REQUEST FOR REGULATIONS AND LETTER OF AUTHORIZATION

FOR THE INCIDENTAL TAKING OF MARINE MAMMALS RESULTING FROM U.S. NAVY TESTING AND TRAINING ACTIVITIES IN THE POINT MUGU SEA RANGE STUDY AREA

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ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
BIA	Biologically Important Area
CFR	Code of Federal Regulations
CSSQT	Combat Systems Ship Qualification Trials
dB	decibel
dB re 1 µPa	Decibels referenced to 1 micropascal
dB re 1 µPa^{2}s	Decibels referenced to 1 micropascal squared seconds
DE	Directed Energy
DoD	Department of Defense
DPS	Distinct Population Segment
E	East
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ESA	Endangered Species Act
EW	Electronic Warfare
FAA	Federal Aviation Administration
FR	Federal Register
ft.	Foot/Feet
GI	Gastrointestinal
HEL	High Energy Laser
HPM	High Power Microwave
Hz	Hertz
in.	Inch(es)
kHz	kilohertz
Km	kilometer
Km/hr	Kilometers per hour
Km^2	Square kilometers
LMR R&D	Living Marine Resources Research and Development
LOA	Letter of Authorization
LRASM	Long-Range Anti-Ship Missile
m	Meter(s)
MEM	Military Expended Material
MMPA	Marine Mammal Protection Act
N	North
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
Navy	U.S. Department of the Navy
NAWCWD	Naval Air Warfare Center Weapons Division
NBVC	Naval Base Ventura County
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
OEIS	Overseas Environmental Impact Statement
OPNAV	Chief of Naval Operations Energy and Environmental Readiness
PMSR	Point Mugu Sea Range
Psi-ms	pounds per square inch per millisecond
PTS	Permanent Threshold Shift
SAR	Stock Assessment Report
SEL	Sound Exposure Level
SNI	San Nicolas Island
SOCAL	Southern California
SPL	Sound Pressure Level
SUA	Special Use Airspace
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UME	Unusual Mortality Event
W	Warning Area
W	West

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1 Description of Specified Activity

1.1 INTRODUCTION

This Request for Regulations and Letter of Authorization (LOA) for the Incidental Taking of Marine Mammals has been prepared in accordance with the applicable regulations of the Marine Mammal Protection Act (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 the 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 Point Mugu Sea Range (PMSR) Draft Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS), which have the potential to incidentally take marine mammals; (3) pinniped monitoring data associated with launches from San Nicolas Island; and (4) a technical risk assessment to determine the likelihood of effects from those activities.

The United States (U.S.) Department of the Navy (Navy) has prepared an EIS/OEIS for the PMSR Study Area to evaluate all components of the proposed testing and training activities. This request for a LOA is based on the proposed testing and training activities of the Navy’s Preferred Alternative (Alternative 1 in the EIS/OEIS, referred to in this document as the Proposed Action). The Navy has prepared this request for regulations and a LOA for the incidental taking (as defined in Chapter 5, Type of Incidental Taking Authorization Requested) of marine mammals during the conduct of testing and training activities within the PMSR Study Area. The Navy is requesting a seven-year LOA for testing and training activities proposed to be conducted for seven years from the date of the Final Rule and issuance of the LOA.

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

The PMSR consists of 36,000 square miles and is located adjacent to Los Angeles, Ventura, Santa Barbara, and San Luis Obispo Counties along the Pacific Coast of Southern California (Figure 1-1). A description of the PMSR Study Area and various components of the range are provided in Chapter 2 (Dates, Duration, and Specified Geographic Region). A description of the testing and training activities for which the Navy is requesting incidental take authorizations is provided in the following sections.

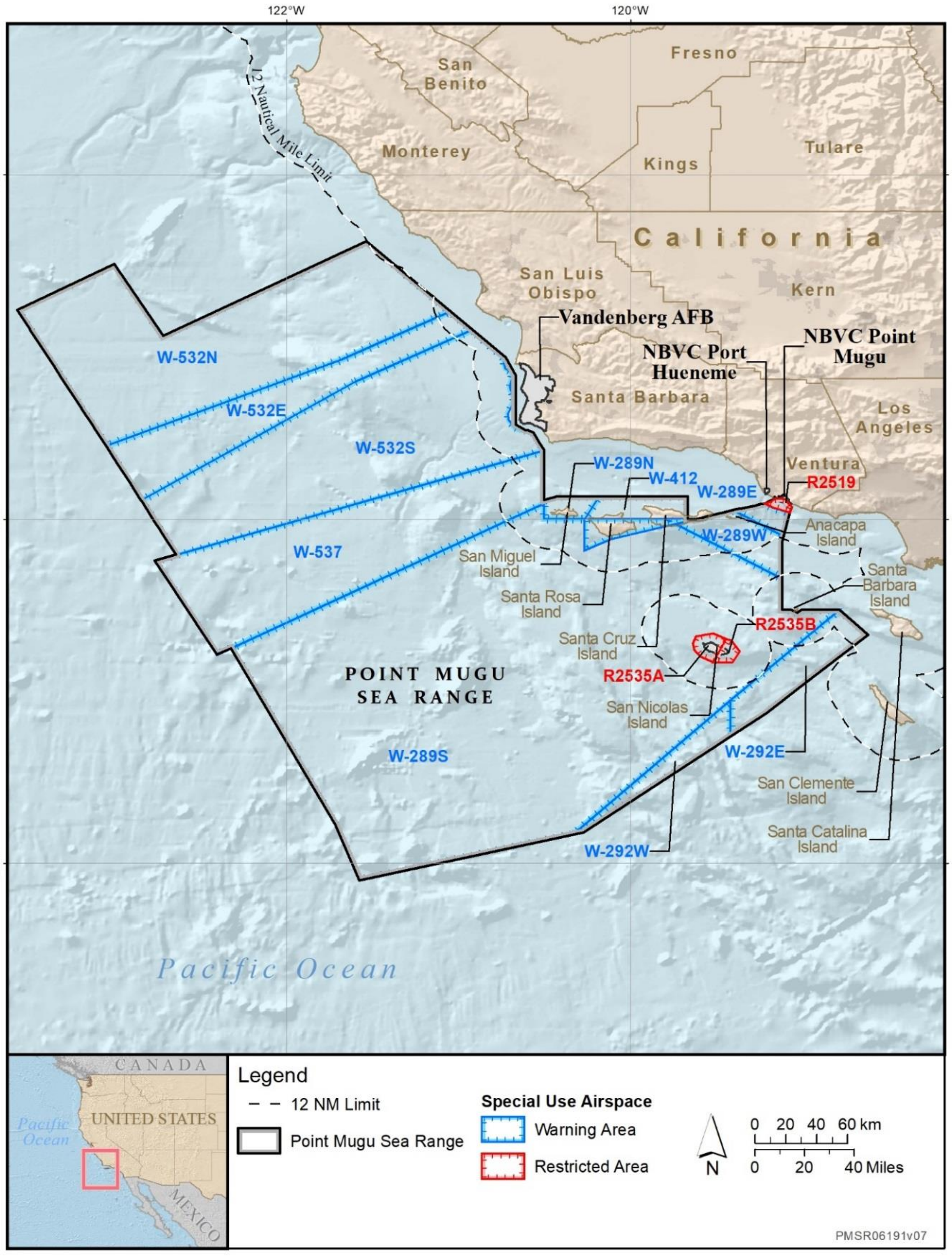

Figure 1-1: Point Mugu Sea Range Study Area

Unlike many other at-sea Navy ranges, proposed testing and training activities within the PMSR does not include testing or training using anti-submarine warfare or mine warfare active sonar systems. Additionally, there are no explosives detonated underwater as part of the Proposed Action, only those that detonate at or near the surface of the water[1]. The remainder of Chapter 1 of this document describes those activities that are likely to result in Level A or Level B harassment under the MMPA; no serious injuries or mortalities are expected. Based on the analysis of proposed testing and training activities, the Navy has determined that only the use of explosives at or near the water's surface and launches of targets and missiles from San Nicolas Island (SNI) have the potential to affect marine mammals to a level that would constitute harassment under the MMPA.

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 ensures the readiness of the naval forces of the United States. The Navy executes this responsibility by establishing and executing training programs, including at-sea training events, 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 tests ships, aircraft, weapons, combat systems, sensors and related equipment; and conducts scientific research activities to achieve and maintain military readiness.

