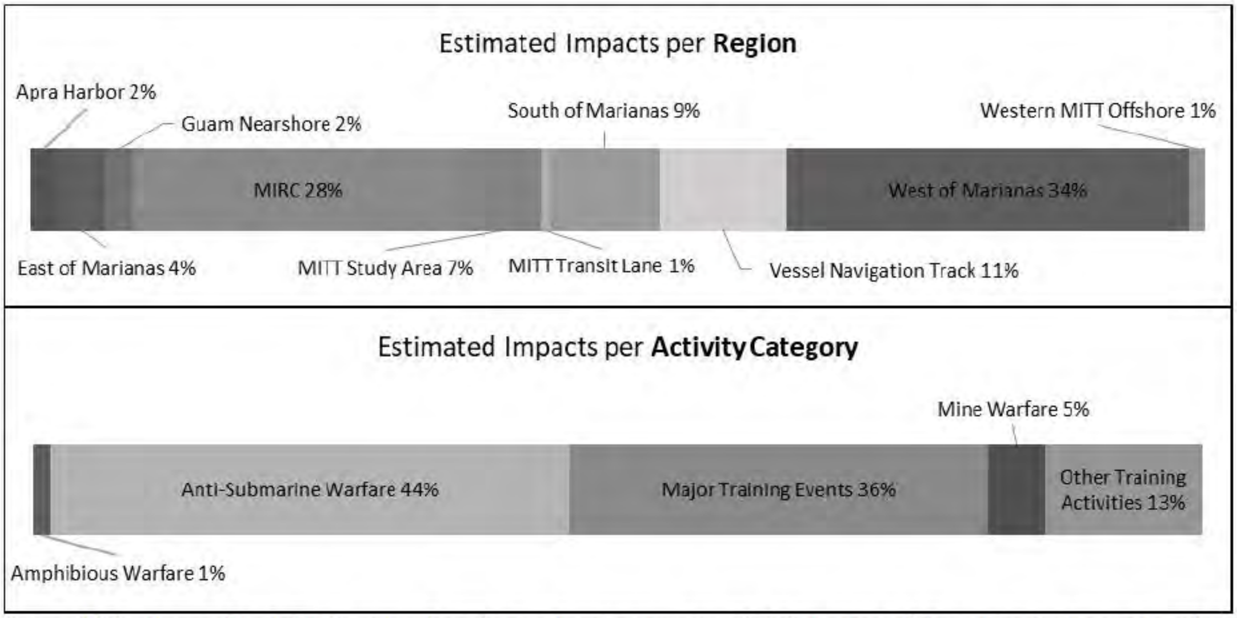
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.18 Spinner Dolphin

Spinner dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-33 and Table 6.4-37). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-33: Spinner Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-37: Estimated Impacts on Individual Spinner Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,185	228	0

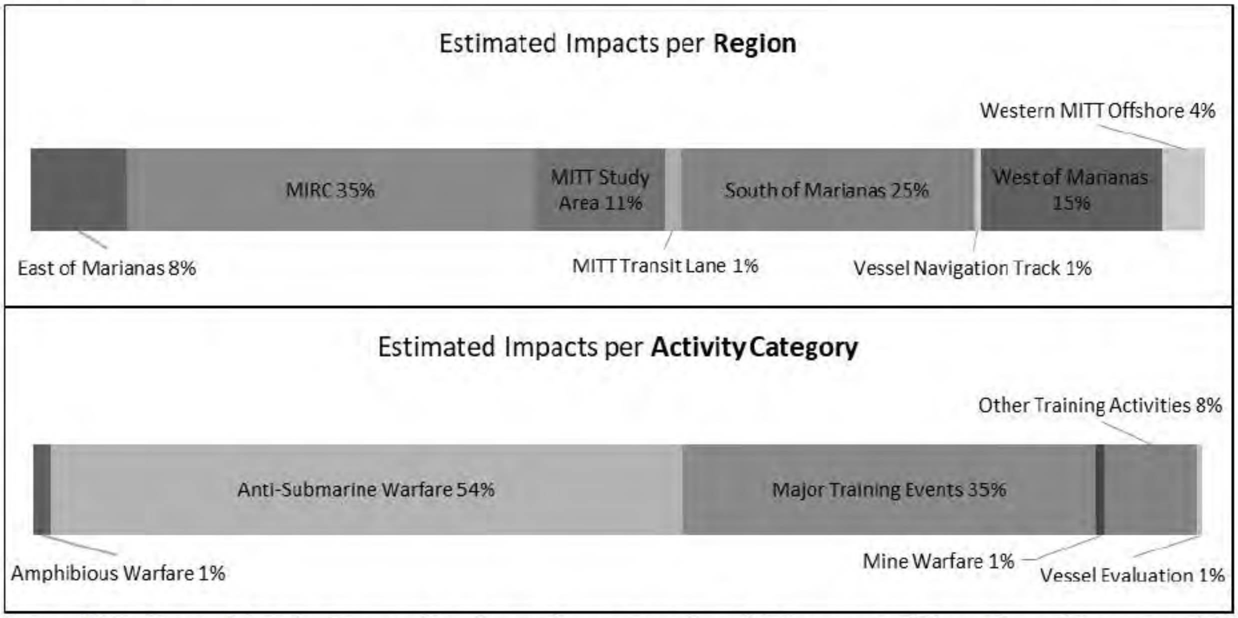
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.4.2.3.3.19 Striped Dolphin

Striped dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities occurring throughout the year. The quantitative analysis estimates behavioral reactions and TTS (Figure 6.4-34 and Table 6.4-38). Impact ranges for this species are discussed in Section 6.4.2.2 (Impact Ranges for Sonar and Other Transducers).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. (2) MIRC = Mariana Islands Range Complex.

Figure 6.4-34: Striped Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Table 6.4-38: Estimated Impacts on Individual Striped Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3,255	750	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5 Explosive Stressors

6.5.1 Background

Assessing whether an explosive detonation may disturb or injure a marine mammal involves understanding the characteristics of the explosive sources, the marine mammals that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on marine mammal hearing and behavior. Many other factors besides the received level or pressure wave of an explosion, such as the animal's physical condition and size, prior experience with the explosive sound, and proximity to the explosion may influence physiological effects and behavioral reactions. The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities).

6.5.1.1 Injury

Injury refers to the direct effects on the tissues or organs of an animal due to exposure to pressure waves. Injury in marine mammals can be caused directly by exposure to explosions. The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on injury and the framework used to analyze this potential impact.

6.5.1.1.1 Injury due to Explosives

Explosive injury to marine mammals would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Greaves et al., 1943; Office of the Surgeon General, 1991; Richmond et al., 1973). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities such as in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (Clark & Ward, 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix H (Acoustic and Explosive Concepts) of the MITT Draft SEIS/OEIS for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving explosives occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, however, a group of approximately 100–150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated, which could not be deactivated, on an explosive with a net explosive weight (NEW) of 8.76 pounds (lb.) (3.97 kilograms [kg]) placed at a depth of 48 ft. (14.6 m). Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful. Approximately one minute after detonation, three animals were observed dead at the surface. The Navy recovered those animals and transferred them to the local stranding network for necropsy. A fourth animal was discovered stranded and dead 42 NM to the north of the detonation three days later. It is unknown exactly how close those four animals were to the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil & St Leger, 2011).

Relatively little is known about auditory system trauma in marine mammals resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 kg explosive used off Newfoundland during demolition of an offshore oil rig platform (Ketten et al., 1993), but the proximity of the whales to the detonation was unknown. Eardrum rupture was examined in submerged terrestrial mammals exposed to underwater explosions (Richmond et al., 1973; Yelverton et al., 1973); however, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects (Section 6.5.1.2, Hearing Loss).

Controlled tests with a variety of lab animals (mice, rats, dogs, pigs, sheep and other species) are the best data sources on actual injury to mammals due to underwater exposure to explosions. In the early 1970s, the Lovelace Foundation for Medical Education and Research conducted a series of tests in an artificial pond at Kirtland Air Force Base, New Mexico to determine the effects of underwater explosions on mammals, with the goal of determining safe ranges for human divers. The resulting data were summarized in two reports (Richmond et al., 1973; Yelverton et al., 1973). Specific physiological observations for each test animal are documented in Richmond et al. (1973). Gas-containing internal organs, such as lungs and intestines, were the principle damage sites in submerged terrestrial mammals; this is consistent with earlier studies of mammal exposures to underwater explosions in which lungs were consistently the first areas to show damage, with less consistent damage observed in the gastrointestinal tract (Clark & Ward, 1943; Greaves et al., 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

6.5.1.1.1.1 Impulse as a Predictor of Explosive Injury

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and the size of an animal’s gas-containing cavities was thought to play a role in blast injury susceptibility. The lungs of most marine mammals are similar in proportion to overall body size as those of terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to marine mammals when scaled for body size. Within the marine mammals, mysticetes and deeper divers (e.g., Kogiidae, Physeteridae, Ziphiidae) tend to have lung-to-body-size ratios that are smaller and more similar to terrestrial animal ratios than the shallow diving odontocetes (e.g., Phocoenidae, Delphinidae) and pinnipeds (Fahlman et al., 2014a; Piscitelli et al., 2010). The use of test data with smaller lung to body ratios to set injury thresholds may result in a more conservative estimate of potential for damaging effects (i.e., lower thresholds) for animals with larger lung to body ratios.

For these shallow exposures of small terrestrial mammals (masses ranging from 3.4 to 50 kg) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 lb. per square inch per millisecond (psi-ms) (40 pascal seconds [Pa-s]), no instances of slight lung hemorrhage occurred below 20 psi-ms (140 Pa-s), and instances of no lung damage were observed in some exposures at higher levels up to 40 psi-ms (280 Pa-s). An impulse of

34 psi-ms (230 Pa-s) resulted in about 50 percent incidence of slight lung hemorrhage. About half of the animals had gastrointestinal tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25–27 psi-ms (170–190 Pa-s). Lung injuries were found to be slightly more prevalent than gastrointestinal tract injuries for the same exposure.

The Lovelace subject animals were exposed near the water surface; therefore, depth effects were not discernible in this data set. In addition, this data set included only small terrestrial animals, whereas marine mammals may be several orders of magnitude larger and have respiratory structures adapted for the high pressures experienced at depth. Goertner (1982) examined how lung cavity size would affect susceptibility to blast injury by considering both marine mammal size and depth in a bubble oscillation model of the lung. Animal depth relates to injury susceptibility in two ways: injury is related to the relative increase in explosive pressure over hydrostatic pressure, and lung collapse with depth reduces the potential for air cavity oscillatory damage. The period over which an impulse must be delivered to cause damage is assumed to be related to the natural oscillation period of an animal's lung, which depends on lung size.

Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth. Adaptations for diving include a flexible thoracic cavity, distensible veins that can fill space as air compresses, elastic lung tissue, and resilient tracheas with interlocking cartilaginous rings that provide strength and flexibility (Ridgway, 1972). Older literature suggested complete lung collapse depths at approximately 70 m for dolphins (Ridgway & Howard, 1979) and 20–50 m for 158donto seals (Falke et al., 1985; Kooyman et al., 1972). Follow-on work by Kooyman and Sinnett (1982), in which pulmonary shunting was studied in harbor seals and sea lions, suggested that complete lung collapse for these species would be about 170 m and about 180 m, respectively. More recently, evidence in sea lions suggests that complete collapse might not occur until depths as great as 225 m; although the depth of collapse and depth of the dive are related, sea lions can affect the depth of lung collapse by varying the amount of air inhaled on a dive (McDonald & Ponganis, 2012). This is an important consideration for all divers who can modulate lung volume and gas exchange prior to diving via the degree of inhalation and during diving via exhalation (Fahlman et al., 2009); indeed, there are noted differences in pre-dive respiratory behavior, with some marine mammals exhibiting pre-dive exhalation to reduce the lung volume (e.g., 158donto seals (Kooyman et al., 1973)).

6.5.1.1.1.2 Peak Pressure as a Predictor of Explosive Injury

High instantaneous peak pressures can cause damaging tissue distortion. Goertner (1982) suggested a peak overpressure gastrointestinal tract injury criterion because the size of gas bubbles in the gastrointestinal tract are variable, and their oscillation period could be short relative to primary blast wave exposure duration. The potential for gastrointestinal tract injury, therefore, may not be adequately modeled by the single oscillation bubble methodology used to estimate lung injury due to impulse. Like impulse, however, high instantaneous pressures may damage many parts of the body, but damage to the gastrointestinal tract is used as an indicator of any peak pressure-induced injury due to its vulnerability.

Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 µPa peak) to feel like slight pressure or a stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974). Around 200 psi, the shock wave felt like a blow to the head and chest. Data from the Lovelace Foundation experiments show instances of gastrointestinal tract contusions after exposures up to 1,147 psi peak pressure, while exposures of up to 588 psi peak pressure resulted in many instances of no observed gastrointestinal tract effects. The lowest exposure for which slight contusions to the gastrointestinal tract were reported was 237 dB re 1 µPa peak. As a vulnerable gas-containing organ, the gastrointestinal tract is vulnerable to both high peak pressure and high impulse, which may vary to differing extents due to blast exposure conditions (i.e., animal depth, distance from the charge). This likely explains the range of effects seen at similar peak pressure exposure levels and shows the utility of considering both peak pressure and impulse when analyzing the potential for injury due to explosives.

6.5.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss may vary depending on the exposure frequency, with frequencies at and above the exposure frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on hearing loss and the framework used to analyze this potential impact.

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns.

6.5.1.2.1 Threshold Shift due to Impulsive Sound Sources

Marine mammal TTS data from impulsive sources are limited to two studies with measured TTS of 6 dB or more: Finneran et al. (2002) reported behaviorally measured TTSs of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun, and Lucke et al. (2009) reported Auditory Evoked Potential-measured TTS of 7 to 20 dB in a harbor porpoise exposed to single impulses from a seismic air gun.

In addition to these data, Kastelein et al. (2015a) reported behaviorally measured mean TTS of 4 dB at 8 kHz and 2 dB at 4 kHz after a harbor porpoise was exposed to a series of impulsive sounds produced by broadcasting underwater recordings of impact pile driving strikes through underwater sound projectors. The cumulative SEL was approximately 180 dB re 1 $\mu Pa^2 s$. The pressure waveforms for the simulated pile strikes exhibited significant “ringing” not present in the original recordings, and most of the energy in the broadcasts was between 500 and 800 Hz. As a result, some questions exist regarding whether the fatiguing signals were representative of underwater pressure signatures from impact pile driving.

Several impulsive noise exposure studies have also been conducted without behaviorally measurable TTS. Finneran et al. (2000) exposed dolphins and belugas to single impulses from an “explosion simulator,” and Finneran et al. (2015) exposed three dolphins to sequences of 10 impulses from a seismic air gun (maximum cumulative SEL = 193 to 195 dB re 1 $\mu Pa^2 s$, peak SPL =196 to 210 dB re 1 µPa) without measurable TTS. Finneran et al. (2003b) exposed two sea lions to single impulses from an arc-gap transducer with no measurable TTS (maximum unweighted SEL = 163 dB re 1 μPa^{2}s, peak SPL = 183 dB re 1 μPa).

6.5.1.3 Physiological Stress

Marine mammals naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). The Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2) provides additional information on physiological stress and the framework used to analyze this potential impact.

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. General research findings regarding physiological stress in marine mammals due to exposure to sound and other stressors are discussed in detail in Physiological Stress under Acoustic Stressors above (Section 6.4.1.3). Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

6.5.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in the Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking may lead to a change in vocalizations or a change in behavior (e.g., cessation of foraging, leaving an area).

There are no direct observations of masking in marine mammals due to exposure to explosive sources. General research findings regarding masking in marine mammals due to exposure to sound and other stressors are discussed in detail in Masking under Acoustic Stressors above (Section 6.4.1.4). Potential masking from explosive sounds is likely to be similar to masking studied for other impulsive sounds such as air guns.

Masking could occur in mysticetes due to the overlap between their low-frequency vocalizations and the dominant frequencies of air gun pulses; however, masking in odontocetes is less likely unless the seismic survey activity is in close range when the pulses are more broadband. For example, differential vocal responses in marine mammals were documented in the presence of seismic survey noise. An overall decrease in vocalizations during active surveying was noted in large marine mammal groups (Potter et al., 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio & Clark, 2010), indicative of a possible compensatory response to the increased noise level. Bowhead whales were found to increase call rates in the presence of seismic air gun noise at lower received levels (below 100 dB re 1 μPa2s cumulative SEL), but once the received level rose above 127 dB re 1 Pa^{2}s cumulative SEL the call rate began decreasing and stopped altogether once received levels reached 170 dB re 1 Pa^{2}s cumulative SEL (Blackwell et al., 2015). Nieukirk et al. (2012) recorded both seismic surveys and fin whale 20 Hz calls at various locations around the mid-Atlantic Ocean and hypothesized that distant seismic noise could mask those calls, thereby decreasing the communication range of fin whales, whose vocalizations may propagate over 400 km to reach conspecifics (Spiesberger & Fristrup, 1990). A spotted seal and ringed seal in captivity were exposed to seismic air gun sounds recorded within 1 km and 30 km of an air gun survey conducted in shallow (<40 m) water. They were then tested on their ability to detect a 500-millisecond upsweep centered at 100 Hz at different points in the air gun pulse (start, middle, and end). Based on these results, a 100 Hz vocalization with a source level of 130 dB re 1Pa would not be detected above a seismic survey 1 km away unless the animal was within 1–5 m, and would not be detected above a survey 30 km away beyond 46 m (Sills et al., 2017).

6.5.1.5 Behavioral Reactions

As discussed in Conceptual Framework for Assessing Effects from Sound-Producing Activities (Section 6.2), any stimuli in the environment can cause a behavioral response in marine mammals, including noise from explosions. There are no direct observations of behavioral reactions from marine mammals due to exposure to explosive sounds. Lammers et al. (2017) recorded dolphin detections near naval mine neutralization exercises and found that although the immediate response (within 30 s of the explosion) was an increase in whistles relative to the 30 s before the explosion, there was a reduction in daytime acoustic activity during the day of and the day after the exercise within 6 km. However, the nighttime activity did not seem to be different than that prior to the exercise, and two days after there appeared to be an increase in daytime acoustic activity, indicating a rapid return to the area by the dolphins (Lammers et al. 2017). Vallejo et al. (2017) report on boat-based line transect surveys that were run over 10 years in an area where an offshore wind farm was built; these surveys included the periods of preconstruction, construction, and postconstruction. Harbor porpoise were observed throughout the area during all three phases, but were not detected within the footprint of the windfarm during the construction phase, and were overall less frequent throughout the study area. However, they returned after the construction was completed at a slightly higher level than in the preconstruction phase. Furthermore, there was no large-scale displacement of harbor porpoises during construction, and in fact their avoidance behavior only occurred out to about 18 km, in contrast to the approximately 25 km avoidance distance found in other windfarm construction and pile driving monitoring efforts.

Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks) and typically utilize large multi-air gun arrays that fire repeatedly. While seismic air gun data (as presented in Section 6.4, Acoustic Stressors) provides the best available science for assessing behavioral responses to impulsive sounds (i.e., sounds from explosives) by marine mammals, it is likely that these responses represent a worst-case scenario compared to most Navy explosive noise sources.

General research findings regarding behavioral reactions from marine mammals due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Behavioral Reactions under Acoustic Stressors above (Section 6.4.1.5).

6.5.1.5.1 Behavioral Reactions to Impulsive Sound Sources

Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. However, at long distances the rise time increases as the signal duration lengthens (similar to a "ringing" sound), making the impulsive signal more similar to a non-impulsive signal. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes, odontocetes, and pinnipeds. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-air gun arrays that fire repeatedly.

6.5.1.5.1.1 Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, attraction to the source, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al., 2003; McCauley et al., 2000; Richardson et al., 1995; Southall et al., 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin, and bowhead whales; it is assumed that these responses are representative of all baleen whale species. The behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond, as does the location and movement of the sound source, more than the received level of the sound.

Migratory behavior seems to lead to a higher likelihood of response, with some species demonstrating more sensitivity than others do. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 µPa (Malme et al., 1986, 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et al., 1998), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al., 2015). However, when comparing received levels and behavioral responses when using ramp-up versus a constant noise level of air guns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decreased their swim speeds (Dunlop et al., 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials; in either case there was no dose-response relationship with the received level of the air gun noise, and similar responses were observed in control trials with vessel movement but no air guns, so some of the response was likely due to the presence of the vessel and not the received level of the air guns. When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different air guns and found responses occurred more towards the smaller, closer source than to the larger source at the same received level, demonstrating the importance of proximity. Responses were found to be more likely when the source was within 3 km or above 140 dB re 1 µPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al., 2017). 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). Bowhead whales seem to be the most sensitive species, perhaps due to a higher overlap between bowhead whale distribution and seismic surveys in Arctic and sub-Arctic waters, as well as a recent history of being hunted. 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. Additionally, Malme et al. (1988) observed clear changes in diving and breathing patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa. Bowhead whales may also avoid the area around seismic surveys, from 6 to 8 km (Koski and Johnson 1987, as cited in Gordon et al., 2003) out to 20 or 30 km (Richardson et al., 1999). However, work by Robertson (2014) supports the idea that behavioral responses are contextually dependent, and that during seismic operations bowhead whales may be less "available" for counting due to alterations in dive behavior but that they may not have left the area after all.

In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates in western gray whales while resting or diving off the coast of Russia (Gailey et al., 2007; Yazvenko et al., 2007). However, the increase in vessel traffic associated with the surveys and the proximity of the vessels to the whales did effect the orientation of the whales relative to the vessels and shortened their dive-surface intervals (Gailey et al., 2016). 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 closer to the noise source, possibly indicating a reduction in net detection associated with the noise through masking or TTS. Distributions of fin and minke whales were modeled with a suite of environmental variables along with the occurrence or absence of seismic surveys, and no evidence of a decrease in sighting rates relative to seismic activity was found for either species (Vilela et al., 2016). Their distributions were driven entirely by environmental variables, particularly those linked to prey, including warmer sea surface temperatures, higher chlorophyll-a values, and higher photosynthetically available radiation (a measure of primary productivity).

Vocal responses to seismic surveys have been observed in a number of baleen whale species, including a cessation of calling, a shift in frequency, increases in amplitude or call rate, or a combination of these strategies. Blue whale feeding/social calls were found to increase when seismic exploration was underway, with seismic pulses at average received SELs of 131 dB re 1 µPa^{2}s (Di Lorio & Clark, 2010), a potentially compensatory response to increased noise level. Responses by fin whales to a 10-day seismic survey in the Mediterranean Sea included possible decreased 20 Hz call production and movement of animals from the area based on lower received levels and changes in bearings (Castellote et al., 2012). However, similarly distant seismic surveys elicited no apparent vocal response from fin whales in the mid-Atlantic Ocean; instead, Nieukirk et al. (2012) hypothesized that 20 Hz calls may have been masked from the receiver by distant seismic noise. Models of humpback whale song off Angola showed significant seasonal and diel variation, but also showed a decrease in the number of singers with increasing received levels of air gun pulses (Cerchio et al., 2014). Bowhead whale calling rates decreased significantly at sites near seismic surveys (41–45 km) where median received levels were between 116 and 129 dB re 1 µPa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where median received levels were 99–108 dB re 1 µPa (Blackwell et al., 2013). In fact, bowhead whale calling rates increased at the lower received levels, began decreasing at around 127 dB re 1 µPa^{2}s cumulative SEL, and ceased altogether at received levels over 170 dB re 1 µPa^{2}s cumulative SEL (Blackwell et al., 2015). Similar patterns were observed for bowhead vocalizations in the presence of tonal sounds associated with drilling activities and were amplified when the presence of both the tonal sounds and air gun pulses (Blackwell et al., 2017).