The Navy has been conducting testing and training activities in the PMSR Study Area since the PMSR was established in 1946. The types and tempo of testing and training 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 (organization of ships, submarines, aircraft, and weapons). Such developments influence the frequency, duration, intensity, and location of required testing and training activities. The Proposed Action includes current activities as analyzed in the 2002 PMSR EIS/OEIS in addition to activities covered by other environmental planning documents for the PMSR since 2002, plus changes in operational activity frequency. The proposed testing and training activities are deemed necessary to accomplish Naval Air System Command's mission of providing for the safe and secure collection of decision-quality data; and developing, operating, managing and sustaining the interoperability of the Major Range Test Facility Base at the PMSR into the foreseeable future. Collectively, the Proposed Action supports current and projected military readiness requirements.

The Navy is preparing an EIS/OEIS to assess the potential environmental impacts associated with ongoing naval testing and training activities in the Study Area. The Navy is the lead agency for the PMSR Draft EIS/OEIS, and the National Marine Fisheries Service (NMFS) is a cooperating agency pursuant to 40 Code of Federal Regulations (CFR) parts 1501.6 and 1508.5. In addition, in accordance with section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, the Navy is required to consult with NMFS for those actions it has determined may affect ESA-listed marine species or critical habitat. The Navy is preparing a Biological Assessment as part of the ESA consultation.

[1] Throughout this document and in the context of the detonation of explosives, the words "…near the surface…" refer to a detonation occurring in air within 10 meters (m) of the ocean surface.

1.3 PRIMARY MISSION AREAS

The military builds upon the purpose and need to train and test (as described in Chapter 1) by describing the Study Area and identifying the primary mission areas for which these training and testing activities are conducted. Each warfare community (e.g., aviation, surface, submarine, and expeditionary) conducts training and testing activities that contribute to the success of these primary mission areas. Each primary mission area requires unique skills, sensors, weapons, and technologies to accomplish the overall mission.

The Navy categorizes its at-sea activities into eight functional warfare areas called primary mission areas. PMSR activities addressed in this EIS/OEIS are categorized under three of those primary mission areas. These mission areas encompass five broad categories that reflect all test and training activities.

- air warfare (air-to-air, surface-to-air)
- electronic warfare (directed energy - lasers and high-powered microwave systems)
- surface warfare (surface-to-surface, air-to-surface, and subsurface-to-surface)

Research, Development, Acquisition, Testing, and Evaluation of new technologies by the U.S. Department of Defense occurs continually to ensure that the U.S. military can counter new and anticipated threats. All new Navy systems and related equipment must be tested to ensure proper functioning before delivery to the Fleets for use. The PMSR is the Navy's primary ocean testing area for guided missiles and related ordnance. Test operations on the Sea Range are conducted under highly controlled conditions, allowing for the collection of empirical data to evaluate the performance of a weapon system or subsystem. Testing conducted in the PMSR is important for maintaining readiness. Two of the U.S. Navy's Systems Commands, Naval Sea Systems Command (NAVSEA) and NAVAIR, sponsor the majority of the testing at PMSR. NAVSEA's five affiliated Program Executive Offices (PEOs) oversee over a dozen Program Manager, Sea offices that sponsor testing activities at PMSR. NAVAIR's four affiliated PEOs, along with NAVAIR Headquarters-managed programs, oversee approximately 20 Program Managers and Air offices that also sponsor testing activities at PMSR.

Aviation warfare training conducted at PMSR, categorized as unit level training, is designed for a small number of aircraft up to a squadron of aircraft. These training events occur at PMSR as it is the only West Coast Navy venue to provide powered air-to-air targets. They are limited in scope and generally focus on one or two tasks. These scenarios require planning and coordination to ensure safe and effective training.

1.3.1 AIR WARFARE

The mission of air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Air warfare provides U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

Aircraft conduct air warfare through radar search, detection, identification, and engagement of airborne threats. Surface ships conduct air warfare through an array of modern anti-aircraft weapon systems such as aircraft-detecting radar, naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled guns for close-in point defense.

Testing of air warfare systems is required to ensure the equipment is fully functional under the conditions in which it will be used. Tests may be conducted on radar and other early-warning detection and tracking systems, new guns or gun rounds, and missiles. Testing of these systems may be conducted on new ships and aircraft, and on existing ships and aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies.

1.3.1.1 Air-to-Air

Air-to-air scenarios involve the employment of an airborne weapon system against airborne targets. Missiles are fired from a fighter aircraft for both testing and training events. Range support includes range clearance, instrumentation, aerial target presentation and recovery, Telemetry (TM), and surveillance aircraft. The missiles are highly instrumented to record the intercept parameters and normally do not carry live warheads. However, the scenarios may require captive carry (inert), live motor but no warhead, or tactical full-capability rounds for firing and warhead detonation. The airborne targets are usually not destroyed and are recovered by boat or helicopter from the water for subsequent use.

1.3.1.2 Surface-to-Air

Surface-to-air scenarios evaluate the overall weapon system performance, warhead effectiveness, and software/hardware modifications or upgrades of ground-based and ship-based weapons systems. Missiles are fired from a ship or a land-based launcher against a variety of supersonic and subsonic airborne targets. The missiles are highly instrumented to record the intercept parameters and normally do not carry live warheads. Range support includes range clearance, instrumentation, aerial target presentation, TM and surveillance aircraft, and other related range support. These scenarios may include use of conventional ordnance for inert warheads or tactical full-capability rounds for firing and warhead detonation.

1.3.2 Electronic Warfare

The mission of electronic warfare is to degrade the enemy's ability to use electronic systems, such as communication systems and radar, and to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to detect enemy threats and counter their attempts to degrade the electronic capabilities of the Navy.

Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices (that block or interfere with other devices) to defeat tracking, navigation, and communications systems.

Testing of electronic warfare systems is conducted to improve the capabilities of systems and ensure compatibility with new systems. Testing involves the use of aircraft, surface ships, and submarine crews to evaluate the effectiveness of electronic systems. Similar to training activities, typical electronic warfare testing activities include the use of airborne and surface electronic jamming devices (including testing chaff and flares; see Appendix A (PMSR Scenario Descriptions) for a description of these devices) to defeat tracking and communications systems. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems' use against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems' use against flare deployment. Electronic warfare also includes Directed Energy weapons tests, including high-energy laser (HEL) and high-power microwave (HPM) systems from land, vessels and aircraft.

1.3.3 Surface Warfare

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

Surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and 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, 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 Fleet training activities.

1.3.3.1 Air-to-Surface

Air-to-surface tests evaluate the integration of a missile or other weapons system into Department of Defense aircraft, or the performance of the missile/system itself. Missiles are fired from an aircraft against a variety of mobile seaborne targets and fixed aim points. The missiles are highly instrumented to record the intercept parameters and normally do not carry live warheads. Range support includes range clearance, instrumentation, surface target presentation and recovery, TM, surveillance aircraft, and fixed land targets. These tests may include use of conventional ordnance for captive carry (inert), live motor but no warhead, or tactical full-capability rounds for firing and warhead detonation. The seaborne targets are usually not destroyed and are recovered for subsequent use.

1.3.3.2 Surface-to-Surface

Surface-to-surface tests evaluate the overall weapon system performance, warhead effectiveness, and software/hardware modifications or upgrades of ground-based and ship-based weapons systems. Missiles are fired from a ship or a land-based launcher against a variety of mobile seaborne targets and fixed aim points. The missiles are highly instrumented to record the intercept parameters and normally do not carry live warheads. Surface targets include mobile seaborne targets and land-based fixed aim points. Range support includes range clearance, instrumentation, surface target presentation and recovery, TM, surveillance aircraft, and fixed land targets. These tests may include use of conventional ordnance for inert warheads or tactical full-capability rounds for firing and warhead detonation. The seaborne targets are usually recovered for subsequent use.

1.3.3.3 Subsurface-to-Surface

Subsurface launches of sub-sonic cruise missiles, which are aerodynamically guided jet-engine powered missiles that fly with constant speed to deliver a warhead at specified fixed aim point targets over a long distance with high accuracy; or ballistic missiles, which are rocket-propelled self-guided missiles that follow a ballistic trajectory with the objective of delivering one or more warheads to a predetermined target. A ballistic missile is only guided during relatively brief periods of flight, and most of its trajectory is unpowered and governed by gravity and air resistance if in the atmosphere. Both missiles are considered a component of subsurface-to-surface events. The PMSR supports the launch phase of a ballistic missile test, the launch and initial missile travel of a cruise missile test, and, on occasion, the terminal phase of a cruise missile test. These tests evaluate the overall weapon system performance, warhead effectiveness, and software/hardware modifications or upgrades of submarine-launched weapons systems. Range support includes range clearance, instrumentation, TM and surveillance aircraft, and other related range support.

1.4 Description of Stressors

The Navy uses a variety of platforms, weapons, and other devices, including ones used to ensure the safety of Sailors and Marines, to meet its mission. Testing and training with these systems may introduce stressors 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 stressors considered for potential impacts on marine mammals in the Study Area are acoustic stressors, including explosives detonated at or near the surface of the water and launch noise from locations on San Nicolas Island.

1.4.1 Acoustic Stressors (Surface Explosives; Target and Missile Launches from San Nicolas Island)

Anthropogenic noise is defined as noise originating from human activity and is generated from a variety of sources, including Navy testing and training activities. These other sources of acoustic stressors noise include commercial vessel, oil and gas production activities, commercial and recreational fishing (including fish finding sonar, fathometers, and acoustic deterrent and explosive harassment devices), whale watching activities, and general recreational boating. Consideration of these other sources of noise is part of the baseline of information and context for analysis of Navy acoustic stressors and their potential impacts on marine mammals as presented in Chapter 6 (Take Estimates for Marine Mammals). Explanations of the terminology and metrics used when describing sound in this request for an LOA can be found in prior NMFS regulations (see for example 83 FR 66846 and 84 FR 28462).

1.4.1.1 Context for Explosives as Acoustic Stressors in the PMSR Study Area

Explosions at or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. The resulting impulse noise from Navy explosions occurs in an environment that is subjected to civilian use of in-water explosives, intensive commercial and recreational vessel traffic, and petroleum industry noise-generating activity that are also sources of impulsive and/or broadband sound.

Passive acoustic monitoring off Southern California since 2009 has documented the routine use of non-military explosives at-sea, commonly known as “seal bombs” in and around the PMSR (Baumann-Pickering et al., 2013b; Bland, 2017; Debich et al., 2015a; Debich et al., 2015b; Rice et al., 2017; Rice et al., 2018; Rice et al., 2019; Širović et al., 2016; Wiggins et al., 2019; Wiggins et al., 2018). These explosive devices are directed at marine mammals to deter those animals from interfering with fishing activities; are only one of a number of deterrent devices that may be used for similar purposes (National Marine Fisheries Service, 2015; Schakner & Blumstein, 2013); and have been in widespread and routine use as the acoustic monitoring data demonstrates. For example at a monitoring site to the northeast of SNI, in seven months from May to November 2013 there were over 24,000 explosions identified as seal bombs (Debich et al., 2015a). In the time period between June 2012 and June 2017 at a site to the south of SNI, there have been an average of 9,514 explosions detected per year (Wiggins et al., 2018), although this average varies within the year based on start and end of the fishing season and between locations based on shifts in fishing effort to the north and south. Echosounder pings, most often used in the area for fish detection or as a depth-finder to aid navigation, were also present in the acoustic record (Hildebrand et al., 2012).

Commercial vessel noise, in particular commercial shipping, is a major contributor to noise in the ocean and predominates in nearshore transit lanes, such as those leading through the PMSR Study Area (Hildebrand et al., 2011; Hildebrand et al., 2012; McKenna et al., 2012; McKenna et al., 2015; Redfern et al., 2017). Given the presence of the ports of Los Angeles/Long Beach and the vessel Traffic Separation Scheme's lanes running through the PMSR, as detailed in Section 3.0.6.1.1 (Vessel Noise) of the PMSR Draft EIS/OEIS, commercial vessel noise is the main source of underwater anthropogenic noise in the area (Rice et al., 2018; Wiggins et al., 2018). Redfern et al. (2017) found that shipping channels leading to and from the ports of Los Angeles and Long Beach may have degraded the habitat for blue, fin, and humpback whales due to the loss of communication space where important habitat for these species overlaps with elevated noise from commercial vessel traffic. These shipping channels running adjacent to the coast also run adjacent to or through portions of the Channel Islands National Marine Sanctuary and some of the designated biologically important areas (BIAs) for cetaceans (Calambokidis et al., 2015; Moore et al., 2018). The San Pedro Channel is where the Traffic Separation Scheme's southern entrance and exit is located for these same ports (Los Angeles and Long Beach; see Figure 3.0-1 in the PMSR Draft EIS/OEIS). It can be assumed that the similar concentration of commercial vessel traffic moving through the San Pedro Channel into and out of the southern corner of the PMSR Study Area also impact marine mammal communication space in a similar manner as suggested for the shipping channels to the north investigated by Redfern et al. (2017). Commercial vessels are a broadband source of noise that at distance will be part of the ambient soundscape along with other sources of anthropogenic noise.

In many areas of the world, oil and gas seismic exploration in the ocean is undertaken using a group of air guns towed behind large research vessels. NMFS routinely issues permits for the taking of marine mammals associated with these commercial activities, although there has not been an oil and gas seismic survey permitted off California since 1995. In January 2018, the Department of Interior issued a Draft Proposed Program to offer lease sales under the National Outer Continental Shelf Oil and Gas Leasing Program, which includes potentially seven leases in Pacific (one in Southern California) although there are already leases in producing status in Southern California Planning Area (Bureau of Ocean Energy Management, 2019). Drilling and oil extraction also creates underwater noise (Erbe et al., 2013; Erbe & McPherson, 2017). Currently, in the nearshore waters of the Santa Barbara Channel in the central portion of the PMSR, there are existing offshore oil and gas production facilities along with additional facilities farther to the south off the Long Beach area (Bureau of Ocean Energy Management, 2012, 2017).

1.4.1.2 Explosive Stressors

The use of explosives under the Proposed Action is quantified in Section 1.5.1.3 (Explosives At or Near the Surface). In order to better organize and facilitate the analysis of various explosives used by the Navy, a series of source classifications, or source bins, were developed for and used in prior recent Navy analyses (U.S. Department of the Navy, 2018b, 2019b) and NMFS regulations (see for example, 83 FR 66846). The use of source classification bins provides the following benefits:

- Provides the ability for new 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 (having the largest net explosive weight) within that bin.
- Allows analyses to be conducted in a more efficient manner, without any compromise of analytical results.
- Provides a framework to support the reallocation of source usage (number of 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 testing and training requirements, which are linked to real world events.

Missiles, rockets, bombs, and medium and large-caliber projectiles may be explosive or non-explosive, depending on the objective of the testing or training activity in which they are used. The Proposed Action does not include explosive munitions used underwater. All explosives used during testing and training activities for the Proposed Action within the PMSR would detonate at or near the water's surface (in air). Several parameters influence the acoustic effect of an explosive: the weight of the explosive warhead, the type of explosive material, the boundaries and characteristics of the propagation medium(s); and the detonation depth underwater. 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.

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 (Urick, 1983). In addition, absorption greatly affects the distance over which higher frequency components of explosive broadband noise can propagate. 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 (U.S. Department of the Navy, 2019a).

To predict marine mammal exposures to explosives and because there is currently no means to model impacts on marine mammals from in air detonations, the Navy's analysis conservatively models all detonations occurring within 10 m above the water's surface, as a point-source located 10 centimeters underwater (U.S. Department of the Navy, 2019a). The model also assumes that all acoustic energy from the detonation remains underwater with no sound transmitted into the air. Important considerations must be factored into the analysis of results with these modeling assumptions, given that the peak pressure and sound from a detonation in air significantly decreases as it is partially reflected by the water's surface and partially transmitted underwater, as detailed in the following paragraphs.