Mysticetes seem to be the most sensitive taxonomic group of marine mammals to impulsive sound sources, with possible avoidance responses occurring out to 30 km and vocal changes occurring in response to sounds over 100 km away. However, responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior.

6.5.1.5.1.2 Odontocetes

Few data are available on odontocete responses to impulsive sound sources, with only a few studies on responses to seismic surveys, pile driving, and construction activity available. However, odontocetes appear to be less sensitive to impulsive sound than mysticetes, with responses occurring at much closer distances. This may be due to the predominance of low-frequency sound associated with these sources that propagates long distances and overlaps with the range of best hearing for mysticetes but is below that range for odontocetes. The exception to this is the harbor porpoise, which has been shown to be highly sensitive to most sound sources, avoiding both stationary (e.g., pile driving) and moving (e.g., seismic survey vessels) impulsive sound sources out to approximately 20 km (e.g., Haelters et al., 2014; Pirotta et al., 2014). However, even this response is short term, with porpoises returning to the area within hours after the cessation of the noise.

Madsen et al. (2006a) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic air gun surveys. Sound sources were from approximately 2 to 7 NM away from the whales, and received levels were as high as 162 dB SPL re 1 µPa (Madsen et al., 2006). The whales showed no horizontal avoidance; however, one whale rested at the water's surface for an extended period of time until air guns ceased firing (Miller et al., 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al., 2009). Similarly, Weir (2008) observed that seismic air gun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to air gun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to air gun impulses within approximately 1 km of the source (Weir, 2008). The dolphins were observed at greater distances from the vessel when the air gun was in use, and when the air gun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized or were reluctant to return to the test station after exposure to single impulses from a seismic water gun (Finneran et al., 2002). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran et al., 2015). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, FL, Stock of bottlenose dolphins, the use of the area by females decreased while males displayed high site fidelity and continued using the area, perhaps indicating differential habitat uses between the sexes (Weaver, 2015).

A study was conducted on the response of harbor porpoises to a seismic survey using aerial surveys and C-PODs (an autonomous recording device that counts odontocete clicks); the animals appeared to have left the area of the survey, and decreased their foraging activity within 5−10 km, as evidenced by both a decrease in vocalizations near the survey and an increase in vocalizations at a distance (Pirotta et al., 2014; Thompson et al., 2013). However, the animals returned within a day after the air gun operation ceased, and the decrease in occurrence over the survey period was small relative to the observed natural seasonal decrease compared to the previous year. A number of studies (Brandt et al., 2011; Dähne et al., 2014; Haelters et al., 2014; Thompson et al., 2010; Tougaard et al., 2005; Tougaard et al., 2009) also found strong avoidance responses by harbor porpoises out to 20 km during pile driving;

however, all studies found that the animals returned to the area after the cessation of pile driving. When bubble curtains were deployed around pile driving, the avoidance distance appeared to be reduced to half that distance (12 km), and the response only lasted about five hours rather than a day before the animals returned to the area (Dähne et al., 2017). Kastelein et al. (2013b) exposed a captive harbor porpoise to impact pile driving sounds and found that above 136 dB re 1 µPa (zero-to-peak) the animal's respiration rates increased, and at higher levels it jumped more frequently. Bergstrom et al. (2014) found that although there was a high likelihood of acoustic disturbance during wind farm construction (including pile driving), the impact was short term. Graham et al. (2017) assessed the occurrence of bottlenose dolphins and harbor porpoises over different area and time scales with and without impact and vibratory pile driving. While there were fewer hours with bottlenose dolphin detections, reduced detection durations within the pile driving area, and increased detection durations outside the area, the effects sizes were small, and the reduced harbor porpoise encounter duration was attributed to seasonal changes outside the influence of the pile driving. However, received levels in this area were lower due to propagation effects than in the other areas described above, which may have led to the lack of or reduced response.

Odontocete behavioral responses to impulsive sound sources are likely species- and context-dependent, with most species demonstrating little to no apparent response. Responses might be expected within close proximity to a noise source, under specific behavioral conditions such as females with offspring, or for sensitive species such as harbor porpoises.

6.5.1.6 Stranding

When a marine mammal (alive or dead) 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 & Lounsbury, 2005; Perrin & Geraci, 2002). Specifically, under U.S. law, a stranding is an event in the wild where: "(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 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. section 1421h).

Impulsive sources (e.g., explosions) also have the potential to contribute to strandings, but such occurrences are even less common than those that have been related to certain sonar activities; see Section 6.5.1.1.1 (Injury due to Explosives). Discussions of procedures associated with these and other training and testing activities are presented in Chapter 11 (Mitigation Measures), which details all mitigation measures.

6.5.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 6.2 (Conceptual Framework for Assessing Effects from Sound-Producing Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking, and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

6.5.2 Impacts from Explosives

Marine mammals could be exposed to energy, sound, and fragments from underwater explosions associated with the proposed activities. Energy from an explosion is capable of causing mortality, injury, hearing loss, a behavioral response, masking, or physiological stress, depending on the level and duration of exposure.

The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries or PTS may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal's abilities, but the individual is likely to recover quickly with little significant effect.

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds, which are within the audible range of most marine mammals, could cause behavioral reactions, masking, and elevated physiological stress. 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 2005). Sounds from explosives could also mask biologically important sounds; however, the duration of individual sounds is very short, reducing the likelihood of substantial auditory masking.

6.5.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be impacted by explosives used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts to marine mammals uses the Navy's Acoustic Effects Model to produce initial estimates of the number of instances that animals that may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures. The steps of this quantitative analysis are described in the MITT Draft SEIS/OEIS Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts on Sea Turtles and Marine Mammals), which takes into account:

- criteria and thresholds used to predict impacts from explosives (see below),
- the density and spatial distribution of marine mammals, and
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation and explosive energy when estimating the received sound level and pressure on the animals.

A detailed explanation of this analysis and how the criteria and thresholds were derived is provided in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a).

6.5.2.1.1 Criteria and Thresholds Used to Estimate Impacts to Marine Mammals from Explosives

6.5.2.1.1.1 Mortality and Injury from Explosives

As discussed above in Section 6.5.1.1 (Injury), two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the "crack" or "stinging" sensation of a blast wave, compared to the "thump" associated with received impulse. Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 µPa SPL peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974).

Because data on explosive injury do not indicate a set threshold for injury, rather a range of risk for explosive exposures, two sets of criteria are provided for use in non-auditory injury assessment. The first set provides thresholds to estimate the number of animals that may be affected during Navy training and testing activities (see Table 6.5-1). The thresholds for the farthest range to effect are based on the received level at which 1 percent risk is predicted and are useful for assessing potential effects to marine mammals and level of potential impacts covered by the mitigation zone. Increasing animal mass and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). For impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. Sub-adult masses are used to determine onset of effect, in order to estimate the farthest range at which an effect may first be observable. The derivation of these injury criteria and the species mass estimates are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2017b).

Table 6.5-1: Criteria to Quantitatively Assess Non-Auditory Injury Due to Underwater Explosions

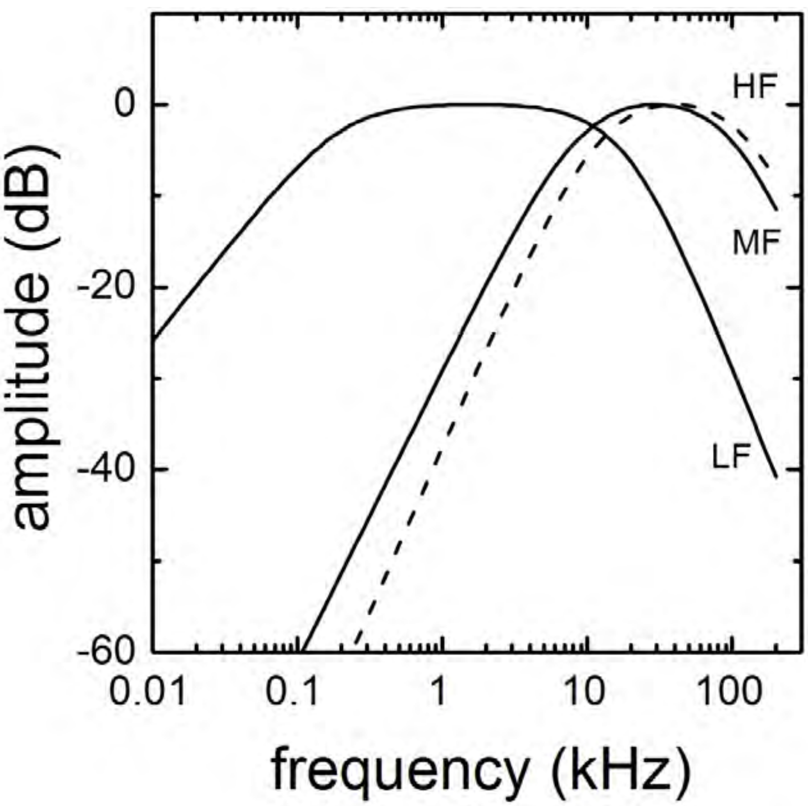
Impact Category	*Impact Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s $144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$103\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s $144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
Injury[1]	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ $65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
	243 dB re 1 μPa SPL peak	237 dB re 1 μPa SPL peak

[1] Impulse delivered over 20 percent of the estimated lung resonance period. See U.S. Department of the Navy (2017b).
[2] Threshold for one percent risk used to assess mitigation effectiveness.
Notes: dB re 1 μPa = decibels referenced to 1 micropascal, SPL = sound pressure level

When explosive ordnance (e.g., bomb or missile) detonates, fragments of the weapon are thrown at high-velocity from the detonation point, which can injure or kill marine mammals if they are struck. Risk of fragment injury reduces exponentially with distance as the fragment density is reduced. Fragments underwater tend to be larger than fragments produced by in-air explosions (Swisdak & Montanaro, 1992). Underwater, the friction of the water would quickly slow these fragments to a point where they no longer pose a threat. On the other hand, the blast wave from an explosive detonation moves efficiently through the seawater. Because the ranges to mortality and injury due to exposure to the blast wave are likely to far exceed the zone where fragments could injure or kill an animal, the above threshold are assumed to encompass risk due to fragmentation.

6.5.2.1.1.2 Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used. Auditory weighting functions are mathematical functions based on a generic band-pass filter and incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL (Figure 6.5-1). Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

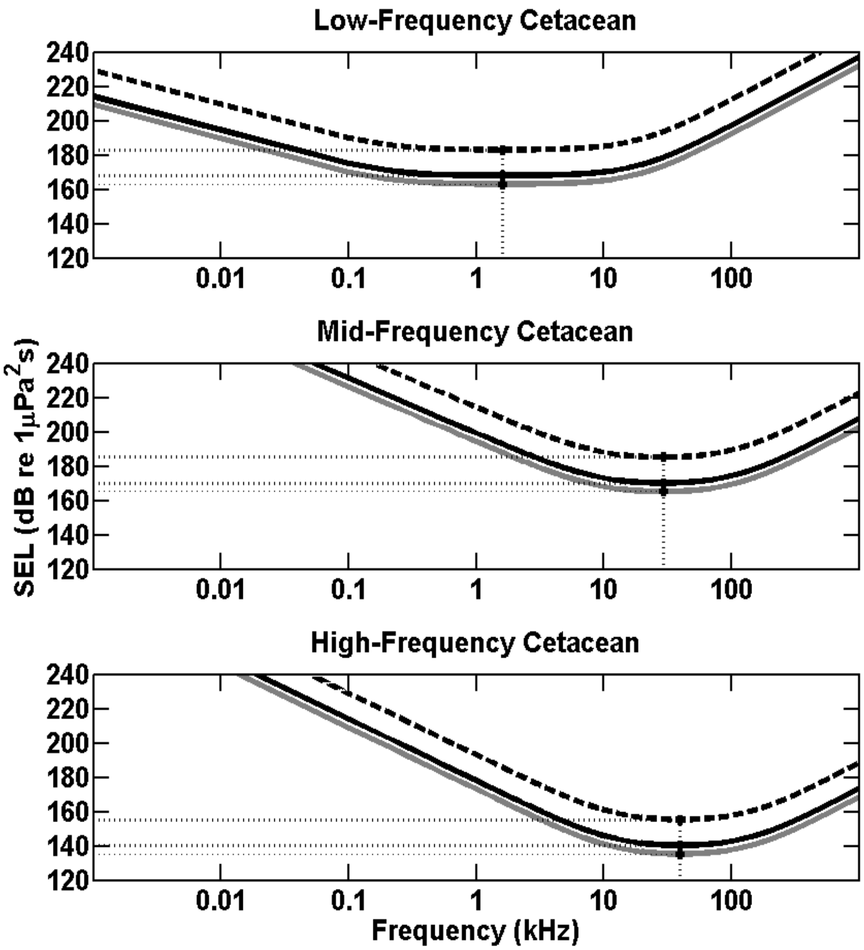


For parameters used to generate the functions and more information on weighting function derivation see Finneran, 2015. Notes: MF = Mid-Frequency Cetacean; HF = High-Frequency Cetacean; LF = Low-Frequency Cetacean

Figure 6.5-1: Navy Phase 3 Weighting Functions for all Species Groups

6.5.2.1.1.3 Hearing Loss from Explosives

Criteria used to define threshold shifts from explosions are derived from the two known studies designed to induce TTS in marine mammals from impulsive sources. Finneran et al. (2002) reported behaviorally measured TTS of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun and Lucke et al. (2009) reported auditory evoked potential-measured TTS of 7–20 dB in a harbor porpoise exposed to single impulses from a seismic air gun. Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for all groups were estimated by adding 15 dB to the threshold for non-impulsive sources. This relationship was derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. These frequency dependent thresholds are depicted by the exposure functions for each group's range of best hearing (see Figure 6.5-2and Table 6.5-2).



Notes: The dark dashed curve is the exposure function for PTS onset, the solid black curve is the exposure function for TTS onset, and the light grey curve is the exposure function for behavioral response. Small dashed lines indicate the SEL threshold for behavioral response, TTS, and PTS onset at each group's most sensitive frequency (i.e., the weighted SEL threshold).

Figure 6.5-2: Navy Phase III Behavioral, TTS and PTS exposure functions for explosives

Table 6.5-2: Navy Phase III Weighted Sound Exposure Level Behavioral Response, Temporary Threshold and Permanent Onset Thresholds and Unweighted Peak Sound Pressure Level Temporary Threshold and Permanent Onset Thresholds for Underwater Explosive Sounds

Hearing Group	*Explosive Sound Source*				
	Behavior (SEL) weighted (dB)	*TTS (SEL) weighted (dB)*	*TTS (Peak SPL) unweighted (dB)*	*PTS (SEL) weighted (dB)*	*PTS (Peak SPL) unweighted (dB)*
Low-frequency Cetacean	**163**	**168**	**213**	**183**	**219**
Mid-frequency Cetacean	**165**	**170**	**224**	**185**	**230**
High-frequency Cetacean	**135**	**140**	**196**	**155**	**202**

Notes: dB = decibels, PTS = permanent threshold shift, SEL = sound exposure level, SPL = sound pressure level, TTS = temporary threshold shift

6.5.2.1.1.4 Behavioral Responses from Explosives

If more than one explosive event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reaction. For exercises with multiple explosions, the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in SEL). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulsive TTS testing (Schlundt et al., 2000).

Some multiple explosive exercises, such as certain naval gunnery exercises, may be treated as a single event because a few explosions occur closely spaced within a very short time (a few seconds). For single explosions 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 the criteria used in this analysis.

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. The number of animats that exceed the thresholds for effects is tallied to provide an estimate of the number of marine mammals that could be affected.

Assumptions in the Navy model intentionally err on the side of overestimation when there are unknowns.

- Naval activities are modeled as though they would occur regardless of proximity to marine mammals (i.e., mitigation is not modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation.
- 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 underwater. This overestimates the amount of explosive and acoustic energy entering the water.

The model estimates the impacts caused by individual training and testing exercises. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances that marine mammals may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances in which an effect threshold was exceeded over the course of a year, but does not estimate the number of individual marine mammals that may be impacted over a year (i.e., some marine mammals could be impacted several times, while others would not experience any impact). A detailed explanation of the Navy's Acoustic Effects Model is provided in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018a).

6.5.2.1.2 Accounting for Mitigation

The Navy will implement at-sea procedural mitigation measures to avoid or reduce potential impacts from explosives as described in Chapter 11 (Mitigation Measures). Procedural mitigation measures include delaying or ceasing applicable detonations when a marine mammal is observed in a mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives. Two factors are considered when quantifying the effectiveness of procedural mitigation: (1) the extent to which the type of mitigation proposed for an explosive activity (e.g., explosive bombing exercise) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018a).

In the quantitative analysis, consideration of procedural mitigation measures means that, for activities that implement mitigation, model-estimated mortality is considered mitigated to the level of injury. The impact analysis does not analyze the potential for mitigation to reduce non-auditory injury, PTS, TTS or behavioral effects, even though mitigation could also reduce some likelihood of these effects for explosive activities. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the ranges to mortality was estimated for each training or testing event. The ability of Navy Lookouts to detect marine mammals within a mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. For example, based on small boat surveys between 2000 and 2012 in the Hawaiian Islands, pantropical spotted dolphins and striped dolphins were frequently observed leaping out of the water, and Cuvier's beaked whales (Baird, 2013) and Blainville's beaked whales (HDR, 2012) were occasionally observed breaching. These behaviors are visible from a great distance and likely increase sighting distances and detections of these species. Environmental conditions under which the training or testing activity could take place are also considered, such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

6.5.2.2 Impact Ranges for Explosives

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria (Section 6.5.2.1.1, Criteria and Thresholds Used to Estimate Impacts to Marine Mammals from Explosives) and the explosive propagation calculations from the Navy Acoustic Effects Model (Section 6.4.2.1.3, The Navy's Acoustic Effects Model). The range to effects for a range of explosive bins are shown in tables within this section below, from E1 (up to 0.25 lb. NEW) to E12 (up to 1,000 lb. NEW). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause behavioral response, TTS, PTS, and non-auditory injury. Range to effects is important information in not only predicting impacts from explosives, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will be mitigated within applicable mitigation zones.

Table 6.5-3 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury as a function of animal mass and explosive bin (i.e., NEW). Ranges to gastrointestinal tract injury typically exceed ranges to slight lung injury; therefore, the maximum range to effect is not dependent on mass. 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.

Table 6.5-3: Ranges[1] to 50 Percent Non-Auditory Injury for All Marine Mammal Hearing Groups as a Function of Animal Mass (10–72,000 kg)

Bin	*Range (m) (min-max)*
E1	12 (11–13)
E2	16 (15–16)
E3	25 (25–25)
E4	30 (30–35)
E5	40 (40–65)
E6	52 (50–60)
E7	120 (120–120)
E8	98 (90–150)
E9	123 (120–270)
E10	155 (150–430)
E11	418 (410–420)
E12	195 (180–675)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
Note: All ranges to non-auditory injury within this table are driven by gastrointestinal tract injury thresholds regardless of animal mass.

Ranges to mortality, based on animal mass, are shown in Table 6.5-4. The following tables (Tables 6.5-5 through Figure 6.4-10) show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 6.5.2.1.1 (Criteria and Thresholds Used to Estimate Impacts to Marine Mammals from Explosives). Ranges are provided for a representative source depth and cluster size for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure-based ranges are estimated using the best available science; however, data on peak pressure at far distances from explosions are very limited. For additional information on how ranges to impacts from explosions were estimated, see the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing Ranges* (U.S. Department of the Navy, 2018a).

Table 6.5-4: Ranges[1] to 50 Percent Mortality Risk for All Marine Mammal Hearing Groups as a Function of Animal Mass

Bin	Animal Mass Intervals (kg)[1]					
	10	250	1,000	5,000	25,000	72,000
E1	3 (3–3)	1 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E2	4 (3–4)	2 (1–3)	1 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)
E3	9 (7–10)	4 (2–8)	2 (1–2)	1 (0–1)	0 (0–0)	0 (0–0)
E4	13 (12–15)	7 (4–12)	3 (3–4)	2 (1–3)	1 (1–1)	1 (0–1)
E5	13 (12–30)	7 (4–25)	3 (2–7)	2 (1–5)	1 (1–2)	1 (0–2)
E6	16 (15–25)	9 (5–23)	4 (3–8)	3 (2–6)	1 (1–2)	1 (1–2)
E7	55 (55–55)	26 (18–40)	13 (11–15)	9 (7–10)	4 (4–4)	3 (2–3)
E8	42 (25–65)	22 (9–50)	11 (6–19)	8 (4–13)	4 (2–6)	3 (1–5)
E9	33 (30–35)	20 (13–30)	10 (9–12)	7 (5–9)	4 (3–4)	3 (2–3)
E10	55 (40–170)	24 (16–35)	13 (11–15)	9 (7–11)	5 (4–5)	4 (3–4)
E11	206 (200–210)	98 (55–170)	44 (35–50)	30 (25–35)	16 (14–18)	12 (10–15)
E12	86 (50–270)	35 (20–210)	16 (13–19)	11 (9–13)	6 (5–6)	5 (4–5)

[1]Average distance (m) to mortality is depicted above the minimum and maximum distances, which are in parentheses.

Table 6.5-5: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction for High-Frequency Cetaceans

Range to Effects for Explosives Bin: High-frequency cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	0.1	1	353 (340–370)	1,303 (1,275–1,775)	2,139 (2,025–4,275)
		18	1,031 (1,025–1,275)	3,409 (2,525–8,025)	4,208 (3,025–11,525)
E2	0.1	1	431 (410–700)	1,691 (1,525–2,775)	2,550 (2,025–4,525)
		5	819 (775–1,275)	2,896 (2,275–6,775)	3,627 (2,525–10,275)
E3	0.1	1	649 (625–700)	2,439 (2,025–4,525)	3,329 (2,525–7,525)
		12	1,682 (1,525–2,275)	4,196 (3,025–11,525)	5,388 (4,525–16,275)
	18.25	1	720 (675–775)	4,214 (2,275–6,275)	7,126 (3,525–8,775)
		12	1,798 (1,525–2,775)	10,872 (4,525–13,775)	14,553 (5,525–17,775)
E4	10	2	1,365 (1,025–2,775)	7,097 (4,275–10,025)	9,939 (5,025–15,275)
	60	2	1,056 (875–2,275)	3,746 (2,775–5,775)	5,262 (3,025–7,775)
E5	0.1	20	2,926 (1,525–6,275)	6,741 (4,525–16,025)	9,161 (4,775–20,025)
	30	20	4,199 (3,025–6,275)	13,783 (8,775–17,775)	17,360 (10,525–22,775)
E6	0.1	1	1,031 (1,025–1,275)	3,693 (2,025–8,025)	4,659 (3,025–12,775)
	30	1	1,268 (1,025–1,275)	7,277 (3,775–8,775)	10,688 (5,275–12,525)
E7	28	1	1,711 (1,525–2,025)	8,732 (4,275–11,775)	12,575 (4,275–16,025)
E8	0.1	1	1,790 (1,775–3,025)	4,581 (4,025–10,775)	6,028 (4,525–15,775)
	45.75	1	1,842 (1,525–2,025)	9,040 (4,525–12,775)	12,729 (5,025–18,525)
E9	0.1	1	2,343 (2,275–4,525)	5,212 (4,025–13,275)	7,573 (5,025–17,025)

Table 6.5-6: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction for High-Frequency Cetaceans

Range to Effects for Explosives Bin: High-frequency cetaceans[1]					
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E10	0.1	1	2,758 (2,275–5,025)	6,209 (4,275–16,525)	8,578 (5,275–19,775)
E11	45.75	1	3,005 (2,525–3,775)	11,648 (5,025–18,775)	14,912 (6,525–24,775)
	91.4	1	3,234 (2,525–4,525)	5,772 (4,775–11,775)	7,197 (5,775–14,025)
E12	0.1	1	3,172 (3,025–6,525)	7,058 (5,025–17,025)	9,262 (6,025–21,775)
		4	4,209 (3,775–10,025)	9,817 (6,275–22,025)	12,432 (7,525–27,775)

[1]Average distance (m) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Table 6.5-7: Peak Pressure Based Ranges to Onset PTS, Onset TTS for High-Frequency Cetaceans

Range to Effects for Explosives Bin: High-frequency cetaceans[1]				
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E1	0.1	1	745 (700–775)	1,275 (1,275–1,275)
		18	745 (700–775)	1,275 (1,275–1,275)
E2	0.1	1	912 (380–975)	1,498 (725–1,525)
		5	912 (380–975)	1,498 (725–1,525)
E3	0.1	1	1,525 (1,525–1,525)	2,397 (2,025–2,525)
		12	1,525 (1,525–1,525)	2,397 (2,025–2,525)
	18.25	1	1,561 (1,525–2,775)	2,919 (2,775–3,525)
		12	1,561 (1,525–2,775)	2,919 (2,775–3,525)

Table 6.5-7: Peak Pressure Based Ranges to Onset PTS, Onset TTS for High-Frequency Cetaceans (continued)

Range to Effects for Explosives Bin: High-frequency cetaceans[1]				
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E4	10	2	2,076 (1,775–2,525)	5,565 (3,525–7,775)
	60	2	2,364 (1,775–4,775)	4,044 (2,025–5,275)
E5	0.1	20	2,267 (1,025–3,275)	3,093 (1,275–5,775)
	30	20	2,567 (2,275–2,775)	3,747 (3,025–5,275)
E6	0.1	1	2,546 (1,275–4,525)	3,356 (1,525–6,525)
	30	1	3,242 (2,775–3,525)	4,598 (3,525–5,275)
E7	28	1	4,261 (3,025–5,025)	7,782 (3,775–12,525)
E8	0.1	1	3,458 (3,025–6,525)	4,324 (3,775–8,275)
	45.75	1	4,790 (4,275–6,525)	11,013 (4,775–23,775)
E9	0.1	1	3,870 (3,275–8,025)	4,620 (3,775–10,275)
E10	0.1	1	3,993 (2,525–9,275)	5,076 (2,775–16,025)
E11	45.75	1	8,388 (4,775–24,275)	17,386 (5,025–33,275)
	91.4	1	5,051 (4,025–7,525)	7,065 (4,275–26,525)
E12	0.1	1	4,519 (3,775–9,775)	5,678 (4,275–13,025)
		4	4,519 (3,775–9,775)	5,678 (4,275–13,025)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Table 6.5-8: SEL Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction for Low-Frequency Cetaceans

Range to Effects for Explosives Bin: Low-frequency cetaceans[1]					
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E1	0.1	1	51 (50–55)	231 (200–250)	378 (280–410)
		18	183 (170–190)	691 (450–775)	934 (575–1,275)
E2	0.1	1	66 (65–70)	291 (220–320)	463 (330–500)
		5	134 (110–140)	543 (370–600)	769 (490–950)
E3	0.1	1	113 (110–120)	477 (330–525)	689 (440–825)
		12	327 (250–370)	952 (600–1,525)	1,240 (775–4,025)
	18.25	1	200 (200–200)	955 (925–1,000)	1,534 (1,275–1,775)
		12	625 (600–625)	5,517 (2,275–7,775)	10,299 (3,775–13,025)
E4	10	2	429 (370–600)	2,108 (1,775–2,775)	4,663 (3,025–6,025)
	60	2	367 (340–470)	1,595 (1,025–2,025)	2,468 (1,525–4,275)
E5	0.1	20	702 (380–1,275)	1,667 (850–11,025)	2,998 (1,025–19,775)
	30	20	1,794 (1,275–2,775)	8,341 (3,775–11,525)	13,946 (4,025–22,275)
E6	0.1	1	250 (190–410)	882 (480–1,775)	1,089 (625–6,525)
	30	1	495 (490–500)	2,315 (2,025–2,525)	5,446 (3,275–6,025)
E7	28	1	794 (775–900)	4,892 (2,775–6,275)	9,008 (3,775–12,525)
E8	0.1	1	415 (270–725)	1,193 (625–4,275)	1,818 (825–8,525)
	45.75	1	952 (900–975)	6,294 (3,025–9,525)	12,263 (4,275–20,025)
E9	0.1	1	573 (320–1,025)	1,516 (725–7,275)	2,411 (950–14,275)

Table 6.5-8: SEL Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction for Low-Frequency Cetaceans (continued)

Range to Effects for Explosives Bin: Low-frequency cetaceans[1]					
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E10	0.1	1	715 (370–1,525)	2,088 (825–28,275)	4,378 (1,025–32,275)
E11	45.75	1	1,881 (1,525–2,275)	12,425 (4,275–27,275)	23,054 (7,025–65,275)
	91.4	1	1,634 (1,275–2,525)	5,686 (3,775–11,275)	11,618 (5,525–64,275)
E12	0.1	1	790 (420–2,775)	2,698 (925–25,275)	6,032 (1,025–31,275)
		4	1,196 (575–6,025)	6,876 (1,525–31,275)	13,073 (3,775–64,275)

[1]Average distance (m) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Table 6.5-9: Peak Pressure Based Ranges to Onset PTS and Onset TTS for Low-Frequency Cetaceans

Range to Effects for Explosives Bin: Low-frequency cetaceans[1]				
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E1	0.1	1	135 (130–140)	249 (220–270)
		18	135 (130–140)	249 (220–270)
E2	0.1	1	173 (120–180)	305 (180–330)
		5	173 (120–180)	305 (180–330)
E3	0.1	1	292 (240–310)	499 (330–550)
		12	292 (240–310)	499 (330–550)
	18.25	1	310 (310–310)	583 (550–600)
		12	310 (310–310)	583 (550–600)

Table 6.5-9: Peak Pressure Based Ranges to Onset PTS and Onset TTS for Low-Frequency Cetaceans (continued)

Range to Effects for Explosives Bin: Low-frequency cetaceans[1]				
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E4	10	2	396 (390–420)	738 (725–750)
	60	2	420 (380–775)	846 (575–2,025)
E5	0.1	20	451 (310–525)	740 (410–1,025)
	30	20	521 (490–600)	971 (925–1,025)
E6	0.1	1	547 (350–700)	842 (460–1,275)
	30	1	622 (600–650)	1,025 (1,025–1,025)
E7	28	1	927 (900–950)	1,524 (1,275–1,525)
E8	0.1	1	799 (450–925)	1,030 (575–1,775)
	45.75	1	1,025 (1,025–1,025)	1,778 (1,525–2,025)
E9	0.1	1	947 (500–1,275)	1,294 (675–3,025)
E10	0.1	1	1,032 (550–1,775)	1,388 (800–4,275)
E11	45.75	1	1,778 (1,525–2,025)	3,067 (2,275–11,275)
	91.4	1	1,676 (1,275–3,275)	2,442 (2,025–3,525)
E12	0.1	1	1,151 (625–2,525)	1,762 (900–5,275)
		4	1,151 (625–2,525)	1,762 (900–5,275)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

Table 6.5-10: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction for Mid-Frequency Cetaceans

Range to Effects for Explosives Bin: Mid-frequency cetaceans[1]					
Bin	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E1	0.1	1	25 (25–25)	116 (110–120)	199 (190–210)
		18	94 (90–100)	415 (390–440)	646 (525–700)
E2	0.1	1	30 (30–35)	146 (140–170)	248 (230–370)
		5	63 (60–70)	301 (280–410)	481 (430–675)
E3	0.1	1	50 (50–50)	233 (220–250)	381 (360–400)
		12	155 (150–160)	642 (525–700)	977 (700–1,025)
	18.25	1	40 (40–40)	202 (190–220)	332 (320–350)
		12	126 (120–130)	729 (675–775)	1,025 (1,025–1,025)
E4	10	2	76 (70–90)	464 (410–550)	783 (650–975)
	60	2	60 (60–60)	347 (310–675)	575 (525–900)
E5	0.1	20	290 (280–300)	1,001 (750–1,275)	1,613 (925–3,275)
	30	20	297 (240–420)	1,608 (1,275–2,775)	2,307 (2,025–2,775)
E6	0.1	1	98 (95–100)	430 (400–450)	669 (550–725)
	30	1	78 (75–80)	389 (370–410)	619 (600–650)
E7	28	1	110 (110–110)	527 (500–575)	1,025 (1,025–1,025)
E8	0.1	1	162 (150–170)	665 (550–700)	982 (725–1,025)
	45.75	1	127 (120–130)	611 (600–625)	985 (950–1,025)
E9	0.1	1	215 (210–220)	866 (625–1,000)	1,218 (800–1,525)

Table 6.5-10: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction for Mid-Frequency Cetaceans (continued)

Range to Effects for Explosives Bin: Mid-frequency cetaceans[1]					
Bin	*Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*	*Behavioral*
E10	0.1	1	270 (250–280)	985 (700–1,275)	1,506 (875–2,525)
E11	45.75	1	241 (230–250)	1,059 (1,000–1,275)	1,874 (1,525–2,025)
	91.4	1	237 (230–270)	1,123 (900–2,025)	1,731 (1,275–2,775)
E12	0.1	1	332 (320–370)	1,196 (825–1,525)	1,766 (1,025–3,525)
		4	572 (500–600)	1,932 (1,025–4,025)	2,708 (1,275–6,775)

[1]Average distance (m) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Table 6.5-11: Peak Pressure Based Ranges to Onset PTS and Onset TTS for Mid-Frequency Cetaceans

Range to Effects for Explosives Bin: Mid-frequency cetaceans[1]				
Bin	*Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*
E1	0.1	1	43 (40–45)	84 (80–90)
		18	43 (40–45)	84 (80–90)
E2	0.1	1	58 (55–60)	105 (95–110)
		5	58 (55–60)	105 (95–110)
E3	0.1	1	98 (95–100)	183 (170–190)
		12	98 (95–100)	183 (170–190)
	18.25	1	100 (100–100)	180 (180–180)
		12	100 (100–100)	180 (180–180)

Table 6.5-11: Peak Pressure Based Ranges to Onset PTS and Onset TTS for Mid-Frequency Cetaceans (continued)

Range to Effects for Explosives Bin: Mid-frequency cetaceans[1]				
Bin	*Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*
E4	10	2	120 (120–120)	255 (250–260)
	60	2	123 (120–130)	239 (230–340)
E5	0.1	20	155 (150–160)	288 (270–300)
	30	20	168 (160–190)	310 (290–350)
E6	0.1	1	197 (190–210)	359 (320–400)
	30	1	200 (200–200)	380 (380–380)
E7	28	1	296 (290–300)	525 (525–525)
E8	0.1	1	333 (310–340)	574 (440–625)
	45.75	1	351 (350–370)	629 (625–725)
E9	0.1	1	442 (370–460)	757 (500–850)
E10	0.1	1	546 (420–700)	939 (550–1,275)
E11	45.75	1	662 (650–800)	1,104 (1,025–1,275)
	91.4	1	748 (600–1,525)	1,353 (1,000–2,525)
E12	0.1	1	663 (470–725)	1,064 (625–1,275)
		4	663 (470–725)	1,064 (625–1,275)

[1] Distances in meters (m). Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

6.5.2.3 Impacts from Explosive Stressors Under the Proposed Action

Under the Proposed Action as described in Section 1.5 (Proposed Action), there could be fluctuation in the amount of explosions that could occur annually, although potential impacts would be similar from year to year. Specifically, the number of torpedo testing activities (both explosive and non-explosive) planned under the Proposed Action testing can vary slightly from year-to-year; however, all other training and testing activities that involve the use of explosives would remain consistent from year-to-year. The acoustic modeling results are presented for a maximum explosive use year; however, during most years, explosive use would be less, resulting in fewer potential impacts. The numbers of explosives proposed for use are described in Section 6.5 (Explosive Stressors).

6.5.2.3.1 Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from explosives (Section 6.5.2.1, Methods for Analyzing Impacts from Explosives) are discussed below. The numbers of potential impacts estimated for individual species of marine mammals from exposure to explosive energy and sound for training activities are shown in Appendix E (Estimated Marine Mammals and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors under Navy Training and Testing Activities) of the MITT Draft SEIS/OEIS. Additionally, estimated numbers of potential impacts from the quantitative analysis for each species are presented below. The most likely regions and activity categories from which the impacts could occur are displayed in the impact graphics for each species. There is a potential for impacts to occur anywhere within the Study Area where sound and energy from explosives and the species overlap, although only regions or activity categories where 0.5 percent of the impacts, or greater, are estimated to occur are graphically represented on the impact graphics below. All (i.e., grand total) estimated impacts are included, regardless of region or category.

6.5.2.3.2 Mysticetes

Mysticetes may be exposed to sound and energy from explosives associated with training and testing activities that occur throughout the year. Explosives produce sounds that are within the hearing range of mysticetes (Section 6.3, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. Impact ranges for mysticetes exposed to explosive sound and energy are discussed under low-frequency cetaceans in Section 6.5.2.2 (Impact Ranges for Explosives).

Mysticetes that do experience threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from a threshold shift begins almost immediately after the noise exposure ceases and can take a few minutes to a few days, depending on the severity of the initial shift, to fully recover. TTS would recover fully and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the short period that a mysticete had TTS, or permanently for PTS, social calls from conspecifics could be more difficult to detect or interpret, the ability to detect predators may be reduced, and the ability to detect and avoid sounds from approaching vessels or other stressors might be reduced. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether a TTS would affect a mysticete’s ability to locate prey or rate of feeding.

Research and observations of auditory masking in marine mammals due to impulsive sounds are discussed in Section 6.5.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in mysticetes that are nearby, although sounds from explosions last for only a few seconds at most. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations, such as some naval gunfire exercises, could create some masking for mysticetes in the area over the short duration of the event. Potential costs to mysticetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water, and the effect is over the moment the sound has ceased.

Research and observations (Section 6.5.2.1.1.4, Behavioral Responses from Explosives) show that if mysticetes are exposed to impulsive sounds such as those from explosion, they may react in a variety of ways, which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, changing vocalization, or showing no response at all. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from mysticetes are likely to be short term and low-to-moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 6.5.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

6.5.2.3.2.1 Blue Whale (Endangered Species Act-Listed)

Blue whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no blue whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of blue whales incidental to those activities.

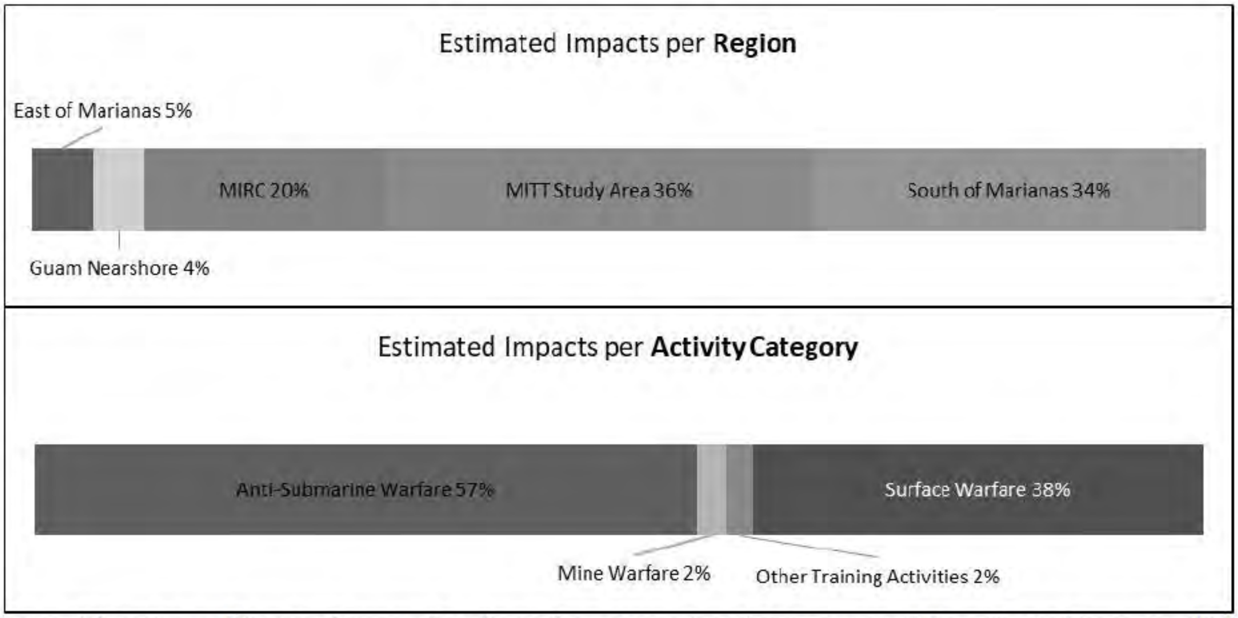
6.5.2.3.2.2 Bryde's Whale

Bryde's whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS (Figure 6.5-3 and Table 6.5-12). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as

described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of Bryde's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. MIRC = Mariana Islands Range Complex.

Figure 6.5-3: Bryde's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-12: Estimated Impacts on Individual Bryde's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	2	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.3 Fin Whale (Endangered Species Act-Listed)

Fin whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no fin whales would be impacted. Long-term consequences for individuals or the species would not be expected.

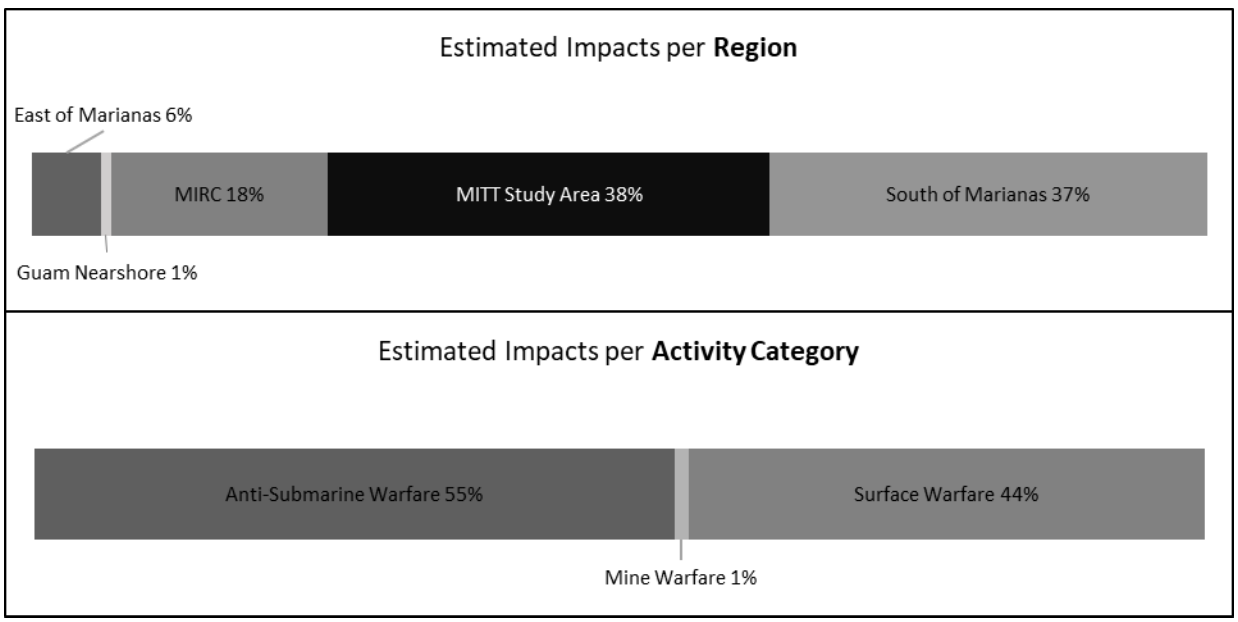
Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of fin whales incidental to those activities.