Detonation of an explosive in air creates a supersonic high pressure shock wave that expands outward from the point of detonation (Kinney & Graham, 1985; Swisdak, 1975). The near-instantaneous rise from ambient to an extremely high peak pressure is what makes the explosive shock wave potentially injurious to an animal experiencing the rapid pressure change (U.S. Department of the Navy, 2017e). As the shock wave-front travels away from the point of detonation, it slows and begins to behave as an acoustic wave-front travelling at the speed of sound. Whereas a shock wave from a detonation in-air has an abrupt peak pressure, that same pressure disturbance when transmitted through the water surface results in an underwater pressure wave that begins and ends more gradually compared with the in-air shock wave, and diminishes with increasing depth and distance from the source (Bolghasi et al., 2017; Chapman & Godin, 2004; Cheng & Edwards, 2003; Moody, 2006; Richardson et al., 1995; Sawyers, 1968; Sohn et al., 2000; Swisdak, 1975; Waters & Glass, 1970; Woods et al., 2015). The propagation of the shock wave in-air and then transitioning underwater, is very different from a detonation occurring deep underwater where there is little interaction with the surface. In the case of an underwater detonation occurring just below the surface, a portion of the energy from the detonation would be released into the air (referred to as surface blow off), and at greater depths a pulsating, air-filled cavitation bubble would form, collapse, and reform around the detonation point (Urick, 1983). The Navy's acoustic effects model for analyzing underwater impacts on marine species does not account for the loss of energy due to surface blow-off or cavitation at depth. Both of these phenomena would diminish the magnitude of the acoustic energy received by an animal under real-world conditions (U.S. Department of the Navy, 2018c).

To more completely analyze the results predicted by the Navy's acoustic effects model from detonations occurring in-air above the ocean surface, it is necessary to consider the transferal of energy across the air-water interface. Much of the scientific literature on the transferal of shock wave impulse across the air-water interface has focused on energy from sonic booms created by fast moving aircraft flying at low altitudes above the ocean (Chapman & Godin, 2004; Cheng & Edwards, 2003; Moody, 2006; Sawyers, 1968; Waters & Glass, 1970). The shock wave created by a sonic boom is similar to the propagation of a pressure wave generated by an explosion (although having a significantly slower rise in peak pressure) and investigations of sonic booms are somewhat informative. Waters and Glass (1970) were also investigating sonic booms, but their methodology involving actual in-air detonations. In those experiments, they detonated blasting caps elevated 30 feet (ft.) above the surface in a flooded quarry and measured the resulting pressure at and below the surface to determine the penetration of the shock wave across the air-water interface. Microphones above the water surface recorded the peak pressure in-air, and hydrophones at various shallow depths underwater recorded the unreflected remainder of the pressure wave after transition across the air-water interface. The peak pressure measurements were compared and the results supported the theoretical expectations for the penetration of a pressure wave from air into water, including the predicted exponential decay of energy with distance from the source underwater. In effect, the air-water interface acted as a low-pass filter eliminating the high-frequency components of the shock wave. At incident angles greater than 14 degrees perpendicular to the surface, most of the shock wave from the detonation was reflected off the water surface, which is consistent with results from similar research (Cheng & Edwards, 2003; Moody, 2006; Yagla & Stiegler, 2003). Within the 14 degree cone directly under the detonation, acoustic energy from the shock wave is partially reflected from the surface and partially transmitted into the water as a propagating acoustic wave (Waters & Glass, 1970). The diameter of the 14-degree cone on the surface is a function of the altitude of the source. As modeled, the in-air detonations of missiles at PMSR will occur within 2 m of the surface resulting in a cone with a base approximately 1.5 m in diameter. For the area within the cone, Waters and Glass (1970) determined; "The amplitude of the reflected component was about 0.78 that of the incident component," or in other words, approximately 78 percent of the energy from the detonations measured in-air was reflected by the water surface. Given that marine mammals spend, on average, up to 90 percent of their time underwater (Costa, 1993;

Costa & Block, 2009), and the shock wave from a detonation is only a few milliseconds in duration, marine mammals are unlikely to be exposed in-air when surfaced.

The underwater onset threshold for gastrointestinal (GI) injury (slight bruising in the GI tract) is a peak pressure equivalent to an (unweighted) sound pressure level (SPL) of 237 decibels referenced to 1 micropascal (dB re 1 µPa) for all marine mammals (20 pounds per square inch per millisecond [psi-ms] from Richmond et al. (1973); see U.S. Department of the Navy (2017e)). Based on the discussion above, the Navy's current modeling of air-to-air, air-to-surface, and surface-to-air testing and training activities involving in-air detonations of missiles at or near the surface of the ocean likely overestimates peak pressure levels below the water surface. Considering that Waters and Glass (1970) determined a majority of the pressure generated by a detonation in-air is reflected by the water surface, peak pressure levels below the surface are almost certainly not equal to modeling such detonations as if they occur below the surface, any predicted occurrence of non-auditory injury to marine mammals is likely overestimated. For this reason, the non-auditory injury impacts for this subset of explosive stressors (i.e., missiles detonating in-air above 10 m of the water's surface) will be discounted.

1.4.1.3 Land-based Launch Noise on San Nicolas Island

There is one unique aspect to noise associated with launches of missiles and aerial targets from land at SNI given the presence of relatively nearby pinniped haulout sites. Noise from target and missile launches results in disturbance of pinnipeds, as documented over nearly two decades of monitoring and reporting of those activities (Burke, 2017; Holst et al., 2011). These ongoing activities affecting pinniped hauled out in the vicinity of launch sites have been analyzed previously (National Marine Fisheries Service, 2019a; National Oceanic and Atmospheric Administration, 2014) are included in this request for authorization of takes resulting from those activities.

1.5 Proposed Action

The Proposed Action includes current activities, as discussed above; proposed activities to include increased use of W-532; and an increase in overall operational tempo as described below. Testing and training activities would be conducted at sea, in designated airspace, and on SNI within the PMSR Study Area. Additionally analyzed as part of the Proposed Action are the missile and target launch operations on SNI.

1.5.1 Current and Proposed Activities

The Navy has been conducting testing and training activities in the PMSR Study Area since the PMSR was established in 1946. The types and tempo of testing and training 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 (organization of ships, submarines, aircraft, and weapons). Such developments influence the frequency, duration, intensity, and location of required testing and training activities. The Proposed Action includes current activities as analyzed in the 2002 PMSR EIS/OEIS in addition to activities covered by other environmental planning documents for the PMSR since 2002, plus changes in operational activity frequency and new mission areas, and systems and platforms. The proposed testing activities are deemed necessary to accomplish Naval Air Systems Command's mission of providing for the safe and secure collection of decision-quality data; and developing, operating, managing and sustaining the interoperability of the Major Range Test Facility Base at the PMSR into the foreseeable future. Collectively, the Proposed Action supports current and projected military readiness requirements into the foreseeable future as shown in Table 1-1.

Table 1-1: Representative Tempo of Current PMSR Annual Events Between the Baseline and the Proposed Action

Activity	Activity Sub Category	Environmental Baseline	Proposed Action
Aerial Targets (# of targets)	-	104	176
Surface Targets (# of targets)	-	430	522
Ordnance (# of ordnance)	Bombs	22	30
	Gun Ammunition	11,670	281,230
	Missiles	231	584
	Rockets	30	40

Notes: The increase in tempo under the Proposed Action is mostly a result of an increase in Combat Systems Ship Qualification Trials as discussed in Section 1.5.1.1 (Combat Systems Tests).

Most of the factors influencing frequency and types of activities are fluid in nature (i.e., continually evolving and changing), and the PMSR activity level will continue to fluctuate in the future from the current baseline. Projecting future testing and training duration and frequency varies depending on Fleet requirements and funding and does not occur on a predictable annual cycle. Future testing depends on scientific and technological developments that are not easy to predict, and experimental designs may evolve with emerging science and technology. Even with these challenges, the Navy makes every effort to forecast all future testing requirements. As a result, testing requirements are driven by the need to support Fleet readiness based on emerging national security interests, and alternatives must have sufficient annual capacity to conduct the research, development, and testing of new systems and technologies, with upgrades, repairs, and maintenance of existing systems. Fleet training activities occur over scheduled continuous and uninterrupted blocks of time, focusing on the development of core capabilities/skills. Training events on the PMSR are conducted to ensure Navy forces can sustain their training cycle requirements. Primarily, changes occur with increases or decreases in annual operational tempo of activities in addition to changes in the types of aircraft, vessels, targets, ordnance, and tasks that are actions or processes performed as part of Navy operations.

1.5.1.1 Combat Systems Tests

The System Command Program Executive Offices are tasked with conducting extensive combat systems tests and trials on each new platform prior to releasing the platform to the Fleet, to include ships that have been in an extended upgrade or overhaul status. The PMSR is the preferred site to conduct these tests, as it offers a venue for a thorough evaluation of combat and weapons system performance through the actual employment of weapon systems. The comprehensive tests are conducted by the responsible Program Manager, with close cooperation from the Fleet Type Commanders (Surface Force, Air Force, or Submarine Force). A frequent test conducted at the PMSR are the Naval Sea Systems Combat Systems Ship Qualification Trials (CSSQT). This is a series of comprehensive tests and trials designed to show that the equipment and systems included in the CSSQT program meet combat system requirements. Live and inert weapons, along with chaff, flares, jammers, and lasers may be used. Naval Sea Systems Command has recently developed two new reporting programs to test and evaluate combat and weapons system performance on new classes of ships, resulting in an increased tempo on the PMSR.

1.5.1.2 Fleet Training

Similar to CSSQTs, Fleet training on PMSR includes the same types of warfare areas. Training conducted in parallel with testing activities provide Fleet operators unique opportunities to train with ship and aircraft combat weapon systems and personnel in scripted warfare environments, including live-fire events. Combat ship crews train in conjunction with scheduled ship testing and qualification trials, to take advantage of the opportunity to provide concurrent training and familiarization for ship personnel in maintaining and operating installed equipment, identifying design problems, and determining deficiencies in support elements (e.g., documentation, logistics, test equipment, or training). Live and inert weapons, along with chaff, flares, jammers, and lasers may be used.

Typically concurrent with testing, surface training available on the PMSR includes tracking events, missile-firing events, gun-firing events, high-speed anti-radiation missile events, and shipboard self-defense system training, (e.g., Phalanx [Close-in Weapons System], Rolling Airframe Missile, and Evolved Sea Sparrow Missile). These events are limited in scope and generally focus on one or two tasks. Missiles may be fired against sub-sonic, supersonic, and hypersonic targets. Certain training events designed for single ships are conducted to utilize unique targets only available for training at the PMSR.

Aviation warfare training conducted at PMSR, categorized as unit-level training, is designed for a small number of aircraft up to a squadron of aircraft. These training events occur at PMSR as it is the only West Coast Navy venue to provide powered air-to-air targets. They are limited in scope and generally focus on one or two tasks. These scenarios require planning and coordination to ensure safe and effective training.

1.5.1.3 Explosives At or Near the Surface

Missiles, bombs, and projectiles that detonate at or near (within 10 m of) the water's surface are considered for the potential that they could result an acoustic impact to marine mammals that may be underwater and nearby. The annually used number of explosives and events by Primary Mission Area and by modeling bin (as described in Section 1.4.1.2, Explosive Stressors) are provided in Table 1-2 for the current Baseline and for the foreseeable future as the Proposed Action.

Table 1-2: Explosives Detonating At or Near the Surface by Bins Supporting Primary Mission Areas for the Baseline and Proposed Action Annually

Primary Mission Area	Bin	Number of HE Munitions Used Annually	
		Environmental Baseline	Proposed Action
Surface-Surface	E1	808	28,600
	E3	1,121	5,530
	E5	110	1,666
Air-Surface; Surface-Air	E6	26	104
Air-Air; Air-Surface	E7	37	64
Air-Air; Air-Surface; Surface-Air	E8	26	71
Air-Surface; Surface-Surface	E9	49	63
Subsurface-Surface	E10	3	13

The explosive energy released by detonations in air has been well studied, and basic methods are available to estimate the explosive energy exposure with distance from the detonation (e.g., U.S. Department of the Navy (1975)). In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind. While basic estimation methods do not consider the unique environmental conditions that may be present on a given day, they allow for approximation of explosive energy propagation under neutral atmospheric conditions. Explosions that occur during air warfare would typically be at a sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude. Based on an understanding of the explosive energy released by detonations in air, detonations occurring in air at altitudes greater than 10 m are not likely to result in acoustic impacts to marine mammals.

2 Dates, Duration, and Specified Geographic Region

This request for regulations and authorization for incidental taking is to cover testing and training activities occurring in the PMSR Study Area from approximately October 2021 through October 2028. The different testing and training activities under the Proposed Action are described in Section 1.5 of this request. The Study Area is depicted in Figure 1-1.

2.1 Point Mugu Sea Range

The NAWCWD PMSR is located adjacent to Los Angeles, Ventura, Santa Barbara, and San Luis Obispo Counties along the Pacific Coast of Southern California and includes a 36,000-square-mile Sea Range. It is a designated Major Range and Test Facility Base and is considered a national asset that exists primarily to provide test and evaluation information for DoD decision makers and to support the needs of weapon system development programs and DoD research needs. The two primary components of the PMSR Complex are Special Use Airspace (SUA) and the ocean Operating Areas.

2.1.1 Special Use Airspace

SUA is airspace designated wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both. SUA consists of both controlled and uncontrolled airspace and has defined dimensions. Flight and other activities for non-participating aircraft are restricted or prohibited for safety or security reasons. SUA is established under procedures outlined in 14 CFR Part 73.1. The majority of SUA is established for military flight activities and, with the exception of prohibited areas (e.g., over the White House), may be used for commercial or general aviation when not reserved for military activities. There are multiple types of SUA, including prohibited, restricted, warning, alert, and military operations areas (Federal Aviation Administration, 2009). Two are components of the PMSR SUA: Warning Areas and Restricted Areas.

Warning Area. One type of SUA, of particular relevance to the Study Area, is a Warning Area (W), which is defined in 14 CFR Part 1 as follows:

> "A Warning Area is airspace of defined dimensions, extending from 3 NM outward from the coast of the United States that contains activity that may be hazardous to non-participating aircraft. The purpose of such warning areas is to warn non-participating pilots of the potential danger. A Warning Area may be located over domestic or international waters or both."

Warning areas are established to contain a variety of hazardous aircraft and non-aircraft activities, such as aerial gunnery, air and surface missile firings, bombing, aircraft carrier operations, surface and subsurface operations, and naval gunfire. When these activities are conducted in international airspace, the FAA regulations may warn against, but do not have the authority to prohibit, flight by non-participating aircraft. The 11 Warning Areas that comprise the PMSR include W-532N, W-532E, W-532S; W-537; W-289N, W-289 S, W-289W, W-289E; W-292W, W-292E; and W-412 (see Figure 1-1: Point Mugu Sea Range Study Area). The Warning Areas are further subdivided by PMSR Schedules into operating areas to safely accommodate simultaneous operation; however, Notices to Airmen and Notices to Mariners do not reflect those subdivisions.

While some SUA is available for scheduled daily use by the military for a designated time period (e.g., from 6:00 am to 6:00 pm), other airspace is only activated by the FAA issuing Notices to Airmen several hours in advance of the military activity.

Restricted Area. Restricted Areas (R) are a type of SUA within which the flight of aircraft, while not wholly prohibited, is subject to restriction. They are designated where operations are hazardous to nonparticipating aircraft and contain airspace within which the operation of aircraft is prohibited when the airspace is active, unless the operator has the advance permission of the using agency or the controlling agency. The Commanding Officer, NAWCWD is designated as the using and scheduling agency for PMSR Restricted Areas. R-2519 overlays a portion of NBVC Point Mugu and extends 3 NM off shore. R-2535A/B overlay NBVC SNI and the ocean out to approximately 3 NM. The R-2535A/B airspace is excluded from W-289S when it is active (see Figure 1-1Figure 1-1: Point Mugu Sea Range Study Area).

The importance of the designated SUA in relation to consideration of marine mammals is that, while the PMSR is overall a large area, the locations of testing and training activities are encumbered by the limited available SUA and other general safety concerns.

2.1.2 Point Mugu Sea Range Controlled Sea Space Operating Areas

The PMSR-controlled sea space parallels the California coast for approximately 225 NM and extends approximately 180 NM seaward (see Figure 1-1), aligning with the PMSR Warning Area airspace. The controlled sea space areas consist of the following:

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

The PMSR provides telemetry, communications, and optics that can be extended over the horizon from land-based assets and instrumented aircraft. In addition to the military uses of the PMSR, civilian recreational and commercial boats and vessels transit the 36,000 square miles of the PMSR daily. When required for test and training events, and when the temporary range expansion is in place, the Sea Range Test Conductor coordinates a Notice to Mariners issued by the United States Coast Guard to provide timely maritime safety within the PMSR-controlled sea space.