6.5.2.3.2.4 Humpback Whale (Endangered Species Act-Listed)

Humpback whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS (Figure 6.5-4 and Table 6.5-13). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of humpback whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-4: Humpback Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-13: Estimated Impacts on Individual Humpback Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
6	3	0	0

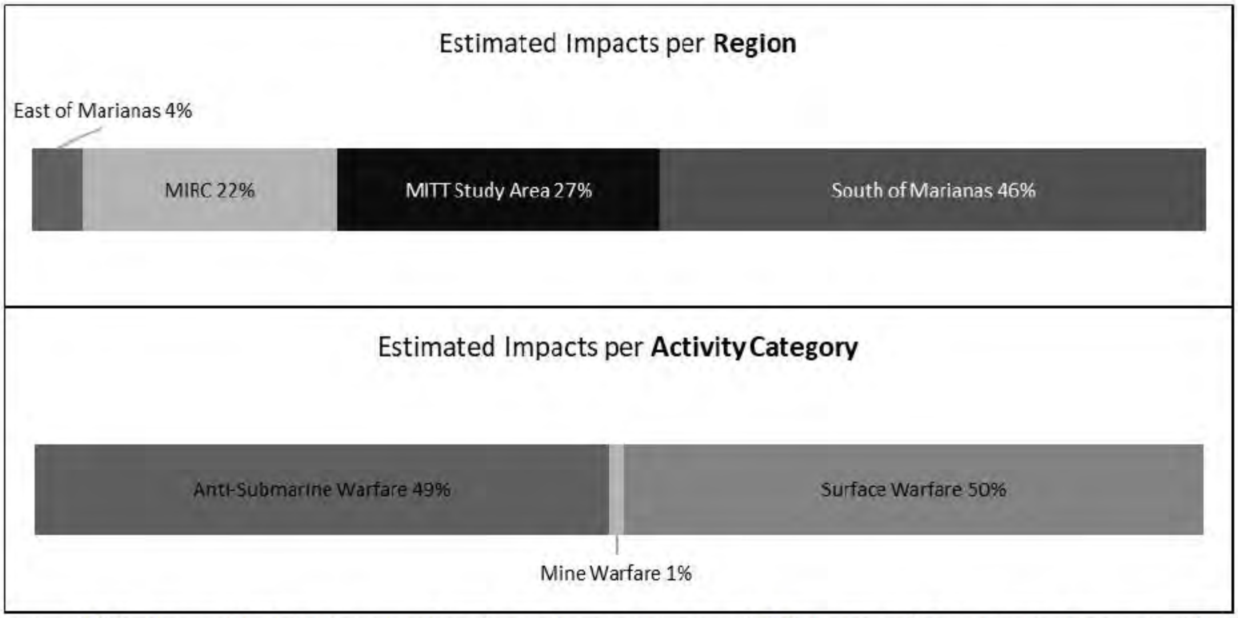
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.5 Minke Whale

Minke whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS (Figure 6.5-5 and Table 6.5-14). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of minke whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-5: Minke Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-14: Estimated Impacts on Individual Minke Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
6	3	0	0

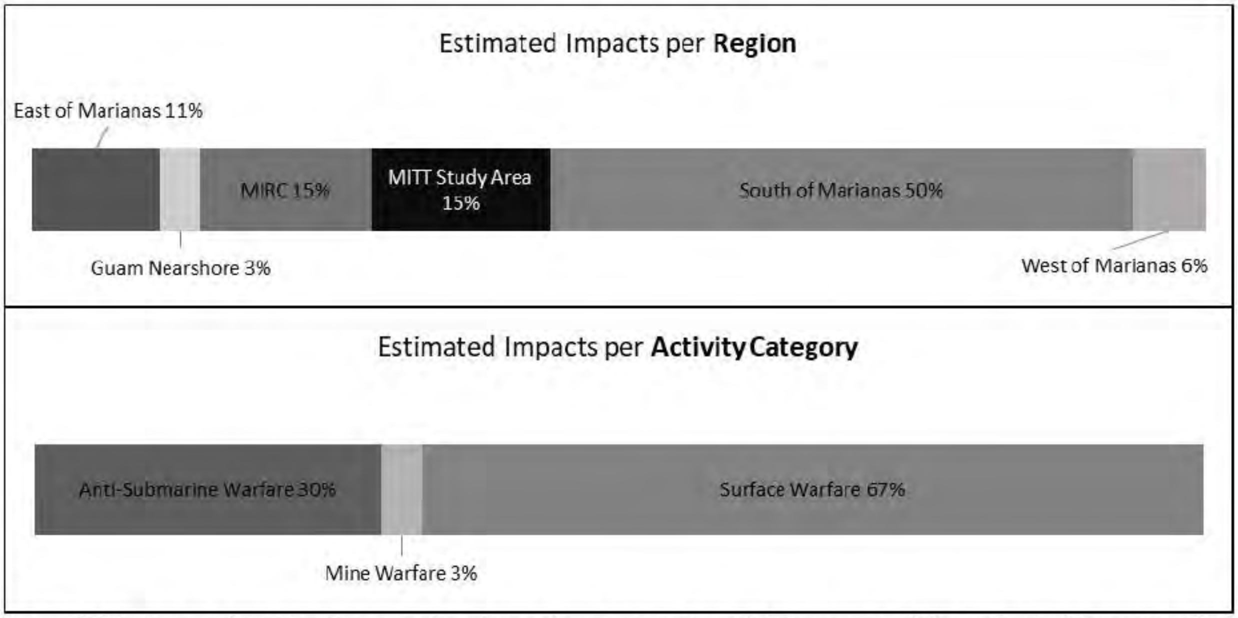
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.6 Omura's Whale

Omura's whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions (Figure 6.5-6 and Table 6.5-15). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for mysticetes above, even a few minor-to-moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of Omura's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-6: Omura's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-15: Estimated Impacts on Individual Omura's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	0	0	0

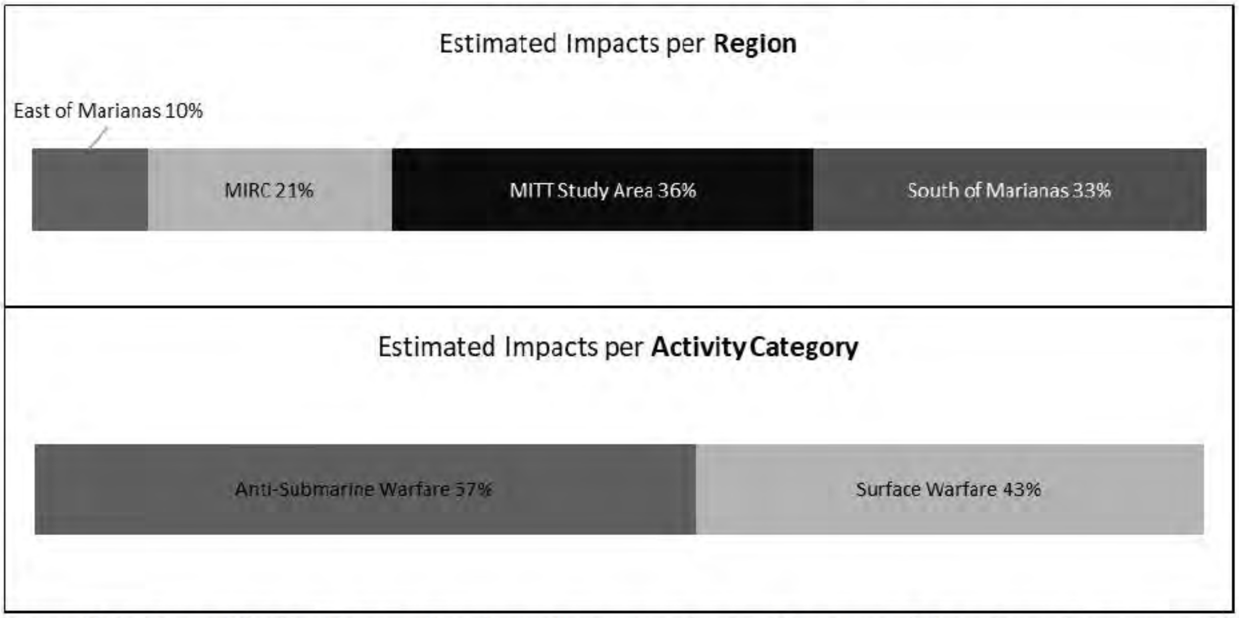
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.2.7 Sei whale

Sei whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS (Figure 6.5-7 and Table 6.5-16). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for mysticetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of sei whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-7: Sei Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-16: Estimated Impacts on Individual Sei Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
2	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3 Odontocetes

Odontocetes may be exposed to sound and energy from explosives associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of odontocetes (see Section 6.3, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. Impact ranges for odontocetes exposed to explosive sound and energy are discussed in Section 6.5.2.2 (Impact Ranges for Explosives) under mid-frequency cetaceans for most species, and under high-frequency cetaceans for Kogia whales.

Non-auditory injuries to odontocetes, if they did occur, could include anything from mild injuries that are recoverable and are unlikely to have long-term consequences, to more serious injuries, including mortality. It is possible for marine mammals to be injured or killed by an explosion in isolated instances. Animals that did sustain injury could have long-term consequences for that individual. Considering that most dolphin species for which these impacts are predicted have populations with tens to hundreds of thousands of animals, removing several animals from the population would be unlikely to have measurable long-term consequences for the species or stocks. As discussed in Section 11.1.2 (Explosive Stressors), the Navy will implement procedural mitigation measures to delay or cease detonations when a marine mammal is sighted in a mitigation zone to avoid or reduce potential explosive impacts.

Odontocetes that experience a hearing threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A threshold shift can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the period that an odontocete had hearing loss, social calls from conspecifics and sounds from predators such as killer whale vocalizations could be more difficult to detect or interpret, although many of these sounds may be above the frequencies of the threshold shift. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few kHz, which are less likely to be affected by threshold shift at lower frequencies and should not affect odontocete's ability to locate prey or rate of feeding.

Research and observations of masking in marine mammals due to impulsive sounds are discussed in Section 6.5.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in odontocetes that are nearby, although sounds from explosions last for only a few seconds at most. Also, odontocetes typically communicate, vocalize, and echolocate at higher frequencies that would be less affected by masking noise at lower frequencies, such as those produced by an explosion. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations, such as some naval gunfire exercises, could create some masking for odontocetes in the area over the short duration of the event. Potential costs to odontocetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Section 6.5.1.5, Behavioral Reactions) show that odontocetes do not typically show strong behavioral reactions to impulsive sounds such as explosions. Reactions, if they did occur, would likely be limited to short ranges, within a few km of multiple explosions. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from odontocetes are likely to be short term and low to moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 6.5.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

6.5.2.3.3.1 Beaked Whales

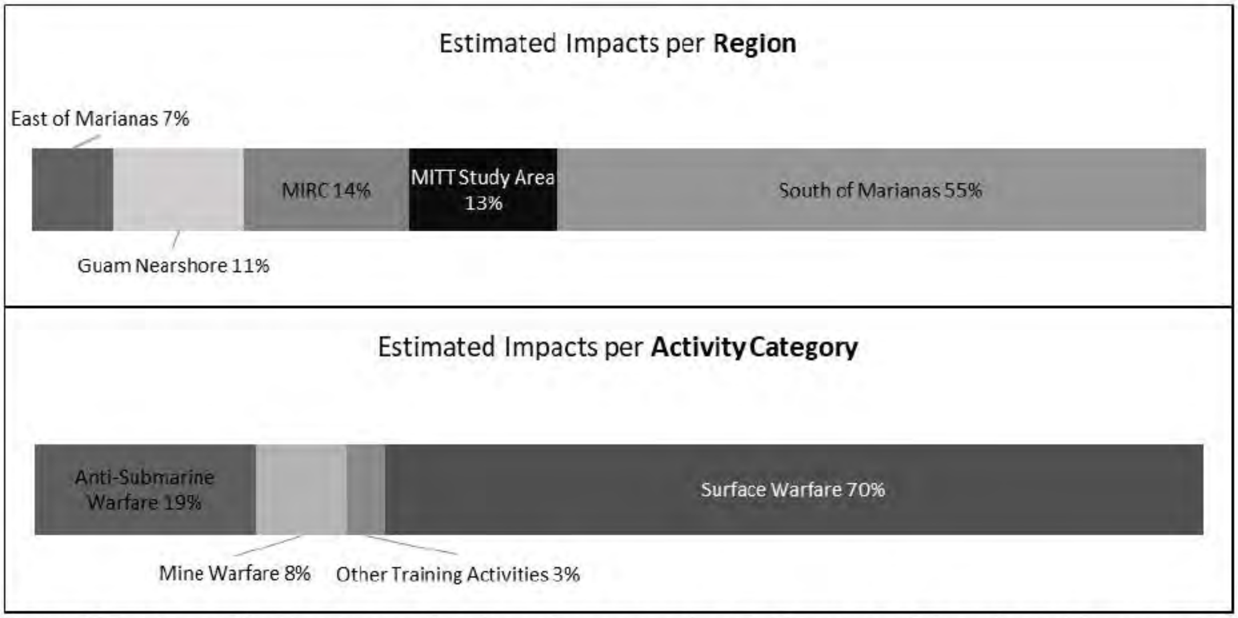
Beaked whales within the Study Area include Blainville's beaked whale, Cuvier's beaked whale, ginkgo-toothed beaked whale, and Longman's beaked whale.

Research and observations (see Section 6.5.2.1.1.4, Behavioral Responses from Explosives) show that beaked whales are sensitive to human disturbance, including noise from sonars, although no research on specific reactions to impulsive or explosion noise is available. Odontocetes overall have shown little responsiveness to impulsive sounds, although it is likely that beaked whales are more reactive than most other odontocetes. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Beaked whales on Navy ranges have been observed leaving the area for a few days during sonar training exercises. It is reasonable to expect that animals may leave an area of more intense explosive activity for a few days. However, most explosive use during Navy activities is short duration, consisting of only a single or few closely timed explosions (i.e., detonated within a few minutes) with a limited footprint due to a single detonation point. Because noise from most activities using explosives is short term and intermittent and because detonations usually occur within a small area, behavioral reactions from beaked whales are likely to be short term and moderate severity.

Beaked whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS for only ginkgo-toothed beaked whales and Longman's beaked whale (Figure 6.5-8 and Figure 6.5-9 and Table 6.5-17 and Table 6.5-18). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). No impacts from explosive stressors are estimated to occur for Blainville's beaked whales or Cuvier's beaked whales.

As described for beaked whales above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for these species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under the Proposed Action will result in the unintentional taking of ginkgo-toothed beaked whale and Longman's beaked whales incidental to those activities.



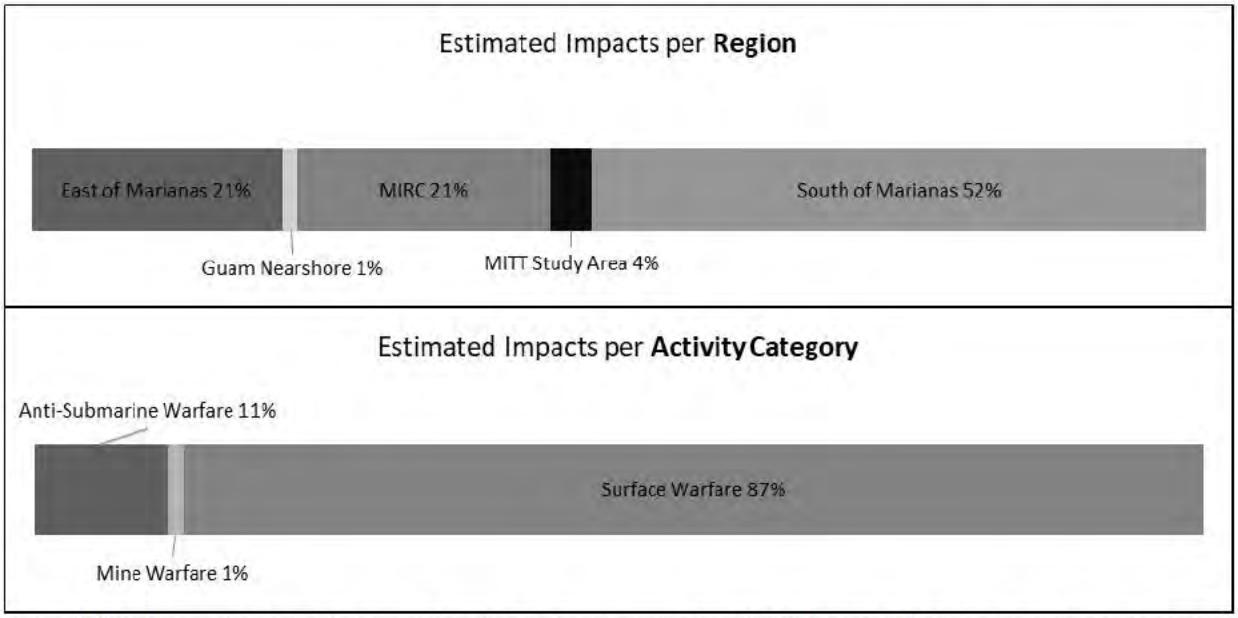
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-8: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-17: Estimated Impacts on Individual Ginkgo-Toothed Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-9: Longman's Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-18: Estimated Impacts on Individual Longman's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.2 Common Bottlenose Dolphin

Common bottlenose dolphins may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no common bottlenose dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

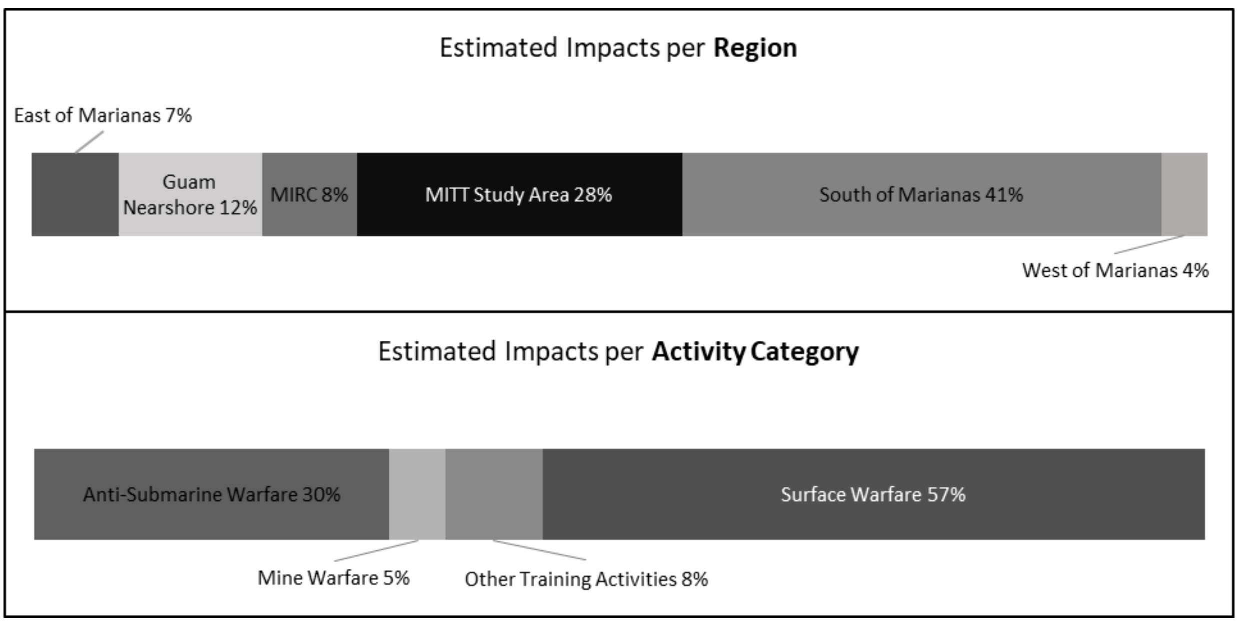
Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of common bottlenose dolphins incidental to those activities.

6.5.2.3.3.3 Dwarf Sperm Whale

Dwarf sperm whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions, TTS, and PTS (Figure 6.5-10 and Table 6.5-19). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives). TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales, are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no-to-minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of dwarf sperm whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-10: Dwarf Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-19: Estimated Impacts on Individual Dwarf Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
64	100	21	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.4 False Killer Whale

False killer whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no false killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

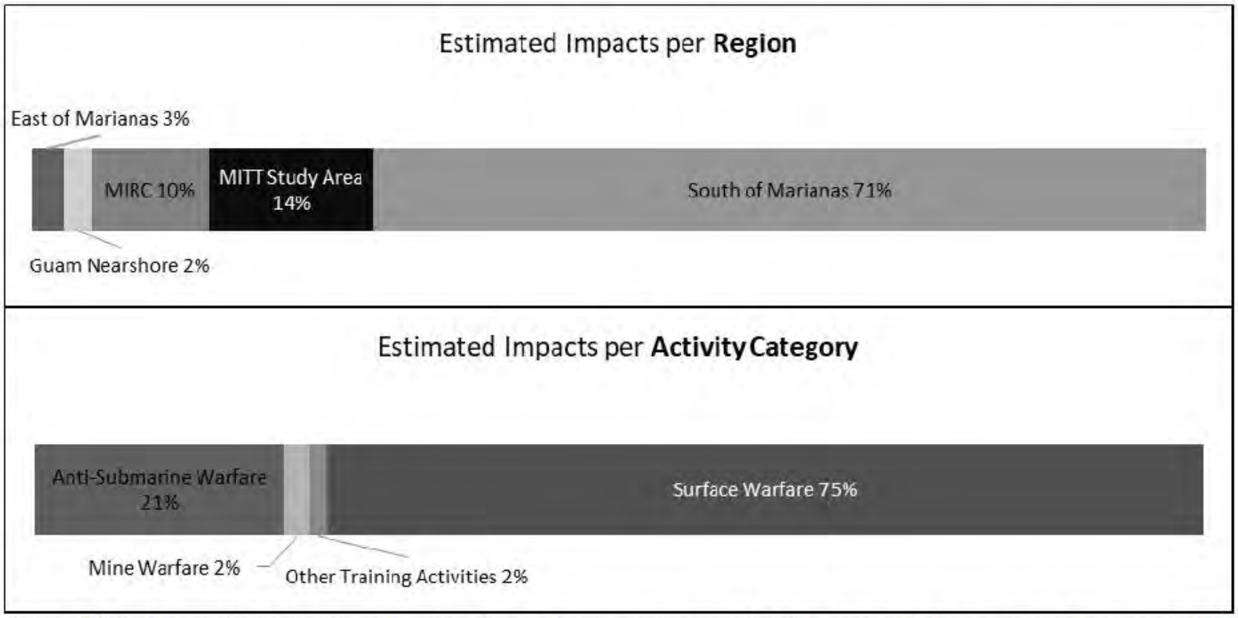
Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of false killer whales incidental to those activities.

6.5.2.3.3.5 Fraser's Dolphin

Fraser's dolphins may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions, TTS, and one PTS (see Figure 6.5-11 and Table 6.5-20). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no-to-minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of Fraser's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-11: Fraser's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-20: Estimated Impacts on Individual Fraser's Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	5	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Propose Action.

6.5.2.3.3.6 Killer Whale

Killer whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

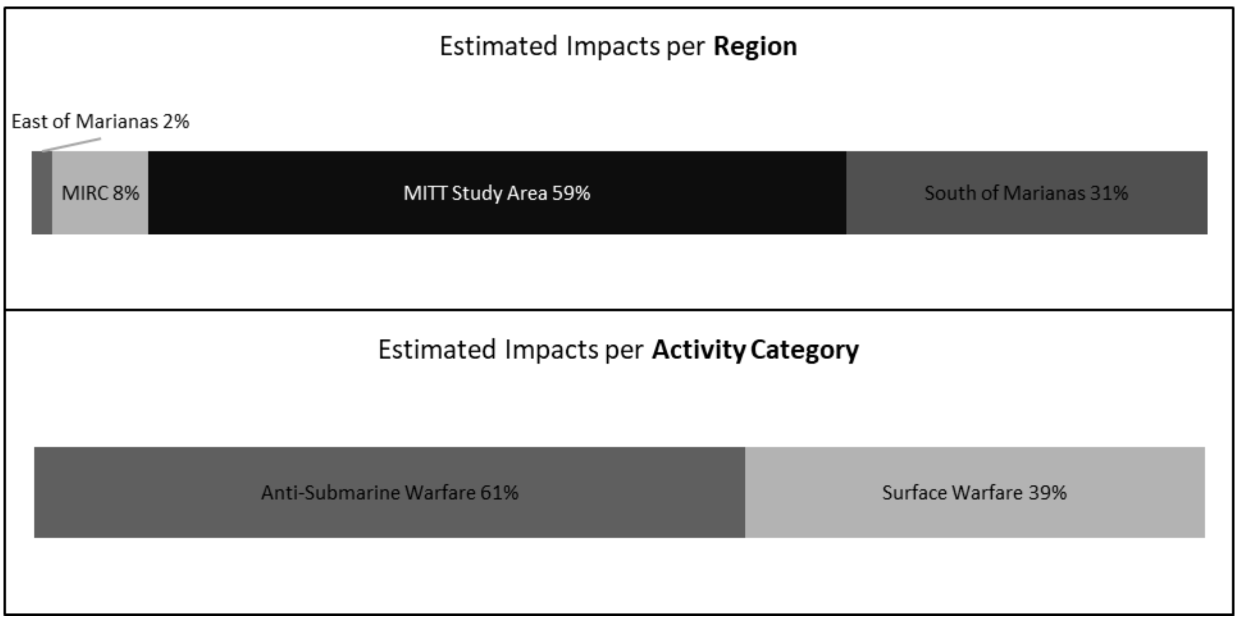
Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of killer whales incidental to those activities.