The location of concentrated commercial and civilian vessel traffic is also a consideration for where testing and training events can occur because the ports of Los Angeles/Long Beach which are adjacent to the PMSR (Figure 2-1), together form the busiest commercial port hub in the United States and the sixth-busiest commercial port in the world (Port of Los Angeles, 2017). The charted commercial vessel Traffic Separation Scheme's lanes leading into the San Pedro Channel (see NOAA Chart #18720, "Point Dume to Purisima Point") run through the central portions of the PMSR and data indicates there are on average in excess of approximately 7,000 commercial vessel transits per year associated with visits to just those ports (American Association of Port Authorities, 2017; McKenna et al., 2012; McKenna et al., 2015; Port of Los Angeles, 2017; U.S. Army Corps of Engineers, 2017). This number of port calls does not account for a substantial number of additional commercial vessels transiting offshore of Point Mugu bound for other major U.S. ports such as Port Hueneme, Seattle/Tacoma, San Francisco, or port locations beyond. Civilian shipping distribution such as cargo and bulk carrier traffic dominates much of the offshore areas, including routes to and from Asia and the Panama Canal or South America.

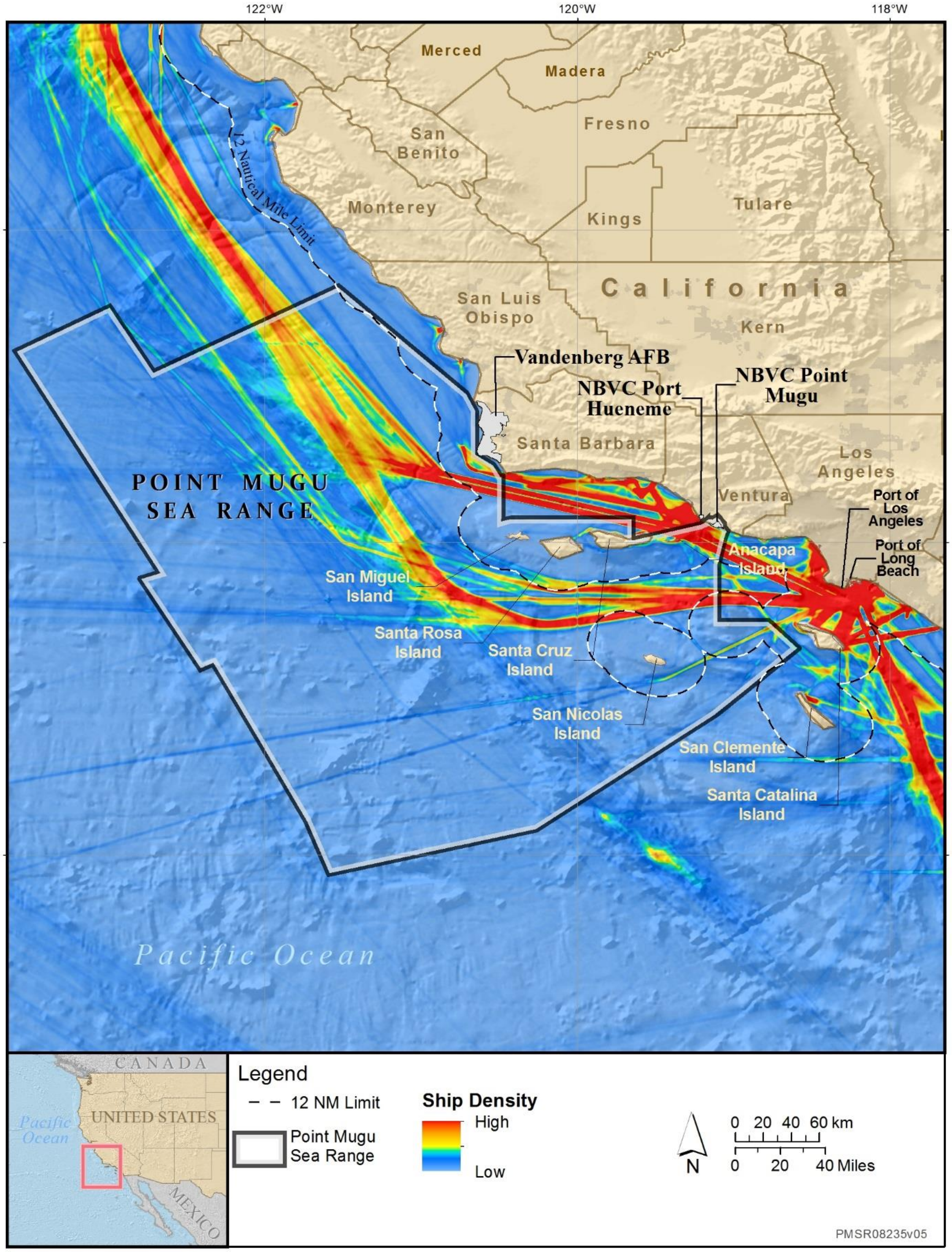

Figure 2-1: Relative Distribution of Commercial Vessel Traffic in the PMSR Study Area

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3 Species and Numbers of Marine Mammals

Thirty-five marine mammal stocks or distinct population segments (DPSs) under the purview of NMFS are present in the PMSR Study Area. A list of the stocks and species are provided in Table 3-1 along with their current MMPA and ESA status, an abundance estimate for the population[2], an associated coefficient of variation for that abundance, and minimum abundance, all based upon the final 2018 Stock Assessment Reports (SARs) from NMFS (Carretta et al., 2019b; Muto et al., 2019). For each species and stock, relevant information on their status, distribution, population trends, and ecology is presented in Chapter 4 (Affected Species Status and Distribution).

[2] Navy recognizes that the stocks, abundances, and the populations of marine mammals provided in the SARs do not all represent the same thing. In particular, some abundances in a SAR are an estimate of only the subset of animals that are estimated to be present within the U.S. Exclusive Economic Zone (EEZ) or in the California Current Ecosystem so takes requested in this application and management of some species (such as for Pacific white-sided dolphin, which is found throughout the temperate North Pacific Ocean) are based on only those small subsets of the population that may present within the area covered by a SAR.

Table 3-1: Marine Mammal Occurrence Within the PMSR Study Area

Common Name	Scientific Name[1]	Stock	Status		Stock Abundance (CV)/Minimum Population
			MMPA	ESA	
Blue whale	*Balaenoptera musculus*	Eastern North Pacific	Depleted	Endangered	1,647 (0.07)/1,551
Bryde's whale	*Balaenoptera brydei/edeni*	Eastern Tropical Pacific	-	-	na
Fin whale	*Balaenoptera physalus*	California, Oregon, and Washington	Depleted	Endangered	9,029 (0.12)/8,127
Gray whale	*Eschrichtius robustus*	Eastern North Pacific	-	-	20,990 (0.05)/20,125
		Western North Pacific	Depleted	Endangered	140 (0.04)/135
Humpback whale	*Megaptera novaeangliae*	California, Oregon, Washington	Depleted	Threatened/ Endangered[1]	1,918 (0.03)/1,876
Minke whale	*Balaenoptera acutorostrata*	California, Oregon, and Washington	-	-	636 (0.72)/369
Sei whale	*Balaenoptera borealis*	Eastern North Pacific	Depleted	Endangered	519 (0.4)/374
Baird's beaked whale	*Berardius bairdii*	California, Oregon, and Washington	-	-	847 (0.81)/466
Common Bottlenose dolphin	*Tursiops truncatus*	California Coastal	-	-	453 (0.06)/346
		California, Oregon, and Washington Offshore	-	-	1,924 (0.54)/1,255
Cuvier's beaked whale	*Ziphius cavirostris*	California, Oregon, and Washington	-	-	6,590 (0.55)/4,481
Dall's porpoise	*Phocoenoides dalli*	California, Oregon, and Washington	-	-	25,750 (0.45)/17,954