6.5.2.3.3.7 Melon-Headed Whale

Melon-headed whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS (Figure 6.5-12 and Table 6.5-21). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of melon-headed whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-12: Melon-Headed Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-21: Estimated Impacts on Individual Melon-Headed Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	*TTS*	*PTS*	*Injury*
1	1	0	0

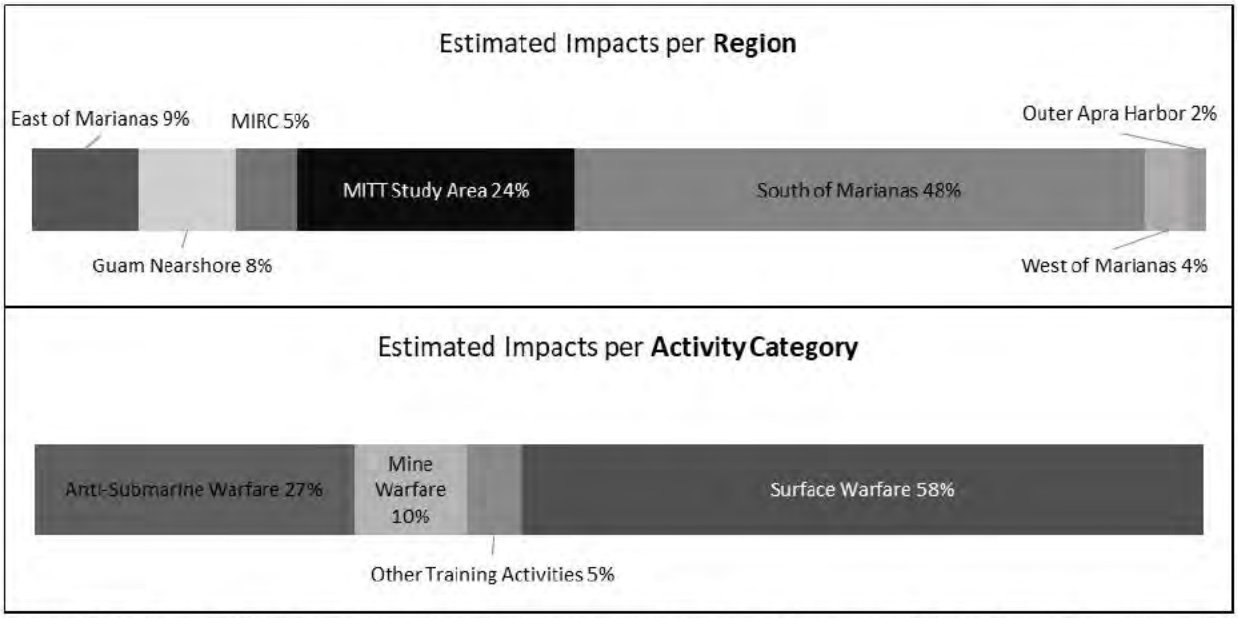
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.8 Pantropical Spotted Dolphin

Pantropical spotted dolphins may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions, TTS, and PTS (Figure 6.5-13 and Table 6.5-22). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no-to-minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-13: Pantropical Spotted Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-22: Estimated Impacts on Individual Pantropical Spotted Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	3	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.9 Pygmy Killer Whale

Pygmy killer whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no pygmy killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

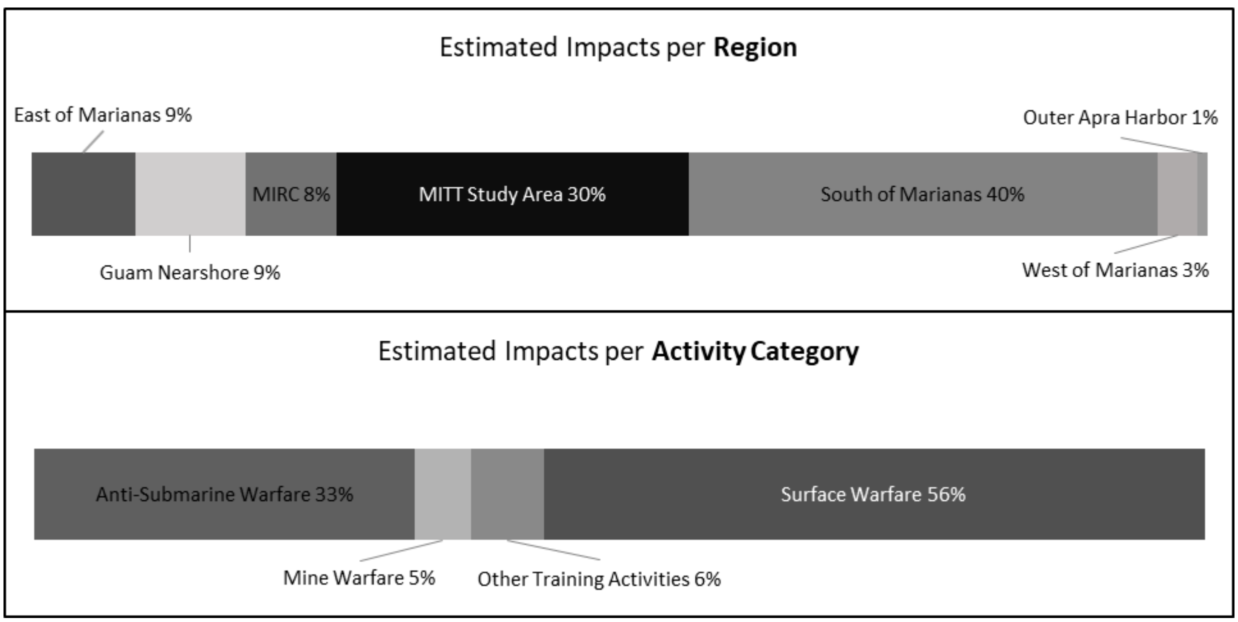
Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of pygmy killer whales incidental to those activities.

6.5.2.3.3.10 Pygmy Sperm Whale

Pygmy sperm whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions, TTS, and PTS (Figure 6.5-14 and Table 6.5-23). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no-to-minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of pygmy sperm whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-14: Pygmy Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-23: Estimated Impacts on Individual Pygmy Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
25	37	8	0

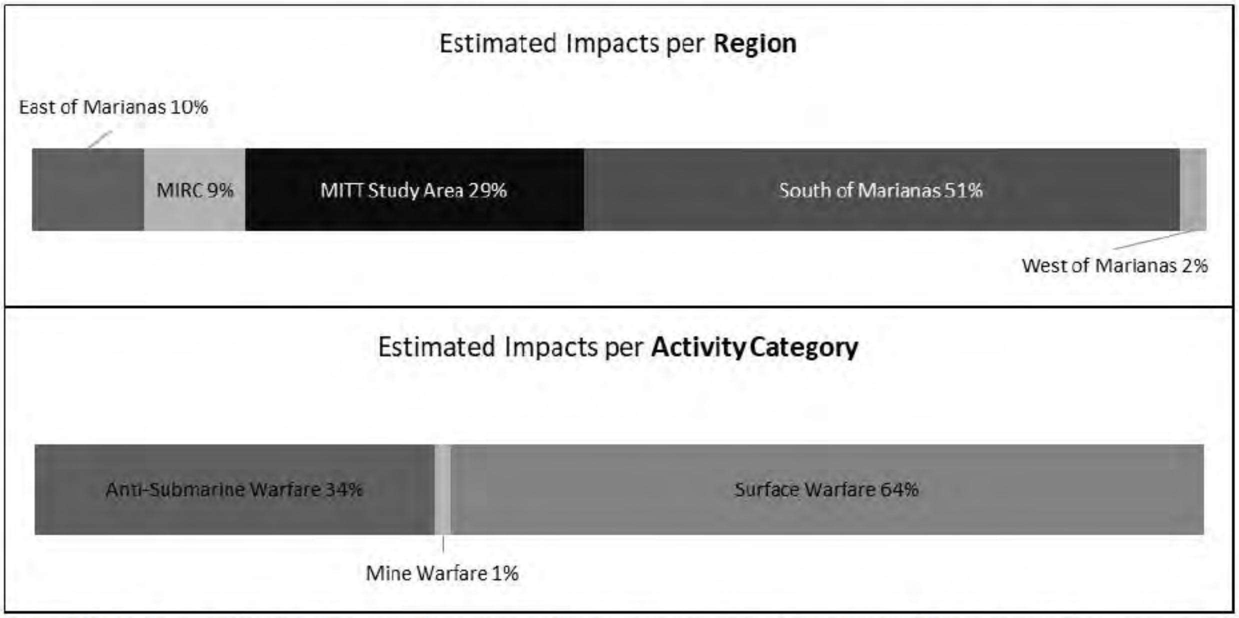
Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.11 Risso's Dolphin

Risso's dolphin may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reaction and TTS (Figure 6.5-15 and Table 6.5-24). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of Risso's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-15: Risso's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-24: Estimated Impacts on Individual Risso's Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.12 Rough-Toothed Dolphin

Rough-toothed dolphins may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no rough-toothed dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of rough-toothed dolphins incidental to those activities.

6.5.2.3.3.13 Short-Finned Pilot Whale

Short-finned pilot whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions (Figure 6.5-16 and Table 6.5-25). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of short-finned pilot whales incidental to those activities.

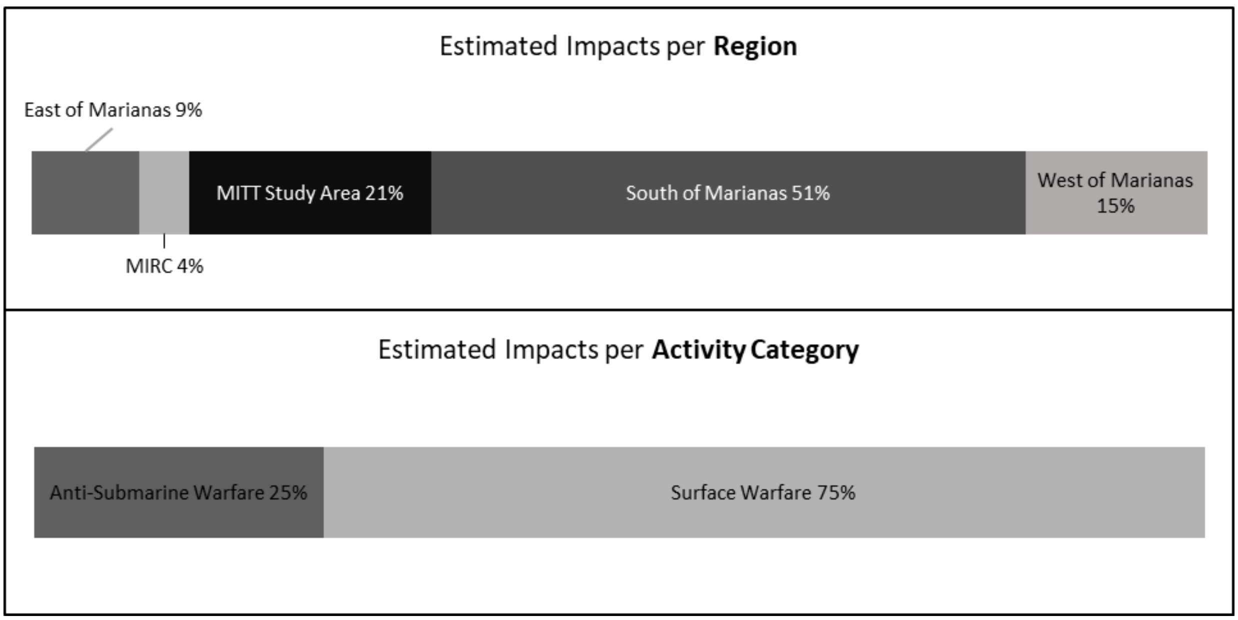


Figure 6.5-16: Short-Finned Pilot Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-25: Estimated Impacts on Individual Short-Finned Pilot Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	*TTS*	*PTS*	*Injury*
1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

6.5.2.3.3.14 Sperm Whale

Sperm whales may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year, although the quantitative analysis estimates that no sperm whales would be impacted. Long-term consequences for individuals or the species would not be expected.

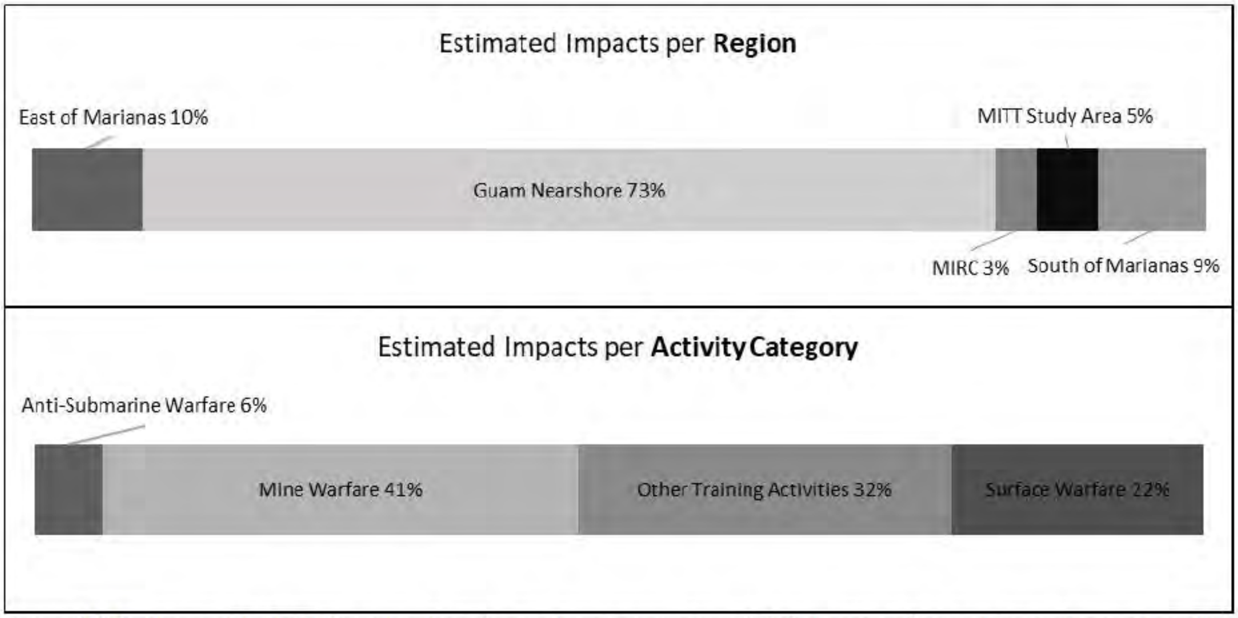
Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will not result in the unintentional taking of sperm whales incidental to those activities.

6.5.2.3.3.15 Spinner Dolphin

Spinner dolphins may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates TTS and PTS (Figure 6.5-17 and Table 6.5-26). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. PTS in an individual could have no-to-minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that will be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-17: Spinner Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-26: Estimated Impacts on Individual Spinner Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
0	1	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

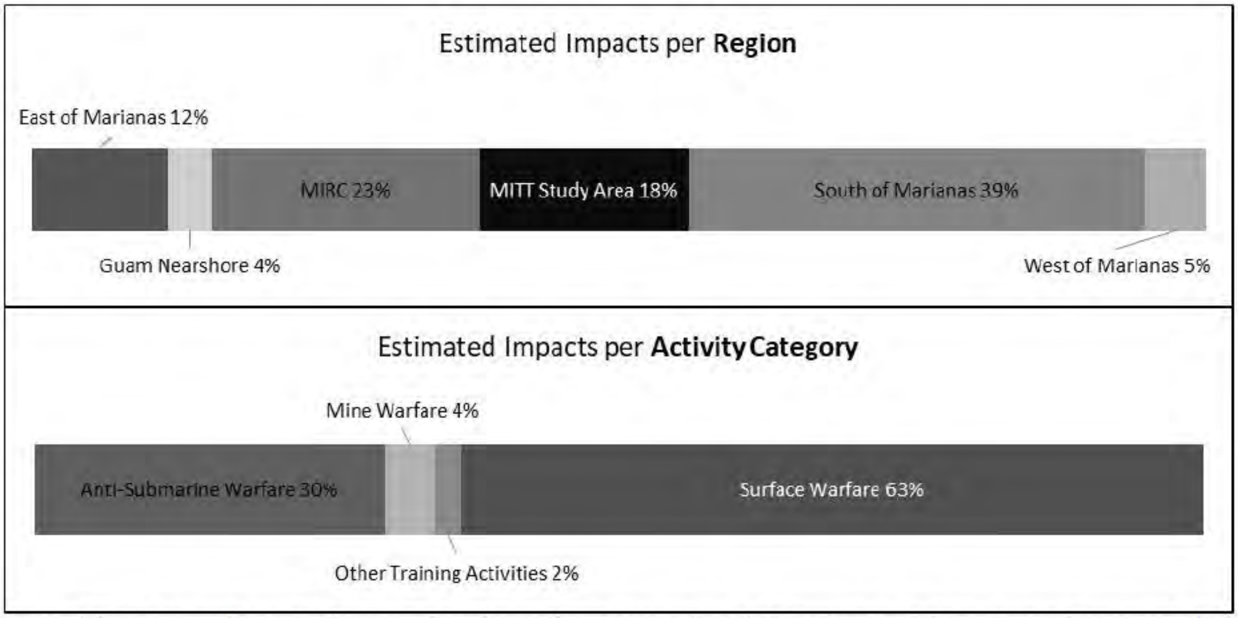
6.5.2.3.3.16 Striped Dolphin

Striped dolphins may be exposed to sound or energy from explosions associated with training and testing activities occurring throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates behavioral reactions and TTS (Figure 6.5-18 and Table 6.5-27). Estimated impacts most years would be less, based on fewer explosions. Impact ranges for this species are discussed in Section 6.5.2.2 (Impact Ranges for Explosives).

As described for odontocetes above, even a few minor-to-moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as

described in Chapter 11 (Mitigation Measures), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under the Proposed Action will result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 99–101 percent. Estimated impacts most years would be less based on fewer explosions. (2) MIRC = Mariana Islands Range Complex.

Figure 6.5-18: Striped Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under the Proposed Action

Table 6.5-27: Estimated Impacts on Individual Striped Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under the Proposed Action

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Proposed Action.

7 Anticipated Impact of the Activity

The Navy concludes that training and testing activities proposed in the Study Area would result in Level B and Level A takes, as summarized in Section 5.1.1 (Incidental Take Request from Acoustic and Explosive Sources for Training and Testing Activities). Based on best available science, the Navy concludes that exposures to marine mammal species and stocks due to training and testing activities would result in only short-term effects on most individuals exposed and would not affect annual rates of recruitment or survival for the following reasons:

- Most acoustic exposures are within the non-injurious temporary threshold shift or behavioral effects zones (Level B harassment).
- Although the numbers presented in Table 5.1-2 represent estimated harassment under the MMPA, they are conservative estimates (i.e., overpredictions) of harassment, primarily by behavioral disturbance.
- The Navy Acoustic Effects Model calculates harassment without taking into consideration mitigation measures, and is not indicative of a likelihood of either injury or harm. Additionally, the mitigation measures described in Chapter 11 (Mitigation Measures) are designed to avoid or reduce sound exposure and explosive effects on marine mammals to achieve the least practicable adverse effect on marine mammal species or stocks.

This request for an LOA 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. While many of these exposures would likely not rise to the level of the National Defense Authorization Act definition of Level B harassment, the Navy has no mechanism to quantify actual Level B harassment. The assumption that exposures predicted to cause behavioral disruptions would qualify as Level B harassment results in an overestimate of reactions qualifying as harassment under MMPA because there is no definitive level of exposure to acoustic energy associated with short-term sonar use or underwater detonations that clearly results in long-term abandonment or significant alteration of behavioral patterns in marine mammals.

7.1 Long-term Consequences to Species and Stocks

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual or for very small populations to the population as a whole; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; 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. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). 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. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found 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.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. West Coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound, including the use of sonar by the U.S. Navy; however, new data has been published that raises uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to 2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, 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. Individuals may move off the range for several days during and following a sonar event but return within a few days (McCarthy et al., 2011; Tyack et al., 2011). Photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to seven years apart (Falcone et al., 2009; Falcone & Schorr, 2014). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates, and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these was associated with her second calf, and a fourth female that was first identified in 2015 without a calf was sighted in 2016 with a calf (Schorr et al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of km by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately

250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km south to Mexico and back again. Given that some beaked whales may routinely move hundreds of km as part of their normal pattern (Schorr et al., 2014), temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

Another approach to investigating long-term consequences of anthropogenic noise exposure has been an attempt to link short-term effects to individuals from anthropogenic stressors with long-term consequences to populations using population models. 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. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and, ultimately, population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance model (National Research Council 2005) proposes a conceptual model 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. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al., 2016a; Costa et al., 2016b; Harwood & King, 2014; Hatch et al., 2012; King et al., 2015; New et al., 2013a; New et al., 2013b; New et al., 2014). Currently, the Population Consequences of Disturbance model provides a theoretical framework and identifies types of data that would be needed to assess population-level impacts using this process. The process is complicated and provides a foundation for the type of data that is needed, which is currently lacking for many marine mammal species. Relevant data needed for improving these analytical approaches for population-level consequences resulting from disturbances will continue to be collected during projects funded by the Navy's marine species monitoring program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory, or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance, can lead to markedly different impact results. For example, Costa et al. (2016a) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent, respectively, of each population would be exposed, and less than 19 percent and 6 percent, respectively, of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Energetic costs were estimated for western gray whales that migrated to possible wintering grounds near China or to the Baja California wintering grounds of eastern gray whales versus the energetic costs of the shorter migration of eastern gray whales (Villegas-Amtmann et al., 2017). Researchers found that when the time spent on the breeding grounds was held constant for both populations, the energetic requirements for the western gray whales were estimated to be 11 percent and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises and, even under the worst-case scenarios, predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to two days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis and De Jong (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent decrease in population size over six years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy-dense prey and high-quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy-dense prey or high-quality habitat. Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only a 0.4 percent population decline in the following year). It should be noted that, in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population-level effects.

The best assessment of long-term consequences from Navy training and testing activities will be to monitor the populations over time within the Study Area. A U.S. workshop on Marine Mammals and Sound (Fitch et al., 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed and implemented comprehensive monitoring plans since 2009 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 mitigation measures. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (e.g., Martin et al., 2017). Preliminary results of this analysis at the Pacific Missile Range Facility off Kauai, Hawaii indicate no changes in detection rates for several species over the past decade, demonstrating that Navy activities may not be having long-term population-level impacts. This type of analysis can be expanded to the other Navy ranges, such as the MIRC. Continued analysis of this 15-year dataset and additional monitoring efforts over time are necessary to fully understand the long-term consequences of exposure to military testing and training activities.