Common Name	Scientific Name[1]	Stock	Status		Stock Abundance (CV)/Minimum Population
			MMPA	ESA	
Dwarf sperm whale	*Kogia sima*	California, Oregon, and Washington	-	-	unk
Harbor Porpoise	*Phocoena phocoena*	Morro Bay	-	-	2,917[2] (0.41)/1,384
Killer whale	*Orcinus orca*	Eastern North Pacific Offshore	-	-	240 (0.49)/162
		Eastern North Pacific Transient/West Coast Transient[3]	-	-	243 unk/243
Long-beaked common dolphin	*Delphinus capensis*	California	-	-	101,305 (0.49)/68,432
Mesoplodont beaked whales[4]	*Mesoplodon spp.*	California, Oregon, and Washington	-	-	694 (0.65)/389
Northern right whale dolphin	*Lissodelphis borealis*	California, Oregon, and Washington	-	-	26,556 (0.44)/18,608
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	California, Oregon, and Washington	-	-	26,814 (0.28)/21,195
Pygmy killer whale	*Feresa attenuata*	-	-	-	na
Pygmy sperm whale	*Kogia breviceps*	California, Oregon, and Washington	-	-	4,111 (1.12)/1,924
Risso's dolphins	*Grampus griseus*	California, Oregon, and Washington	-	-	6,336 (0.32)/4,817
Short-beaked common dolphin	*Delphinus delphis*	California, Oregon, and Washington	-	-	969,861 (0.17)/839,325
Short-finned pilot whale	*Globicephala macrorhynchus*	California, Oregon, and Washington	-	-	836 (0.79)/466

Common Name	Scientific Name[1]	Stock	Status		Stock Abundance (CV)/Minimum Population
			MMPA	ESA	
Sperm whale	*Physeter macrocephalus*	California, Oregon, and Washington	Depleted	Endangered	2,106 (0.58)/1,332
Striped dolphin	*Stenella coeruleoalba*	California, Oregon, and Washington	-	-	29,211 (0.20)/24,782
Harbor seal	*Phoca vitulina*	California	-	-	30,968 na/27,348
Northern elephant seal	*Mirounga angustirostris*	California	-	-	179,000 na/81,368
California sea lion	*Zalophus californianus*	U.S. Stock	-	-	296,750 na/153,337
Northern fur seal	*Callorhinus ursinus*	California	-	-	14,050 na/7,524
Guadalupe fur seal	*Arctocephalus townsendi*	Mexico to California	Depleted	Threatened	20,000 na/15,830

[1] Taxonomy follows Committee on Taxonomy (2018)

[2] The abundance number as presented is from the "fine-scale transects" as documented in Forney (2014).

[3] This stock is mentioned briefly in the Pacific Stock Assessment Report and referred to as the "Eastern North Pacific Transient" stock, however, the Alaska Stock Assessment Report contains assessments of all transient killer whale stocks in the Pacific, and the Alaska Stock Assessment Report refers to this same stock as the "West Coast Transient" stock (Muto et al., 2019).

[4] The six *Mesoplodont* beaked whale species off California are *M. densirostris, M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri*.

Notes: na = not available; unk = unknown or not provided in the 2018 SAR for the Pacific (Carretta et al., 2019b).

4 Affected Species Status and Distribution

4.1 Marine Mammal Species Within the Study Area

The marine mammal species discussed in this section are those for which general regulations governing potential incidental takes of small numbers of marine mammals are sought. Relevant information on their status, distribution, and seasonal distribution (when applicable) is presented below, as well as additional information about the numbers of marine mammals likely to be found within the activity areas. NMFS annually publishes SARs for all marine mammals in U.S. EEZ waters, including stocks that occur within the PMSR Study Area.

4.1.1 Blue Whale (*Balaenoptera musculus*)

4.1.1.1 Status and Management

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. In the PMSR Study Area, the subspecies *Balaenoptera musculus* is present. 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 (Carretta et al., 2018a; Muto et al., 2018a).

4.1.1.2 Geographic Range and Distribution

Blue whales inhabit all oceans and typically occur near the coast and over the continental shelf, though they are also found in oceanic waters, having been sighted, acoustically recorded, and satellite tagged in the eastern tropical Pacific (Ferguson, 2005; Stafford et al., 2004); (Barlow, 2016; Bradford et al., 2013; Hamilton et al., 2009b; Klinck et al., 2015; Stafford et al., 2001). Blue whales tagged in and around Navy ranges with satellite tracking devices between 2014 and 2017, were found to have ranged from northern British Columbia, Canada, to as far south as waters near the equator (Mate et al., 2018).

The Eastern North Pacific Stock of blue whales includes animals found in the eastern north Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al., 2017a; Carretta et al., 2018b). Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, relatively high densities of blue whales are predicted off Southern California during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2016; Forney et al., 2012). Data from year-round surveys conducted off Southern California from 2004 to 2013 show that most blue whales were sighted in summer (62 sightings) and fall (9 sightings), with only single sightings in winter and spring (Campbell et al., 2015). In the Southern California Bight in summer and fall, the highest densities of blue whales occurred along the 200- m isobath in waters with high surface chlorophyll concentrations (Redfern et al., 2013). Campbell et al. (2015) documented blue whale sightings along both the Southern California shelf and over deep ocean water (>2,000 m). This species has also frequently been heard on passive acoustic recording devices in Southern California (Lewis & Širović, 2018; Širović et al., 2015). Based on approximately 3 million detections in the waters of the Southern California Bight between 2006 and 2012, Širović et al. (2015) found that blue whale vocalizations were more common at coastal sites and near the northern Channel Islands and generally heard between June and January, peaking in September. Spatial distribution among blue whales tagged in Southern California in 2014 varied largely, with the distance to shore ranging from less than 1 kilometer (km) up to 884.8 km, and blue whale movement along the Pacific coastline extending south to 7.4 degrees north latitude and north to 50 degrees north latitude just off British Columbia, Canada (Mate et al., 2015b). Results from blue whales tagged along the U.S. West Coast from 2014 to 2017 indicate blue whales occurred on average where the depth was 1,260 meters, the distance to the nearest shoreline was 63 km, and the distance to the continental shelf break was 33 km (Mate et al., 2018).

Blue whale tagging data in 2014, 2015, and 2016 off Southern California waters indicated year-to-year variation in the highest use areas within the Southern California Bight (Mate et al., 2015b; Mate et al., 2016, 2017; Mate et al., 2018). In 2014, the area of highest use was between Point Dume and Mugu Canyon, out to approximately 30 km from shore (Mate et al., 2015b). Most of this highest use area is to the east and inshore of the PMSR boundary and the range areas where the majority of activities occur. The area of highest use in 2015 was off the west end of San Miguel Island, but in 2016 very few blue whales were present in the Southern California Bight when the high use area shifted to Point Arena in Northern California to the north of San Francisco (Mate et al., 2017; Mate et al., 2018).

Most blue whale sightings are in nearshore and continental shelf waters (Calambokidis & Barlow, 2004, 2013); however, blue whales also frequently travel through deep oceanic waters during migration or movements between feeding areas (Bailey et al., 2009; Mate et al., 1999; Mate et al., 2016, 2017; Širović et al., 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al., 2004). Blue whales in the eastern north Pacific are known to migrate between higher latitude feeding grounds of the Gulf of Alaska and the Aleutian Islands to lower latitudes, including Southern California; Baja California, Mexico; and the Costa Rica Dome (Calambokidis & Barlow, 2004; Calambokidis et al., 2009a; Calambokidis et al., 2009b; Mate et al., 2015b; Mate et al., 2016). The West Coast is known to be a blue whale feeding area for the Eastern North Pacific stock during summer and fall (Bailey et al., 2009; Calambokidis et al., 2009a; Calambokidis et al., 2015; Mate et al., 2015b). Photographs of blue whales off California that have been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and the northern Gulf of Alaska (Calambokidis et al., 2009a), and satellite tag data have also demonstrated this link between these areas (Mate et al., 2015b). These animals have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis & Barlow, 2004).

Blue whales in Southern California are generally feeding during their seasonal presence along the U.S. West Coast (Abrahms et al., 2019a; Bailey et al., 2009; Calambokidis et al., 2009a; Calambokidis et al., 2015; Mate et al., 2015b; Mate et al., 2018). Three of nine feeding areas for blue whales identified by Calambokidis et al. (2015) along the U.S. West Coast partially overlap the Point Mugu Sea Range in the summer to fall (June through October) feeding season (Figure 4-1). The seasonality for use of the feeding areas has subsequently been verified in 2014–2017 tagging results showing consistent transits out of California/U.S. waters heading south toward the eastern tropical Pacific by the end of October (Mate et al., 2017; Mate et al., 2018).