7.1.1 The Context of Behavioral Disruption, TTS, and PTS – 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 or the potential for injury to 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 (King et al., 2015; National Research Council, 2005). However, recent research concludes that it is theoretically possible to implement monitoring that assesses the chain of potential relations from initiation of a human activity to population dynamics—from physical and behavioral responses to the activity, to shifts in health, and to changes in vital rates (Fleishman et al., 2016). In practice, the primary impediment to predicting indirect, long-term, and cumulative effects is that the processes must be well understood and the underlying data available for models. In response to the National Research Council review (2005), the Office of Naval Research founded a working group to formalize the PCAD framework. In addition, Navy-funded efforts and other research efforts are underway to try to improve understanding of and the ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a). With respect to acoustically induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether it is naïve or experienced with the sound [e.g., prior experience with a stressor may result in a reduced response due to habituation (Finneran & Branstetter, 2013; St. Aubin & Dierauf, 2001)]. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, the Navy assumes in its effect analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response. 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 the Study Area, and the application of mitigation procedures proposed in Chapter 11 (Mitigation Measures), MITT training and testing activities are anticipated to have a negligible impact on marine mammal populations within the Study Area.

8 Anticipated Impacts on Subsistence Uses

Potential marine mammal impacts resulting from the Proposed Action in the Mariana Islands Training and Testing Study Area will be limited to individuals present in the Study Area and where no marine mammal subsistence uses exist. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9 Anticipated Impacts on Habitat

Activity components with the potential to impact marine mammal habitat as a result of the Proposed Action include (1) changes in water quality, (2) the introduction of sound into the water column, and (3) temporary changes to prey distribution and abundance. Each of these components was considered in the 2015 MITT Final EIS/OEIS and was determined to have no impact on marine mammal habitat. A summary of the conclusions is included below.

Water Quality. The 2015 MITT Final EIS/OEIS analyzed the potential effects on water quality from military expended materials. Training and testing activities may introduce contaminants into the water column. Based on the analysis of the 2015 MITT Final EIS/OEIS, military expended materials (e.g., undetonated explosive materials) would be released in quantities and at rates that would not result in a violation of any water quality standard or criteria. High-order explosions consume most of the explosive material, creating typical combustion products (Carr & Nipper, 2003; Hewitt et al., 2003; Juhasz & Naidu, 2007; Walker et al., 2006). For example, in the case of royal demolition explosive, 98 percent of the products are common seawater constituents and the remainder are rapidly degraded below threshold effect level (Juhasz & Naidu, 2007; Walker et al., 2006). Explosion by-products associated with high order detonations present no secondary stressors to marine mammals through sediment or water.

Indirect effects of explosives and unexploded ordnance to marine mammals via sediment are not expected, even in the immediate vicinity of the ordnance (Briggs et al., 2016; Edwards et al., 2016; Environmental Sciences Group, 2005; Kelley et al., 2016; Koide et al., 2015; U.S. Department of the Navy, 2013c; University of Hawaii, 2010). Degradation products of royal demolition explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Any remnant undetonated components from explosives such as TNT, royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems (Cruz-Uribe et al., 2007; Juhasz & Naidu, 2007; Pavlostathis & Jackson, 2002; Singh et al., 2009; Walker et al., 2006). Furthermore, while explosives and their degradation products were detectable in marine sediment next to degrading unexploded ordnance, the concentrations of these compounds were not statistically distinguishable from the natural background found in control samples taken from the environment around the degrading ordnance (Briggs et al., 2016; Edwards et al., 2016; Environmental Sciences Group, 2005; Kelley et al., 2016; Koide et al., 2015; U.S. Department of the Navy, 2013c; University of Hawaii, 2010).

Equipment used by the Navy within the Study Area, including ships and other marine vessels, aircraft, and other equipment, are also potential sources of contaminants. All equipment is properly maintained in accordance with applicable Navy or legal requirements. All such operating equipment meets federal water quality standards, where applicable.

Sound in the Water Column. Various activities and events, both natural and anthropogenic, above and below the water's surface, contribute to oceanic ambient or background noise. Anthropogenic noise in the area from non-Navy sources includes commercial shipping and recreational boats. Low-frequency (15-30 Hz) ambient noise peaks during fall and winter and is likely due to seasonal presence of vocalizing mysticetes (Hill et al., 2015; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017a; Klinck et al., 2015; Munger et al., 2015; Nieukirk et al., 2016; Norris et al., 2017; Oleson et al., 2015; Yack et al., 2016).

Anthropogenic noise attributable to Navy training and testing activities in the Study Area emanates from multiple sources, including sonar and other transducers, in-water detonations, as well as from other incidental sounds such as vessels, aircraft, weapons, and explosions in-air. Sound produced from training and testing activities in the Study Area is temporary and transitory and the affected area would be expected to immediately return to the original state when these activities cease. The Navy has determined that only the use of sonar and other transducers and in-water detonations have the potential to affect marine mammals to a level that would constitute harassment under the MMPA. Stressor/resource interactions that were determined to have negligible or no impacts (e.g., vessel noise, aircraft noise, weapons noise, and explosions in-air) are all sound sources other than sonar and other transducers and in-water detonations as is consistent with previous rule-making pursuant to the MMPA (National Oceanic and Atmospheric Administration, 2015a).

Prey Distribution and Abundance. Fish and invertebrate (e.g., squid) marine mammal prey species are present in the Study Area. Fishes, like other vertebrates, have a variety of different sensory systems to glean information from ocean around them (Astrup & Mohl, 1993; Astrup, 1999; Braun & Grande, 2008; Carroll et al., 2017; Hawkins & Johnstone, 1978; Ladich & Popper, 2004; Ladich & Schulz-Mirbach, 2016; Mann et al., 2001; Nedwell et al., 2004; Popper, 2003; Popper et al., 2005). Fish detect both pressure and particle motion (terrestrial vertebrates generally only detect pressure). Most marine fishes primarily detect particle motion using the inner ear and lateral line system, while some fishes possess additional morphological adaptations or specializations that can enhance their sensitivity to sound pressure, such as a gas-filled swim bladder (Braun & Grande, 2008; Popper & Fay, 2010).

Hearing capabilities vary considerably between different fish species, with data available for just over 100 species out of the 34,000 marine and freshwater fish species (Eschmeyer & Fong, 2016). In order to better understand acoustic impacts on fishes, fish hearing groups are defined by species that possess a similar continuum of anatomical features, which result in varying degrees of hearing sensitivity (Popper & Hastings, 2009). There are four hearing groups defined for all fish species (modified from Popper et al. (2014)) within this analysis. They include (1) fishes without a swim bladder (e.g., flatfish, sharks, rays, etc.), (2) fishes with a swim bladder not involved in hearing (e.g., salmon, cod, pollock, etc.), (3) fishes with a swim bladder involved in hearing (e.g., sardines, anchovy, herring, etc.), and (4) fishes with a swim bladder involved in high-frequency hearing (e.g., shad and menhaden). Most fish species preyed upon by marine mammals would not be likely to perceive or hear Navy mid- or high-frequency sonars. While hearing studies have not been done on sardines and northern anchovies, it would not be unexpected for them to have hearing similarities to Pacific herring (up to 2-5 kHz) (Mann et al., 2005). Currently, less data are available to estimate the range of best sensitivity for fishes without a swim bladder.

In terms of physiology, multiple scientific studies have documented a lack of mortality or physiological effects to fish from exposure to low- and mid-frequency sonar and other sounds (Halvorsen et al., 2012; Jørgensen et al., 2005; Juanes et al., 2017; Kane et al., 2010; Kvadsheim & Sevaldsen, 2005; Popper et al., 2007; Popper & Hawkins, 2016; Watwood et al., 2016). Techer et al. (2017) exposed carp in floating cages for up to 30 days to low-power 23 and 46 kHz sources without any significant physiological response. Other studies have documented either a lack of TTS in species whose hearing range cannot perceive Navy sonar or, for those species that could perceive sonar-like signals, that any TTS experienced would be recoverable (Halvorsen et al., 2012; Jørgensen et al., 2005; Juanes et al., 2017; Kane et al., 2010; Kvadsheim & Sevaldsen, 2005; Ladich & Fay, 2013; Popper et al., 2007; Popper & Hawkins, 2016; Smith, 2016; Watwood et al., 2016). Only fishes that have specializations that enable them to hear sounds above about 2,500 Hz (2.5 kHz) such as herring (Halvorsen et al., 2012; Mann et al., 2005; Popper et al., 2014) would have the potential to receive TTS or exhibit behavioral responses from exposure to mid-frequency sonar. In addition, any sonar-induced TTS to fish whose hearing range could perceive sonar would only occur in the narrow spectrum of the source (e.g., 3.5 kHz) compared to the fish's total hearing range (e.g., 0.01 kHz to 5kHz). Overall, Navy sonar sources are much narrower in terms of source frequency compared to a given fish species' full hearing range (Halvorsen et al., 2012; Jørgensen et al., 2005; Juanes et al., 2017; Kane et al., 2010; Kvadsheim & Sevaldsen, 2005; Popper et al., 2007; Popper & Hawkins, 2016; Watwood et al., 2016).

In terms of behavioral responses, fish exposed to sources they can detect could show a number of responses such as, but not limited to, a startle response, changes in swim speed or depth, or avoidance. However, there is also evidence that these reactions are short term and many fish even show signs of recovery after initial exposure. Many observed behaviors are also specific to the type of noise source used in the exposure and can be highly species specific. For example, Juanes et al. (2017) discuss the potential for negative impacts from anthropogenic soundscapes on fish, but the author's focus was on broader-based sounds such as ship and boat noise sources. Watwood et al. (2016) also documented no behavioral responses by reef fish after exposure to mid-frequency active sonar. Doksaeter et al. (2009); Doksaeter et al. (2012) reported no behavioral responses to mid-frequency naval sonar by Atlantic herring—specifically, no escape reactions (vertically or horizontally) observed in free swimming herring exposed to mid-frequency sonar transmissions. Based on these results (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012a), Sivle et al. (2014) created a model in order to report on the possible population-level effects on Atlantic herring from active naval sonar. The authors concluded that the use of naval sonar poses little risk to populations of herring regardless of season, even when the herring populations are aggregated and directly exposed to sonar. Finally, Bruintjes et al. (2016) commented that fish exposed to any short-term noise within their hearing range might initially startle but would quickly return to normal behavior.

Occasional behavioral reactions to intermittent explosions and impulsive sound sources are unlikely to cause long-term consequences for individual fish or populations. Fish that experience hearing loss as a result of exposure to explosions and impulsive sound sources may have a reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. However, PTS has not been known to occur in fishes, and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2005; Popper et al., 2014; Smith et al., 2006). It is not known if damage to auditory nerve fibers could occur and, if so, whether fibers would recover during this process. It is also possible for fish to be injured or killed by an explosion in the immediate vicinity of the surface from dropped or fired ordnance, or near the bottom from shallow water bottom-placed underwater mine warfare detonations. Physical effects from pressure waves generated by underwater sounds (e.g., underwater explosions) could potentially affect fish within proximity of training or testing activities. The shock wave from an underwater explosion is lethal to fish at close range, causing massive organ and tissue damage and internal bleeding (Keevin & Hempen, 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors, including fish size, body shape, orientation, and species (Keevin & Hempen, 1997; Wright, 1982). At the same distance from the source, larger fish are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fish oriented sideways to the blast suffer the greatest impact (Edds-Walton & Finneran, 2006; O'Keeffe, 1984; O'Keeffe & Young, 1984; Wiley et al., 1981; Yelverton et al., 1975). Species with gas-filled organs have a higher potential for mortality than those without them ((Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994).

Fish not killed or driven from a location by an explosion might change their behavior, feeding pattern, or distribution. Changes in behavior of fish have been observed as a result of sound produced by explosives, with effect intensified in areas of hard substrate (Wright, 1982). However, the Navy avoids hard substrate to the best extent practical during in-water detonations or surface detonations over deep water. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

In conclusion, for fishes exposed to Navy sonar, there would be limited sonar use spread out in time and space across large offshore areas such that only small areas are actually ensonified (tens of miles) compared to the total life history distribution of fish prey species. There would be no probability for mortality and physical injury from sonar and, for most species, no or little potential for hearing or behavioral effects, except to a few select fishes with hearing specializations (e.g., herring) that could perceive mid-frequency sonar. Training and testing exercises involving explosions are dispersed in space and time; therefore, repeated exposure of individual fishes is unlikely. Mortality and injury effects to fishes from explosives would be localized around the area of a given in-water explosion, but only if individual fish and the explosive (and immediate pressure field) were co-located at the same time. Fishes deeper in the water column or on the bottom would not be affected by water surface explosions. Repeated exposure of individual fish to sound and energy from underwater explosions is not likely given fish movement patterns, especially schooling prey species. Most acoustic effects, if any, are expected to be short term and localized. Long-term consequences for fish populations, including key prey species within the Study Area, would not be expected.

Vessels and in-water devices do not normally collide with adult fish, most of which can detect and avoid them. Exposure of fishes to vessel strike stressors is limited to those fish groups that are large, slow-moving, and may occur near the surface, such as ocean sunfish, whale sharks, basking sharks, and manta rays, which are not marine mammal prey species. Vessel strikes would not pose a risk to most of the other marine fish groups, because many fish can detect and avoid vessel movements, making strikes rare and allowing the fish to return to their normal behavior after the ship or device passes. As a vessel approaches a fish, it could have a detectable behavioral or physiological response (e.g., swimming away and increased heart rate) as the passing vessel displaces it. However, such reactions are not expected to have lasting effects on the survival, growth, recruitment, or reproduction of these marine fish groups at the population level.

In addition to fish, prey sources such as marine invertebrates could potentially be impacted by sound stressors as a result of the proposed activities. Data on response of invertebrates such as squid has been documented (de Soto, 2016; Sole et al., 2017). Sole et al. (2017) reported physiological injuries to cuttlefish in cages placed at sea when exposed during a controlled exposure experiment to low-frequency sources (315 Hz, 139–142 dB re 1 μPa^2 and 400 Hz, 139–141 dB re 1 μPa^2). Fewtrell and McCauley (2012) reported squids maintained in cages displayed startle responses and behavioral changes when exposed to seismic air gun sonar (136–162 re 1 μPa^2-sec). However, the sources Sole et al. (2017) and Fewtrell and McCauley (2012) used are not similar and are much lower frequency than typical Navy sources or those included in the proposed action within the Study Area. Nor do the studies address the issue of individual displacement outside of a zone of impact when exposed to sound. Squids, like most fish species, are likely more sensitive to low-frequency sounds, and may not perceive mid- and high-frequency sonars such as Navy sonars. Like fish, cumulatively individual and population-level impacts from exposure to Navy sonar and explosives for squid are not likely to be significant, and explosive impacts would be short term, localized, and likely inconsequential to invertebrate populations. Explosions could kill or injure nearby marine invertebrates. Vessels also have the potential to impact marine invertebrates by disturbing the water column or sediments, or directly striking organisms (Bishop, 2008). The propeller wash (water displaced by propellers used for propulsion) from vessel movement and water displaced from vessel hulls can potentially disturb marine invertebrates in the water column and is a likely cause of zooplankton mortality (Bickel et al., 2011). The localized and short-term exposure to explosions or vessels could displace, injure, or kill zooplankton, invertebrate eggs or larvae, and macro-invertebrates. However, mortality or long-term consequences for a few animals is unlikely to have measurable effects on overall stocks or populations. Long-term consequences to marine invertebrate populations would not be expected as a result of exposure to sounds or vessels in the Study Area.

Military expended materials resulting from training and testing could potentially result in minor long-term changes to benthic habitat. Military expended materials may be colonized over time by benthic organisms that prefer hard substrate and would provide structure that could attract some species of fish or invertebrates. Overall, the combined impacts of sound exposure, explosions, vessel strikes, and military expended materials resulting from the proposed activities would not be expected to have measurable effects on populations of marine mammal prey species.

Overall, the combined impacts of the Proposed Action would not be expected to have measurable effects on populations of marine mammal prey species and marine mammal habitat.

10 Anticipated Effects of Habitat Impacts on Marine Mammals

The proposed training and testing events for the MITT 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 (Anticipated Impacts on Habitat), there will be no impacts on marine mammals resulting from loss or modification of marine mammal habitat.

11 Mitigation Measures

The Navy will continue to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors. As applicable to marine mammals, the Navy's mitigation measures are organized into two categories: procedural mitigation and mitigation areas. A more detailed and complete discussion of the evaluation process used to develop, assess, and select mitigation measures can be found in Chapter 5 (Mitigation) of the MITT Draft SEIS/OEIS.

The mitigation measures are designed to achieve one or more benefits, such as the following:

- Effect the least practicable adverse impact on marine mammal species or stocks and their habitat and have a negligible impact on marine mammal species and stocks (as required under the MMPA)
- Ensure that the Proposed Action does not jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of critical habitat (as required under the ESA)
- Avoid or minimize adverse effects on essential fish habitat (as required under the Magnuson-Stevens Fishery Conservation and Management Act)

The following sections summarize the mitigation measures that will be implemented in association with the training and testing activities analyzed in this document. Navy operators, environmental planners, and scientific experts developed mitigation that is likely to be effective at avoiding or reducing impacts on marine mammals, and that is practical to implement by the definitions provided in Section 5.2.4 (Practicality of Implementation) of the MITT Draft SEIS/OEIS. This section includes mitigation measures designed specifically for marine mammals. For some activities, the Navy also implements mitigation for other species or resources, such as sea turtles and scalloped hammerhead sharks, as detailed in Chapter 5 (Mitigation) of the MITT Draft SEIS/OEIS.

11.1 Procedural Mitigation

The first procedural mitigation (Table 11.1-1) is designed to aid Lookouts and other personnel with the observation and environmental compliance responsibilities that are outlined in the remainder of this section, as well as training and testing activity reporting requirements. The remainder of the procedural mitigation measures are organized by stressor type and activity category.

Table 11.1-1: Procedural Mitigation for Environmental Awareness and Education

Procedural Mitigation Description
Stressor or Activity All training and testing activities, as applicable
Mitigation Requirements Appropriate personnel (including civilian personnel) involved in mitigation and training or testing activity reporting under the Proposed Action will complete one or more modules of the U.S. Navy Afloat Environmental Compliance Training Series, as identified in their career path training plan. Modules include: – **Introduction to the U.S. Navy Afloat Environmental Compliance Training Series.** The introductory module provides information on environmental laws (e.g., Endangered Species Act, Marine Mammal Protection Act) and the corresponding responsibilities that are relevant to Navy training and testing activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship. – **Marine Species Awareness Training.** All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare and mine warfare rotary-wing aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including floating vegetation, jellyfish aggregations, and flocks of seabirds. – **U.S. Navy Protective Measures Assessment Protocol.** This module provides the necessary instruction for accessing mitigation requirements during the event planning phase using the Protective Measures Assessment Protocol software tool. – **U.S. Navy Sonar Positional Reporting System and Marine Mammal Incident Reporting.** This module provides instruction on the procedures and activity reporting requirements for the Sonar Positional Reporting System and marine mammal incident reporting.

11.1.1 Acoustic Stressors

Mitigation measures for acoustic stressors are provided in Table 11.1-2 and Table 11.1-3.

Table 11.1-2: Procedural Mitigation for Active Sonar

Procedural Mitigation Description
Stressor or Activity • **Low-frequency active sonar, mid-frequency active sonar, high-frequency active sonar** – For vessel-based active sonar activities, mitigation applies only to sources that are positively controlled and deployed from manned surface vessels (e.g., sonar sources towed from manned surface platforms) – For aircraft-based active sonar activities, mitigation applies only to sources that are positively controlled and deployed from manned aircraft that do not operate at high altitudes (e.g., rotary-wing aircraft). Mitigation does not apply to active sonar sources deployed from unmanned aircraft or aircraft operating at high altitudes (e.g., maritime patrol aircraft)

Procedural Mitigation Description

Number of Lookouts and Observation Platform

- **Hull-mounted sources:**
  - 1 Lookout: Platforms with space or manning restrictions while underway (at the forward part of a small boat or ship) and platforms using active sonar while moored or at anchor (including pierside)
  - 2 Lookouts: Platforms without space or manning restrictions while underway (at the forward part of the ship)
- **Sources that are not hull-mounted:**
  - 1 Lookout on the ship or aircraft conducting the activity

Mitigation Requirements

- **Mitigation zones:**
  - 1,000 yd. power down, 500 yd. power down, and 200 yd. shut down for low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar
  - 200 yd. shut down for low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar
- **Prior to the initial start of the activity (e.g., when maneuvering on station):**
  - Observe the mitigation zone for marine mammals; if marine mammals are observed, relocate or delay the start of active sonar transmission.
- **During the activity:**
  - Low-frequency active sonar at ≥200 decibels (dB) or more, and hull-mounted mid-frequency active sonar: Observe the mitigation zone for marine mammals; power down active sonar transmission by 6 dB if observed within 1,000 yd. of the sonar source; power down an additional 4 dB (10 dB total) within 500 yd.; cease transmission within 200 yd.
  - Low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar: Observe the mitigation zone for marine mammals; cease active sonar transmission if observed within 200 yd. of the sonar source.
- **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:**
  - The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-deployed sonar sources or 30 min. for vessel-deployed sonar sources; (4) for mobile activities, the active sonar source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or (5) for activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal sightings within the mitigation zone).

Table 11.1-3: Procedural Mitigation for Weapons Firing Noise

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Weapons firing noise associated with large-caliber gunnery activities**
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout positioned on the ship conducting the firing** • **Depending on the activity, the Lookout could be the same as the one described in** • **Table 11.1-6 (Procedural Mitigation for Explosive Medium- and Large-Caliber Projectiles) or Table 11.1-15 (Procedural Mitigation for Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions).**
<u>Mitigation Requirements</u> • **Mitigation Zone:** – 30° on either side of the firing line out to 70 yards (yd.) from the muzzle of the weapon being fired • **Prior to the initial start of the activity:** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of weapons firing • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease weapons firing. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing weapons firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the firing ship; (3) the mitigation zone has been clear from any additional sightings for 30 min.; or (4) for mobile activities, the firing ship has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

11.1.2 Explosive Stressors

Mitigation measures for explosive stressors are provided in Table 11.1-4 through Table 11.1-12.

Table 11.1-4: Procedural Mitigation for Explosive Sonobuoys

Procedural Mitigation Description
<u>**Stressor or Activity**</u> • **Explosive sonobuoys**
Number of Lookouts and Observation Platform • **1 Lookout positioned in an aircraft or on a small boat** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>**Mitigation Requirements**</u> • **Mitigation Zone:** – 600 yd. around an explosive sonobuoy • **Prior to the initial start of the activity (e.g., during deployment of a sonobuoy pattern, which typically lasts 20–30 minutes):** – Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. – Visually observe the mitigation zone for marine mammals; if observed, relocate or delay the start of sonobuoy or source/receiver pair detonations. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease sonobuoy or source/receiver pair detonations. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonobuoy; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained. • **After completion of the activity (e.g., prior to maneuvering off station):** – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-5: Procedural Mitigation for Explosive Torpedoes

Procedural Mitigation Description
Stressor or Activity • **Explosive Torpedoes**
Number of Lookouts and Observation Platform • **1 Lookout positioned in an aircraft** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
Mitigation Requirements • **Mitigation Zone:** – 2,100 yd. around the intended impact location • **Prior to the start of the activity (e.g., during deployment of the target):** – Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. – Visually observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease firing. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained. • **After completion of the activity (e.g., prior to maneuvering off station):** – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-6: Procedural Mitigation for Explosive Medium- and Large-Caliber Projectiles

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Gunnery activities using explosive medium-caliber and large-caliber projectiles** – Mitigation applies to activities using a surface target
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout on the vessel or aircraft conducting the activity** – For activities using explosive large-caliber projectiles, depending on the activity, the Lookout could be the same as the one described in – Table 11.1-3 (Weapons Firing Noise) • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>Mitigation Requirements</u> • **Mitigation zones:** – 200 yd. around the intended impact location for air-to-surface activities using explosive medium-caliber projectiles – 600 yd. around the intended impact location for surface-to-surface activities using explosive medium-caliber projectiles – 1,000 yd. around the intended impact location for surface-to-surface activities using explosive large-caliber projectiles • **Prior to the initial start of the activity (e.g., when maneuvering on station):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease firing. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-based firing or 30 min. for vessel-based firing; or (4) for activities using mobile targets, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • **After completion of the activity (e.g., prior to maneuvering off station):** – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-7: Procedural Mitigation for Explosive Missiles and Rockets

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Aircraft-deployed explosive missiles and rockets**   – Mitigation applies to activities using a surface target
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout positioned in an aircraft** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**

<u>Mitigation Requirements</u>
• **Mitigation zones:**
  – 900 yd. around the intended impact location for missiles or rockets with 0.6–20 lb. net explosive weight
  – 2,000 yd. around the intended impact location for missiles with 21–500 lb. net explosive weight
• **Prior to the initial start of the activity (e.g., during a fly-over of the mitigation zone):**
  – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing.
• **During the activity:**
  – Observe the mitigation zone for marine mammals; if observed, cease firing.
• **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:**
  – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained.
• **After completion of the activity (e.g., prior to maneuvering off station):**
  – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures.
  – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-8: Procedural Mitigation for Explosive Bombs

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Explosive bombs**
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout positioned in the aircraft conducting the activity** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>Mitigation Requirements</u> • **Mitigation zone:** – 2,500 yd. around the intended target • **Prior to the initial start of the activity (e.g., when arriving on station):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of bomb deployment. • **During the activity (e.g., during target approach):** – Observe the mitigation zone for marine mammals; if observed, cease bomb deployment. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 min.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • **After completion of the activity (e.g., prior to maneuvering off station):** – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-9: Procedural Mitigation for Sinking Exercises

Procedural Mitigation Description
<u>**Stressor or Activity**</u> • **Sinking exercises**
<u>**Number of Lookouts and Observation Platform**</u> • **2 Lookouts (one positioned in an aircraft and one on a vessel)** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>**Mitigation Requirements**</u> • **Mitigation Zone:** – 2.5 NM around the target ship hulk • **Prior to the initial start of the activity (90 min. prior to the first firing):** – Conduct aerial observations of the mitigation zone for marine mammals; if observed, delay the start of firing. • **During the activity:** – Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. – Visually observe the mitigation zone for marine mammals from the vessel; if observed, cease firing. – Immediately after any planned or unplanned breaks in weapons firing of longer than 2 hours, observe the mitigation zone for marine mammals from the aircraft and vessel; if observed, delay recommencement of firing. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the target ship hulk; or (3) the mitigation zone has been clear from any additional sightings for 30 min. • **After completion of the activity (for 2 hours after sinking the vessel or until sunset, whichever comes first):** – Observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-10: Procedural Mitigation for Explosive Mine Countermeasure and Neutralization Activities

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Explosive mine countermeasure and neutralization activities**
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout positioned on a vessel or in an aircraft** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>Mitigation Requirements</u> • **Mitigation Zone:** – 600 yd. around the detonation site • **Prior to the initial start of the activity (e.g., when maneuvering on station; typically, 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of detonations. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease detonations. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to detonation site; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained. • **After completion of the activity (typically 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained):** – Observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-11: Procedural Mitigation for Explosive Mine Neutralization Activities Involving Navy Divers

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Explosive mine neutralization activities involving Navy divers**
<u>Number of Lookouts and Observation Platforms</u> • **2 Lookouts (two small boats with one Lookout each, or one Lookout on a small boat and one in a rotary-wing aircraft) when implementing the smaller mitigation zone** • **4 Lookouts (two small boats with two Lookouts each), and a pilot or member of an aircrew will serve as an additional Lookout if aircraft are used during the activity, when implementing the larger mitigation zone** • **All divers placing the charges on mines will support the Lookouts while performing their regular duties and will report applicable sightings to their supporting small boat or Range Safety Officer.** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>Mitigation Requirements</u> • **Mitigation Zones:** – 500 yd. around the detonation site during activities under positive control – 1,000 yd. around the detonation site during activities using time-delay fuses • **Prior to the initial start of the activity (e.g., when maneuvering on station for activities under positive control; 30 min. for activities using time-delay firing devices):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of detonations or fuse initiation. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease detonations or fuse initiation. – To the maximum extent practical depending on mission requirements, safety, and environmental conditions, boats will position themselves near the mid-point of the mitigation zone radius (but outside of the detonation plume and human safety zone), will position themselves on opposite sides of the detonation location (when two boats are used), and will travel in a circular pattern around the detonation location with one Lookout observing inward toward the detonation site and the other observing outward toward the perimeter of the mitigation zone. – If used, aircraft will travel in a circular pattern around the detonation location to the maximum extent practicable. – The Navy will not set time-delay firing devices to exceed 10 min.
• **Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the detonation site; or (3) the mitigation zone has been clear from any additional sightings for

Procedural Mitigation Description
10 min. during activities under positive control with aircraft that have fuel constraints, or 30 min. during activities under positive control with aircraft that are not typically fuel constrained and during activities using time-delay firing devices. • **After completion of an activity (for 30 min):** – Observe the vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Table 11.1-12: Procedural Mitigation for Maritime Security Operations – Anti-Swimmer Grenades

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Maritime Security Operations – Anti-Swimmer Grenades**
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout positioned on the small boat conducting the activity** • **If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.**
<u>Mitigation Requirements</u> • **Mitigation zone:** – 200 yd. around the intended detonation location • **Prior to the initial start of the activity (e.g., when maneuvering on station):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of detonations. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease detonations.
• **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended detonation location; (3) the mitigation zone has been clear from any additional sightings for 30 min.; or (4) the intended detonation location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

Procedural Mitigation Description
• **After completion of the activity (e.g., prior to maneuvering off station):** – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe vicinity of where detonations occurred; if any injured or dead marine mammals are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

11.1.3 Physical Disturbance and Strike Stressors

Mitigation measures for physical disturbance and strike stressors are provided in Table 11.1-13 through Table 11.1-17.

Table 11.1-13: Procedural Mitigation for Vessel Movement

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Vessel movement** – The mitigation will not be applied if (1) the vessel's safety is threatened, (2) the vessel is restricted in its ability to maneuver (e.g., during launching and recovery of aircraft or landing craft, during towing activities, when mooring, etc.), (3) the vessel is operated autonomously, or (4) when impractical based on mission requirements (e.g., during Amphibious Assault and Amphibious Raid exercises).
<u>Number of Lookouts and Observation Platform</u> • **1 Lookout on the vessel that is underway**
<u>Mitigation Requirements</u> • **Mitigation Zones:** – 500 yd. around whales – 200 yd. around other marine mammals (except bow-riding dolphins) • **During the activity:** – When underway, observe the mitigation zone for marine mammals; if observed, maneuver to maintain distance. • **Additional requirements:** – If a marine mammal vessel strike occurs, the Navy will follow the established incident reporting procedures.

Table 11.1-14: Procedural Mitigation for Towed In-Water Devices

Procedural Mitigation Description
<u>Stressor or Activity</u> • **Towed in-water devices** – Mitigation applies to devices that are towed from a manned surface platform or manned aircraft

Procedural Mitigation Description
– The mitigation will not be applied if the safety of the towing platform or in-water device is threatened
Number of Lookouts and Observation Platform • **1 Lookout positioned on a manned towing platform**
Mitigation Requirements • **Mitigation Zones:** – 250 yd. around marine mammals • **During the activity (i.e., when towing an in-water device):** – Observe the mitigation zone for marine mammals; if observed, maneuver to maintain distance.

Table 11.1-15: Procedural Mitigation for Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions

Procedural Mitigation Description
Stressor or Activity • **Gunnery activities using small-, medium-, and large-caliber non-explosive practice munitions** – Mitigation applies to activities using a surface target
Number of Lookouts and Observation Platform • **1 Lookout positioned on the platform conducting the activity** • **Depending on the activity, the Lookout could be the same as the one described in** • **Table 11.1-3 (Procedural Mitigation for Weapons Firing Noise)**
Mitigation Requirements • **Mitigation Zone:** – 200 yd. around the intended impact location • **Prior to the initial start of the activity (e.g., when maneuvering on station):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease firing. • **Commencement/recommencement conditions after a marine mammal sighting before or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-based firing or 30 min. for vessel-based firing; or (4) for activities using a mobile target, the

Procedural Mitigation Description
intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

Table 11.1-16: Procedural Mitigation for Non-Explosive Missiles and Rockets

Procedural Mitigation Description
Stressor or Activity • **Aircraft-deployed non-explosive missiles and rockets** • **Mitigation applies to activities using a surface target**
Number of Lookouts and Observation Platform • **1 Lookout positioned in an aircraft**
Mitigation Requirements • **Mitigation Zone:** – 900 yd. around the intended impact location • **Prior to the initial start of the activity (e.g., during a fly-over of the mitigation zone):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay the start of firing. • **During the activity:** – Observe the mitigation zone for marine mammals; if observed, cease firing. • **Commencement/recommencement conditions after a marine mammal sighting prior to or during the activity:** The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained.

Table 11.1-17: Procedural Mitigation for Non-Explosive Bombs and Mine Shapes

Procedural Mitigation Description
Stressor or Activity • **Non-explosive bombs** • **Non-explosive mine shapes during mine laying activities**
Number of Lookouts and Observation Platform • **1 Lookout positioned in an aircraft** Mitigation Requirements • **Mitigation Zone:**

Procedural Mitigation Description
– 1,000 yd. around the intended target
• **Prior to the start of the activity (e.g., when arriving on station):** – Observe the mitigation zone for marine mammals; if observed, relocate or delay start of bomb deployment or mine laying. • **During the activity (e.g., during approach of the target or intended minefield location):** – Observe the mitigation zone for marine mammals; if observed, cease bomb deployment or mine laying. • **Commencement/recommencement conditions after a marine mammal sighting prior to or during the activity:** – The Navy will allow a sighted marine mammal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment or mine laying) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target or minefield location; (3) the mitigation zone has been clear from any additional sightings for 10 min.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

11.2 MITIGATION AREAS

As detailed in the MITT Draft SEIS/OEIS, Section 5.4 (At-Sea Mitigation Areas to be Implemented), there are large portions of nearshore area around Guam, Tinian, and Saipan (totaling approximately 588 km^2) that the Navy has established as geographic mitigation areas for seafloor devices (see the MITT Draft SEIS/OEIS, Figures 5.4-1 and 5.4-2). These areas are designed to avoid or reduce potential impacts on seafloor resources in the Study Area consisting of shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks. Limiting some specific types of training and testing in those areas to protect seafloor resources (e.g., not conducting explosive mine countermeasure and neutralization activities in these areas) could help avoid or reduce potential impacts on marine mammals that use these habitats (e.g., marine mammals that feed near shallow-water coral reefs).

In addition to developing mitigation areas for seafloor resources, the Navy conducted a biological assessment and operational analysis of potential mitigation areas for marine mammals, which is detailed in Appendix I (Geographic Mitigation Assessment) of the MITT Draft SEIS/OEIS. The appendix includes background information and details for each of the areas considered, and includes analyses of areas identified during the NEPA scoping process. The Navy will finalize assessment of potential mitigation areas during the consultation and permitting processes and will summarize its final mitigation measures in Section 5.4 (At-Sea Mitigation Areas to be Implemented) of the Final SEIS/OEIS.

The Navy considered the potential for a mitigation area to be effective if it met the following criteria:

- **The mitigation area is a key area of biological importance to marine mammals**: The best available science suggests that the mitigation area is important to one or more species or resources for a biologically important life process (i.e., foraging, migration, reproduction); and
- **The mitigation would result in an avoidance or reduction of impacts**: Implementing the mitigation would likely result in an avoidance or reduction of impacts on species, stocks, or populations of marine mammals based on data regarding their seasonality, density, and

behavior. Furthermore, implementing the mitigation will not shift or transfer adverse effects from one species to another (e.g., to a more vulnerable or sensitive species).

The benefits of mitigation areas are considered qualitatively and are not factored into the quantitative analysis process or reductions in take for MMPA and ESA impact estimates. In Appendix I (Geographic Mitigation Assessment) of the MITT Draft SEIS/OEIS, potential geographic mitigation area benefits are discussed in terms of the context of impact avoidance or reduction.

During its assessment to determine how and to what degree the implementation of mitigation would be compatible with meeting the purpose and need of the Proposed Action, the Navy considered a mitigation measure to be practical to implement if it met all criteria listed below:

- **Implementing the mitigation is safe**: Mitigation measures must not increase safety risks to Navy personnel and equipment, or to the public. When assessing whether implementing a mitigation measure would be safe, the Navy factored in the potential for increased pilot fatigue; accelerated fatigue-life of aircraft; typical fuel restrictions of participating aircraft; locations of refueling stations; proximity to aircraft emergency landing fields, critical medical facilities, and search and rescue capabilities; space restrictions of the observation platforms; the ability to de-conflict platforms and activities to ensure that training and testing activities do not impact each other; and the ability to avoid interaction with non-Navy sea space and airspace uses, such as established commercial air traffic routes, commercial vessel shipping lanes, and areas used for energy exploration or alternative energy development. Other safety considerations included identifying if mitigation measures would reasonably allow Lookouts to safely and effectively maintain situational awareness while observing the mitigation zones during typical activity conditions, or if the mitigation would increase the safety risk for personnel. For example, the safety risk would increase if Lookouts were required to direct their attention away from essential mission requirements.
- **Implementing the mitigation is sustainable**: One of the primary factors that the Navy incorporates into the planning and scheduling of its training and testing activities is the amount and type of available resources, such as funding, personnel, and equipment. Mitigation measures must be sustainable over the life of the Proposed Action, meaning that they will not require the use of resources in excess of what is available. When assessing whether implementing a mitigation measure would be sustainable, the Navy considered if the measure would require excessive time on station or time away from homeport for Navy personnel, require the use of additional personnel (i.e., manpower) or equipment (e.g., adding a small boat to serve as an additional observation platform), or result in additional operational costs (e.g., increased fuel consumption, equipment maintenance, or acquisition of new equipment).
- **Implementing the mitigation allows the Navy to continue meeting its statutory requirements**: The Navy considered if each individual measure and the iterative and cumulative impact of all potential measures would be within the Navy's legal authority to implement. The Navy also considered if mitigation would modify training or testing activities in a way that would prevent individual activities from meeting their mission objectives and if mitigation would prevent the Navy from meeting its national security requirements or statutorily-mandated Title 10 requirements, such as by:

    - Impacting training and testing realism or preventing ready access to ranges, operating areas, facilities, or range support structures (which would reduce realism and present sea space and airspace conflicts).

- Impacting the ability for Sailors to train and become proficient in using sensors and weapon systems as would be required in areas analogous to where the military operates or causing an erosion of capabilities or reduction in perishable skills (which would result in a significant risk to personnel or equipment safety during military missions and combat operations).
- Impacting the ability for units to meet their individual training and certification requirements (which would impact the ability to deploy with the required level of readiness necessary to accomplish any tasking by Combatant Commanders).
- Impacting the ability to certify forces to deploy to meet national security tasking (which would limit the flexibility of Combatant Commanders to project power, engage in multi-national operations, and conduct the full range of naval warfighting capabilities in support of national security interests).
- Impacting the ability of researchers, program managers, and weapons system acquisition programs to conduct accurate acoustic research to meet research objectives, effectively test systems and platforms (and components of these systems and platforms) before full-scale production or delivery to the fleet, or complete shipboard maintenance, repairs, or pierside testing prior to at-sea operations (which would not allow the Navy to ensure safety, functionality, and accuracy in military mission and combat conditions per required acquisition milestones or on an as-needed basis to meet operational requirements).
- Requiring the Navy to provide advance notification of specific times and locations of Navy platforms, such as platforms using active sonar (which would present national security concerns).
- Reducing the Navy's ability to be ready, maintain deployment schedules, or respond to national emergencies or emerging national security challenges (which would present national security concerns).

Based on the analysis presented in Appendix I (Geographic Mitigation Assessment) of the MITT Draft SEIS/OEIS, the Navy is considering implementing mitigation measures to avoid or reduce impacts to marine mammals within the following potential mitigation areas as provided in Table 11.2-1 and shown in Figure 11.2-1

Table 11.2-1: Potential Geographic Mitigation Areas within the MITT Study Area

Potential Geographic Mitigation Area Name	Approximate km^2	Resource Protection Focus
Marpi Reef	31	Humpback whales (seasonally); marine mammals present year-round
Chalan Kanoa Reef	80	Humpback whales (seasonally); marine mammals present year-round
Agat Bay Nearshore	5	Spinner dolphins and sea turtles year-round

Information on potential mitigation areas specific to marine mammals is summarized in Section 11.3 (Mitigation Summary) and includes the stressors addressed by the mitigation and the details on the requirements for implementation the mitigation.

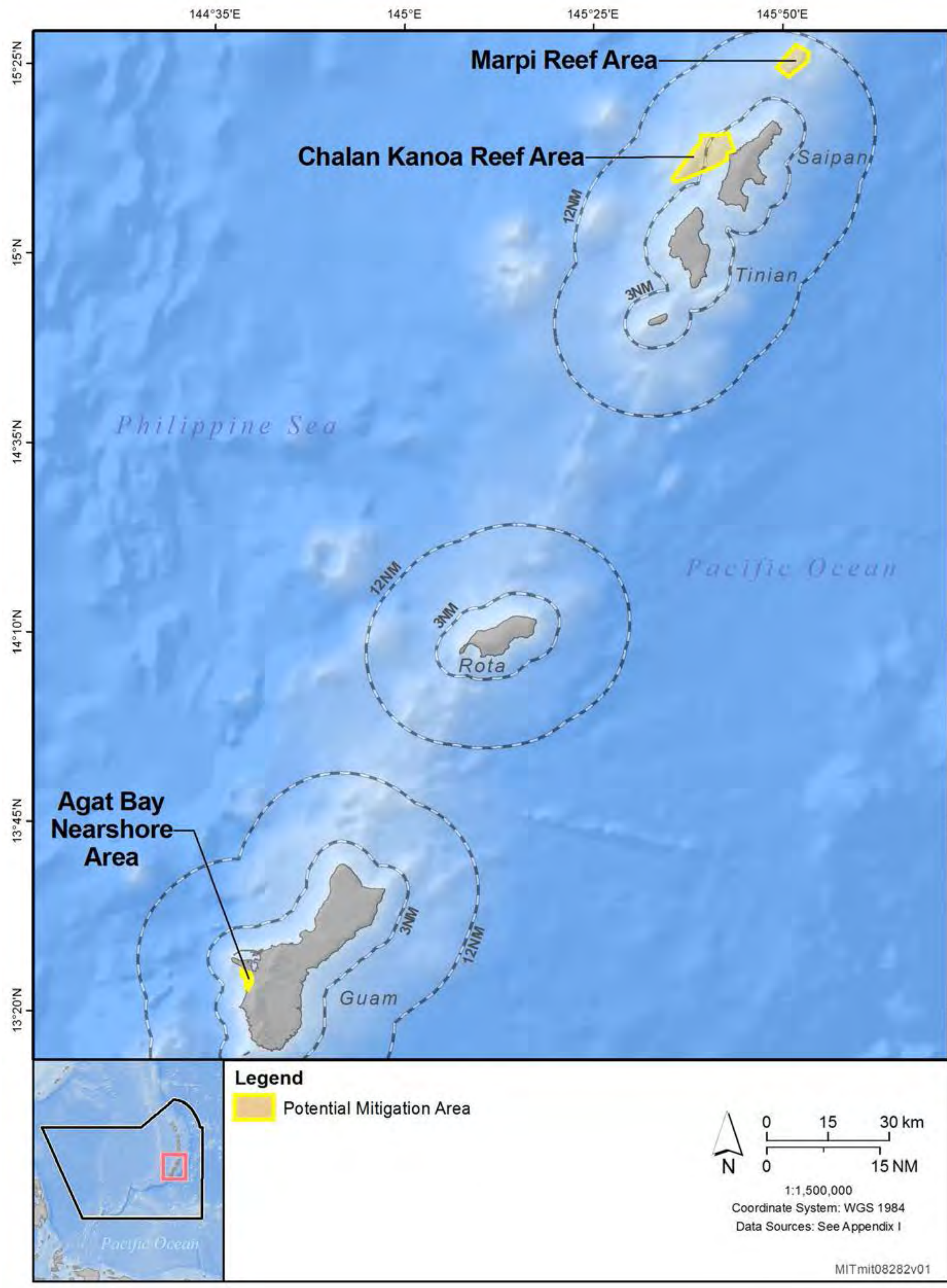


Figure 11.2-1 Potential Mitigation Areas

11.3 MITIGATION SUMMARY

The Navy's procedural mitigation measures for marine mammals are summarized in Table 11.3-1 (note that these are the same procedural mitigation measures presented in the MITT Draft SEIS/OEIS, Table 5.7-1, where applicable to marine mammals). The Navy's geographic mitigation measures focused on marine mammals are presented in Table 11.3-2Error! Reference source not found..

Table 11.3-1: Summary of At-Sea Procedural Mitigation for Marine Mammals

Stressor or Activity	***Mitigation Zone Sizes and Other Requirements***
Environmental Awareness and Education	Afloat Environmental Compliance Training program for applicable personnel
Active Sonar	Depending on sonar source: 1,000 yd. power down, 500 yd. power down, and 200 yd. shut down
Weapons Firing Noise	30° on either side of the firing line out to 70 yd.
Explosive Sonobuoys	600 yd.
Explosive Torpedoes	2,100 yd.
Explosive Medium-Caliber and Large-Caliber Projectiles	1,000 yd. (large-caliber projectiles), 600 yd. (medium-caliber projectiles during surface-to-surface activities), or 200 yd. (medium-caliber projectiles during air-to-surface activities)
Explosive Missiles and Rockets	2,000 yd. (>21–500 lb. net explosive weight), or 900 yd. (0.6–20 lb. net explosive weight)
Explosive Bombs	2,500 yd.
Sinking Exercises	2.5 NM
Explosive Mine Countermeasure and Neutralization Activities	600 yd.

Table 11.3-1: Summary of At-Sea Procedural Mitigation for Marine Mammals (continued)

Stressor or Activity	***Mitigation Zone Sizes and Other Requirements***
Explosive Mine Neutralization Activities involving Navy Divers	1,000 yd. (charges using time delay fuses), or 500 yd. (positive control charges)
Maritime Security Operations – Anti-Swimmer Grenades	200 yd.
Vessel Movement	500 yd. (whales) or 200 yd. (other marine mammals)
Towed In-Water Devices	250 yd.
Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions	200 yd.
Non-Explosive Missiles and Rockets	900 yd.
Non-Explosive Bombs and Mine Shapes	1,000 yd.

Table 11.3-2: Potential Mitigation Areas for Marine Mammals in the MITT Study Area

Mitigation Area Description
<u>**Stressor or Activity**</u> • MF1 Sonar • Explosives

<u>**Mitigation Area Requirements**</u>
• **Marpi Reef:**
  o Seasonal (December–April): The Navy will report the total hours of MF1 surface ship hull-mounted mid-frequency active sonar used in this area in its annual training and testing activity reports submitted to NMFS.
  o Year-round prohibition on in-water explosives.
  o Should national security present a requirement to use explosives that could potentially result in the take of marine mammals during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., explosives usage) in its annual activity reports submitted to NMFS.
• **Chalan Kanoa Reef:**
  o Seasonal (December–April): The Navy will report the total hours of MF1 surface ship hull-mounted mid-frequency active sonar used in this area in its annual training and testing activity reports submitted to NMFS.
  o Year-round prohibition on in-water explosives.
  o Should national security present a requirement to use explosives that could potentially result in the take of marine mammals during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., explosives usage) in its annual activity reports submitted to NMFS.
• **Agat Bay Nearshore:**
  o Year-round prohibition on use of MF1 ship hull-mounted mid-frequency active sonar and in-water explosives.
  o Should national security present a requirement to use surface ship hull-mounted active sonar or explosives that could potentially result in the take of marine mammals during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., sonar hours or explosives usage) in its annual activity reports submitted to NMFS.

12 Arctic Plan of Cooperation

Subsistence use is the traditional exploitation of marine mammals by native peoples (i.e., for their own consumption). In terms of this LOA request, none of the proposed training or testing activities in the Study Area occurs in or near the Arctic. Based on the Navy discussions and conclusions in Chapter 7 (Anticipated Impact of the Activity) and Chapter 8 (Anticipated Impacts on Subsistence Uses), there are no anticipated impacts on any species or stocks migrating through the Study Area that might be impact their availability for subsistence use.

13 Monitoring and Reporting

The Navy has been conducting marine species research and monitoring for over 20 years in areas where the Navy has been training and testing. The Navy developed a formal marine species monitoring program in support of the MMPA and ESA authorizations in 2009. This robust program has resulted in hundreds of technical reports and publications on marine mammals that have informed Navy and NMFS analysis in environmental planning documents, Rules, and Biological Opinions. The reports are made available to the public on the Navy's marine species monitoring website (https://www.navymarinespeciesmonitoring.us) and the data on the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (http://www.seamap.env.duke.edu).

The Navy commits to continue monitoring the occurrence, exposure, response and consequences of marine species to Navy training and testing and to further research the effectiveness of implemented mitigation measures. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

Consistent with the cooperating agency agreement with NMFS, monitoring measures presented here, as well as mitigation measures discussed in Chapter 11 (Mitigation Measures), focus on the requirements for protection and management of marine resources. A well-designed monitoring program can provide important feedback for validating assumptions made in analyses and allow for adaptive management of marine resources. Monitoring is required for compliance with final rules issued under the MMPA, and details of the monitoring program under the Proposed Action have already been developed in coordination with NMFS through the regulatory process for previous Navy at-sea training and testing actions. No changes are anticipated to the monitoring program or reporting that has been conducted to date. However, discussions with resource agencies during the consultation and permitting processes may result in changes to the mitigation as described in this document.

13.1 Monitoring, Research, and Reporting Initiatives

The Navy, NMFS, and the Marine Mammal Commission have held annual adaptive management meetings and additional meetings as needed. These meetings have provided both agencies with an opportunity to clarify information and provide feedback on progress as well as revise monitoring projects and goals within permit cycles.

Dynamic revisions to the monitoring program as a result of adaptive management review include the further development of the Strategic Planning Process (U.S. Department of the Navy, 2013a), which is a planning tool for selection of monitoring investments, and its incorporation into the Integrated Comprehensive Monitoring Program for future monitoring. Recent monitoring efforts address the Integrated Comprehensive Monitoring Program top-level goals through a collection of specific regional and ocean basin studies based on scientific objectives. The adaptive management review process and reporting requirements serve as the basis for evaluating performance and compliance.

The adaptive management review process is anticipated to continue between the Navy, NMFS, the Marine Mammal Commission, and other experts in the scientific community through technical review meetings and ongoing discussions.

13.2 Integrated Comprehensive Monitoring Program

The Integrated Comprehensive Monitoring Program (U.S. Department of the Navy, 2010a) provides the overarching framework for coordination of the Navy's marine species monitoring efforts and serves as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the Integrated Comprehensive Monitoring Program does not identify specific field work or individual projects, it is designed to provide a flexible, scalable, and adaptable framework using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives.

The Integrated Comprehensive Monitoring Program is evaluated through the Adaptive Management Review process to (1) assess progress, (2) provide a matrix of goals and objectives, and (3) make recommendations for refinement and analysis of monitoring and mitigation techniques. This process includes conducting an annual Adaptive Management Review meeting at which the Navy and NMFS jointly consider the prior-year goals, monitoring results, and related scientific advances to determine if monitoring plan modifications are warranted to more effectively address program goals. Modifications to the Integrated Comprehensive Monitoring Program that result from annual Adaptive Management Review discussions are incorporated by an addendum or revision to the Integrated Comprehensive Monitoring Program as needed.

Under the Integrated Comprehensive Monitoring Program, Navy-funded monitoring relating to the effects of Navy training and testing activities on protected marine species should be designed to accomplish one or more top-level goals as described in the current version of the Integrated Comprehensive Monitoring Program charter (U.S. Department of the Navy, 2010a):

- An increase in the understanding of the likely occurrence of marine mammals and ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and density of species)
- An increase in the understanding of the nature, scope, or context of the likely exposure of marine mammals and ESA-listed species to any of the potential stressors associated with the action (e.g., sound, explosive detonation, or expended materials), through better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (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 ESA-listed marine species with the action (in whole or part), and (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas)
- An increase in the 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])
- An increase in the 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 impacts on annual rates of recruitment or survival)

- An increase in the understanding of the effectiveness of mitigation and monitoring measures
- A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement
- An increase in the probability of detecting marine mammals (through improved technology or methods), both specifically within the mitigation zone (thus allowing for more effective implementation of the mitigation) and in general, to better achieve the above goals
- A reduction in the adverse impact of activities to the least practicable level, as defined in the MMPA

In 2011, a Scientific Advisory Group provided specific programmatic recommendations that serve as guiding principles for the continued evolution of the Integrated Comprehensive Monitoring Program. Key recommendations included

- working within a conceptual framework of knowledge, from basic information on the occurrence of species within each range complex, to more specific matters of exposure, response, and consequences;
- facilitating collaboration among researchers in each region, with the intent to develop a coherent and synergistic regional monitoring and research effort; and
- approaching the monitoring program holistically and selecting projects that offer the best opportunity to advance understanding of the issues, as opposed to establishing range-specific requirements.

13.3 Strategic Planning Process

The Strategic Planning Process (U.S. Department of the Navy, 2013a) serves to guide the investment of resources to most efficiently address Integrated Comprehensive Monitoring Program objectives and intermediate scientific objectives developed through this process.

The U.S. Navy marine species monitoring program has evolved and improved as a result of the adaptive management review process through changes that include:

- recognizing the limitations of effort-based compliance metrics;
- developing a conceptual framework based on recommendations from the Scientific Advisory Group (U.S. Department of the Navy, 2013a);
- shifting focus to projects based on scientific objectives that facilitate generation of statistically meaningful results upon which natural resources management decisions may be based;
- focusing on priority species or areas of interest as well as best opportunities to address specific monitoring objectives in order to maximize return on investment; and
- increasing transparency of the program and management standards, improving collaboration among participating researchers, and improving accessibility to data and information resulting from monitoring activities.

As a result, the Navy's marine species monitoring program has undergone a transition with the implementation of the Strategic Planning Process under MMPA authorizations. Under this process, Intermediate Scientific Objectives serve as the basis for developing and executing new monitoring projects across Navy training and testing areas in the Atlantic and Pacific Oceans. Implementation of the Strategic Planning Process involves coordination among Fleets, system commands, Chief of Naval

Operations Energy and Environmental Readiness Division, NMFS, and the Marine Mammal Commission, and has five primary steps:

- **Identify overarching intermediate scientific objectives.** Through the adaptive management process, the Navy coordinates with NMFS as well as the Marine Mammal Commission to review and revise the list of intermediate scientific objectives that are used to guide development of individual monitoring projects. Examples include addressing information gaps in species occurrence and density, evaluating behavioral response of marine mammals to Navy training and testing activities, and developing tools and techniques for passive acoustic monitoring.
- **Develop individual monitoring project concepts.** This step generally takes the form of soliciting input from the scientific community in terms of potential monitoring projects that address one or more of the intermediate scientific objectives. This can be accomplished through a variety of forums, including professional societies, regional scientific advisory groups, and contractor support.
- **Evaluate, prioritize, and select monitoring projects.** Navy technical experts and program managers review and evaluate all monitoring project concepts and develop a prioritized ranking. The goal of this step is to establish a suite of monitoring projects that address a cross-section of intermediate scientific objectives spread over a variety of range complexes.
- **Execute and manage selected monitoring projects.** Individual projects are initiated through appropriate funding mechanisms and include clearly defined objectives and deliverables (e.g., data, reports, publications).
- **Report and evaluate progress and results.** Progress on individual monitoring projects is updated through the Navy Marine Species Monitoring Program website as well as annual monitoring reports submitted to NMFS. Both internal review and discussions with NMFS through the adaptive management process are used to evaluate progress toward addressing the primary objectives of the Integrated Comprehensive Monitoring Program and serve to periodically recalibrate the focus of the monitoring program.

These steps serve three primary purposes: (1) to facilitate the Navy in developing specific projects addressing one or more intermediate scientific objectives; (2) to establish a more structured and collaborative framework for developing, evaluating, and selecting monitoring projects across all areas where the Navy conducts training and testing activities; and (3) to maximize the opportunity for input and involvement across the research community, academia, and industry. Furthermore, this process is designed to integrate various elements, including

- Integrated Comprehensive Monitoring Program top-level goals,
- Scientific Advisory Group recommendations,
- integration of regional scientific expert input,
- ongoing adaptive management review dialog between NMFS and the Navy,
- lessons learned from past and future monitoring at Navy training and testing ranges, and
- leverage of research and lessons learned from other Navy-funded science programs.

The Strategic Planning Process will continue to shape the future of the U.S. Navy Marine Species Monitoring Program and serve as the primary decision-making tool for guiding investments. Information on monitoring projects currently underway in the Atlantic and Pacific oceans, as well as results, reports, and publications can be accessed through the U.S. Navy Marine Species Monitoring Program website (www.navymarinespeciesmonitoring.us).

13.4 Monitoring Progress

The monitoring program has undergone significant changes that highlight its progress through adaptive management. The monitoring program developed for the first cycle of environmental compliance documents (e.g., (U.S. Department of the Navy, 2008a, 2008b) utilized effort-based compliance metrics that were somewhat limiting. Through adaptive management discussions, the Navy designed and conducted monitoring studies according to scientific objectives and eliminated specific effort requirements.

Progress has also been made on the conceptual framework categories from the Scientific Advisory Group for Navy Marine Species Monitoring (U.S. Department of the Navy, 2011c), ranging from occurrence of animals, to their exposure, response, and population consequences. The Navy continues to manage the Atlantic and Pacific program as a whole, with monitoring in each range complex taking a slightly different but complementary approach. The Navy has continued to use the approach of layering multiple simultaneous components in many of the range complexes to leverage an increase in return of the progress toward answering scientific monitoring questions. This included, in the Marianas for example, (a) glider deployment in offshore areas, (b) analysis of existing passive acoustic monitoring datasets, (c) small boat surveys using visual, biopsy and satellite tagging and (d) seasonal, humpback specific surveys.

Numerous publications, dissertations and conference presentations have resulted from research conducted under the marine species monitoring program (https://www.navymarinespeciesmonitoring.us/reading-room/publications/), resulting in a significant contribution to the body of marine mammal science. Publications on occurrence, distribution, and density have fed the modeling input, and publications on exposure and response have informed Navy and NMFS analysis of behavioral response and consideration of mitigation measures.

Furthermore, collaboration between the monitoring program and the Navy's research and development (e.g., the Office of Naval Research) and demonstration-validation (e.g., Living Marine Resources) programs has been strengthened, leading to research tools and products that have already transitioned to the monitoring program. These include Marine Mammal Monitoring on Ranges, controlled exposure experiment behavioral response studies, acoustic sea glider surveys, and global positioning system-enabled satellite tags. Recent progress has been made with better integration with monitoring across all Navy at-sea study areas, including the Atlantic Fleet Training and Testing Study Area in the Atlantic Ocean, and various other ranges. Publications from the Living Marine Resources and Office of Naval Research programs have also resulted in significant contributions to hearing, acoustic criteria used in effects modeling, exposure, and response, as well as in developing tools to assess biological significance (e.g., consequences).

NMFS and Navy also consider data collected during procedural mitigation measures as monitoring. Data are collected by shipboard personnel on topic such as hours spent training, hours of observation, hours of sonar, marine mammals observed within the mitigation zone during Major Training Exercises, and mitigation measures implemented. This data is provided to NMFS in both classified and unclassified annual exercise reports.

13.5 Proposed Navy-Funded Monitoring

Prior to Phase I monitoring, the information on marine mammal presence and occurrence in the MIRC was largely absent and limited to anecdotal information from incidental sightings and stranding events

(U.S. Department of the Navy, 2005). In 2007, the Navy-funded MISTCS (U.S. Department of the Navy, 2007) to proactively support the baseline data feeding the MIRC EIS (U.S. Department of the Navy, 2010b). The MISTCS research effort was the first systematic marine survey in these waters. This survey provided the first empirically-based density estimates for marine mammals (Fulling et al., 2011). In cooperation with NMFS, the Phase I monitoring program beginning in 2010 was designed to address basic occurrence-level questions in the MIRC, whereas monitoring the impacts of Navy training such as exposure to mid-frequency active sonar was planned for other Navy range complexes where marine mammal occurrence was already better characterized.

This emphasis on studying occurrence continued through Phase I and II monitoring in the MIRC, and combined various complementary methodologies. Small vessel visual surveys collected occurrence information, and began building the first individual identification catalog for multiple species (Hill et al., 2014). During these visual surveys, biopsies were collected for genetic analysis and satellite tags were also applied, resulting in a progressively improving picture of the habitat use and population structure of various species. Deep water passive acoustic deployments, including autonomous gliders with passive acoustic recorders, added complementary information on species groups such as baleen whales and beaked whales that were rarely sighted on the vessel surveys (Klinck et al., 2015; Munger et al., 2014; Munger et al., 2015; Nieukirk et al., 2016; Norris et al., 2015). Other methodologies were also explored to fill other gaps in waters generally inaccessible to the small boat surveys including a shore-station to survey waters on the windward side of Guam (Deakos et al., 2016). When available, platforms of opportunity on large vessels were utilized for visual survey and tagging (Oleson & Hill, 2010b).

At the close of Phase II monitoring, establishing the fundamentals of marine mammal occurrence in the MITT has now been largely completed. The various visual and acoustic platforms have encountered nearly all of the species that are expected to occur in the MITT Study Area. The photographic catalogs have progressively grown to the point that abundance analyses may be attempted for the most commonly-encountered species. Beyond occurrence, questions related to exposure to Navy training have been addressed, such as utilizing satellite tag telemetry to evaluate overlap of habitat use with underwater detonation training sites. Also during Phase II monitoring, a pilot study to investigate reports of humpback whales occasionally occurring off Saipan has proven fruitful, yielding confirmation of this species there, photographic matches of individuals to other waters in the Pacific Ocean, as well as genetics data that provide clues as to the population identity of these animals (Hill et al., 2016a; Hill et al., 2017b). Importantly, the compiled data were also used to inform proposals for new mitigation areas for Phase III documents and associated consultations.

The ongoing regional species-specific study questions and results from recent efforts are publicly available on the Navy's Monitoring Program website. With basic occurrence information now well-established, the goal of Phase III monitoring in the MITT will be to close out these studies with final analyses. The focus of monitoring across all Navy range complexes will progressively move toward to addressing the important questions of exposure and response to mid-frequency active sonar and other Navy training. The Navy's hydrophone-instrumented ranges have proven to be a powerful tool towards this end and because of the lack of such an instrumented range in the MITT Study Area, monitoring investments are expected to begin shifting to other Navy range complexes as the currently ongoing research efforts in the Mariana Islands are completed. Any future monitoring results for MITT will continue to be published on the Navy's Monitoring Program website, as well as discussed during annual adaptive management meetings between NMFS and Navy.

14 Suggested Means of Coordination

14.1 OVERVIEW

The U.S. Navy is one of the world's leading organizations in assessing the effects of human activities the marine environment including marine mammals. 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. There are three pillars to the Navy's monitoring and research program: the Research and Development programs under the Navy's Chief of Naval Operations Energy and Environmental Readiness (OPNAV N45), the Office of Naval Research marine mammal and biology program, and the Fleet/Systems Commands compliance monitoring program. The goal of the Navy's Research and Development 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. Research and Development programs are funded and developed by OPNAV N45 and the Office of Naval Research, 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. The third pillar of the Navy's marine species research and monitoring programs is the Fleet Systems Command compliance program that started in 2009 with the first MMPA permits. Coordination is frequent between the three programs, with members of each program sitting on advisory or steering committees of the others' to facilitate collaboration, transition, and feedback loops to all three.

The Office of Naval Research's current Marine Mammals and Biology Program focus areas 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, in 2011 OPNAV N45 developed a new Living Marine Resources Research and Development Program. The goal of the Living Marine Resources Research and Development Program is to identify and fill knowledge gaps and to demonstrate, validate, and integrate new processes and technologies to minimize potential effects to marine mammals and other marine resources. The Living Marine Resources has an Advisory Committee comprised of Navy biologists and staff from the Fleets, Systems Commands, and service providers, providing a nexus for feedback and collaboration for the three pillars of the Navy's Research and Monitoring programs. Key elements of the Living Marine Resources 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;
- interact with key stakeholders outside of the Navy via the Regional Advisory Committee;

- identify key enabling capabilities and investment areas with advice and assistance from a Navy Technical Review Committee;
- maintain close interaction and coordination with the Office of Naval Research's basic and early-stage applied research program;
- develop effective information for Navy environmental planners and operators; and
- provide effective management of project funding.

The Navy also collaborates regularly with the Bureau of Ocean Energy Management, NMFS, and other federal agencies on projects with mutual goals. Examples are Atlantic Marine Assessment Program for Protected Species; Pacific Marine Assessment Program for Protected Species; and monitoring projects in the Mariana Islands, Hawaii, Southern California, and the Atlantic.

14.2 Navy Research and Development

14.2.1 Navy Funded Research

In the Study Area, because training and testing events are, by comparison to other Navy areas, less frequent and generally small in scope, the majority of Navy's research effort has been focused elsewhere. Despite this, funding by the Navy has provided nearly the entirety of marine mammal science collected in the Marianas. In fact, prior to Navy funding of marine mammal science, there had not been any dedicated marine mammal surveys performed in the Mariana Islands. The bulk of these Navy-funded research efforts span two primary methodologies: small-vessel surveys and bottom-moored acoustic deployments. These primary data collection methods have been supplemented by additional results from acoustic surveys by autonomous gliders, acoustic towed-arrays, visual survey from shore-stations, augmentations from marine mammal observers on large-vessel surveys, and further analysis and collection of incidental and stranding data. Since the 2015 MITT Final EIS/OEIS and the issuance of the current authorization, new research has continued to be funded by Navy in the Mariana Islands and has included, but not been limited to the following:

- The continuation of annual small vessel nearshore surveys, sightings, satellite tagging, biopsy and genetic analysis, photo-identification, and opportunistic acoustic recording off Guam, Saipan, Tinian, Rota, and Aguigan in partnership with NMFS (Hill et al., 2015; Hill et al., 2016b; Hill et al., 2017a). The satellite tagging and genetic analyses have resulted in the first information discovered on the movement patterns, habitat preference, and population structure of multiple odontocete species in the Study Area.
- Since 2015, the addition of a series of small vessel surveys in the winter season dedicated to humpback whales has provided new information relating to the occurrence, calving behavior, and population identity of this species (Hill et al., 2016a; Hill et al., 2017b), which had not previously been sighted during the previous small vessel surveys in the summer or winter. This work has included sighting data, photo ID matches of individuals to other areas demonstrating migration as well as re-sights within the Marianas across different years, and the collection of biopsy samples for genetic analyses of populations.
- The continued deployment of passive acoustic monitoring devices and analysis of acoustic data obtained using bottom-moored acoustic recording devices deployed by NMFS has provided information on the presence and seasonal occurrence of mysticetes, as well as the occurrence of cryptic odontocetes typically found offshore, including beaked whales and Kogia spp. (Hill et

al., 2015; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017a; Munger et al., 2015; Norris et al., 2017; Oleson et al., 2015; Yack et al., 2016).

- Acoustic surveys using autonomous gliders were used to characterize the occurrence of odontocetes and mysticetes in abyssal offshore waters near Guam and CNMI, including species not seen in the small vessel visual survey series such as killer whales and Risso's dolphins. Analysis of collected data also provided new information on the seasonality of baleen whales, patterns of beaked whale occurrence and potential call variability, and identification of a new unknown marine mammal call (Klinck et al., 2016b; Nieukirk et al., 2016).
- Visual surveys were conducted from a shore-station at high elevation on the north shore of Guam to document the nearshore occurrence of marine mammals in waters where small vessel visual surveys are challenging due to regularly high sea states (Deakos & Richlen, 2015; Deakos et al., 2016).
- Analysis of archive data that included marine mammal sightings during Guam Department of Agriculture Division of Aquatic and Wildlife Resources aerial surveys undertaken between 1963 and 2012 (Martin et al., 2016).
- Analysis of archived acoustic towed-array data for an assessment of the abundance and density of minke whales (Norris et al., 2017), abundance and density of sperm whales (Yack et al., 2016), and the characterization of sei and humpback whale vocalizations (Norris et al., 2014).

As detailed in the 2015 MITT Final EIS/OEIS, these reporting, monitoring, and research efforts by the Navy have added to the baseline data for marine mammal species inhabiting the Study Area. In addition, subsequent research and monitoring across the Navy has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where Navy has been conducting training and testing activities for decades, which has been considered in the analysis of marine mammal impacts presented in this request for authorization in the same manner that the previous findings were used in the analyses associated with the 2015 MITT Final EIS/OEIS, the prior NMFS authorization of takes under MMPA in the Study Area (National Oceanic and Atmospheric Administration, 2015a), and the NMFS Biological Opinion pursuant to the ESA (National Marine Fisheries Service, 2015b).

14.2.2 Other Government Funded Research

The Navy also periodically coordinates with, shares information with, and on occasion contributes funding to NMFS' Pacific Islands Fisheries Science Center, which conducts marine mammal studies across the Pacific Islands Region, including the Mariana Islands. The objective of this coordination is to ensure both agencies are aware of each other's efforts, as well as aware of data and resource gaps when specific projects overlap with the Navy's interests in the Mariana Islands area.

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