The area covering 1,743 square kilometers (km^2) and designated the "Point Conception/Arguello" blue whale feeding area (Calambokidis et al., 2015) is farthest to the north within the PMSR. There are four oil production platforms and the Eastbound Lane for Traffic Separation Scheme through the Santa Barbara Channel leading to the ports of Los Angeles/Long Beach present within this BIA (Figure 4-1), with those platforms and vessels creating noise with the potential to disturb feeding blue whales in that BIA. Approximately 87 percent of this BIA is within the PMSR Study Area boundary.

Immediately to the south (approximately 2 NM distance) is a second blue whale BIA, covering 1,981 km^2 and designated the "Santa Barbara Channel and San Miguel" blue whale feeding area (Calambokidis et al., 2015), which has a 61 percent overlap with the PMSR Study Area. The Westbound Lane for Traffic Separation Scheme leading from the ports of Los Angeles/Long Beach is present within this BIA.

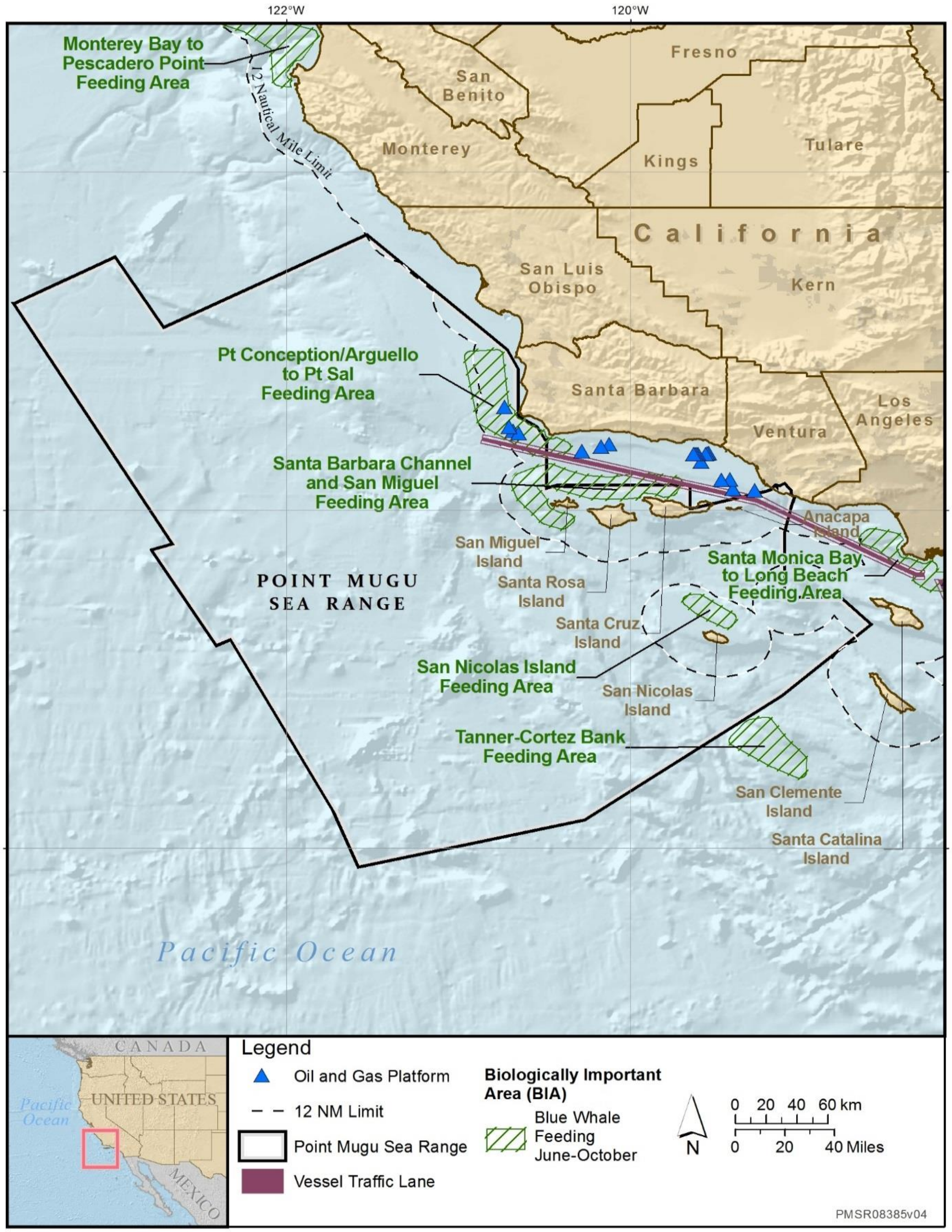

Figure 4-1: Blue Whale Biologically Important Feeding Areas Identified in the Vicinity of the PMSR Study Area (per Calambokidis et al. 2015)

A third blue whale BIA, covering 427 km^2, is located just to the north of SNI and was designated the "San Nicolas Island" feeding area (Calambokidis et al., 2015); this BIA is completely within the PMSR Study Area boundary.

Blue whales feed almost exclusively on various types of zooplankton, especially krill (Jefferson et al., 2015). However, it has recently been shown that blue whales in the Indian Ocean can locate and feed on dense swarms of other larger prey when present (De Vos et al., 2018). Researchers have suggested that blue whales in Southern California waters, which includes the PMSR, tend to return to the same feeding areas each year either due to the persistence of foraging hotspots or due to learned behavior (Abrahms et al., 2019a; Becker et al., 2018; Calambokidis et al., 2009a; Calambokidis et al., 2009b; Calambokidis et al., 2015; Irvine et al., 2014). This would suggest that the identified feeding BIAs may be good indicators for where blue whales will be found despite year-to-year changes in prey availability. Santora et al. (2011) found that between 2000 and 2009 in the PMSR Study Area, concentrations of krill were inversely correlated with oceanographic upwelling, such as occurs off Point Conception, or locations of strong offshore transport, and instead were found aggregated at the edges of such locations. The blue whale BIAs are only partially associated with identified high-density krill and other forage fish locations (Santora et al., 2011; Santora et al., 2017a; Santora et al., 2017b).

The blue whale feeding areas identified in waters extending from Point Conception to the Mexico border represent only a fraction of the total area within those waters where habitat models predict high densities of blue whales (Calambokidis et al., 2015; Ferguson et al., 2015b). Additionally, while those identified areas tend to have the highest blue whale density from July through October when averaged over multiple years, the areas are associated with ephemeral prey distributions that are less predictable over the short term (Abrahms et al., 2019b; Ferguson et al., 2015b). As a result, the designated feeding areas may not reflect the highest density or certain presence of blue whales in a given area in any one season or within the short time period involving most Navy testing and training events. Although limited by the relatively small sample sizes, this season-to-season variability in the use of the feeding areas has been demonstrated at the level of individual blue whales by satellite tags (Mate et al., 2018). Location data from tags deployed on 171 blue whales between 1993 and 2008 demonstrated home range and core area presence (Irvine et al., 2014) over a larger area than reflected by the two designated blue whale feeding area boundaries. Tags were also deployed on blue whales off Southern California from 2014 through 2017, specifically to determine blue whale presence and use of areas in and around Navy ranges (Mate et al., 2015b; Mate et al., 2017; Mate et al., 2018). In 2014, the San Diego and the Santa Monica Bay to Long Beach BIAs (located outside and to the south and east of the PMSR) were the most heavily used areas by the tagged individuals, whereas the Santa Barbara Channel and San Miguel Island BIA and the Point Conception/Arguello BIA were the most heavily used by tagged individuals in 2015. The remaining two BIAs, consisting of the SNI BIA and the Tanner/Cortez Banks BIA, were used only minimally by tagged blue whales in all four years (Mate et al., 2017; Mate et al., 2018). In 2016 researchers found Santa Barbara Channel and San Miguel Island and the Point Conception/Arguello BIAs minimally used by any blue whales, and the whales encountered in those BIAs and elsewhere in Southern California were too thin or otherwise in poor body condition to meet the tagging protocols (Oregon State University, 2017). Tagging efforts were therefore shifted to Central California waters where the researchers identified good numbers of blue, fin, and humpback whales in better condition, which was likely indicative of better prey availability in those more northern waters during that season (Oregon State University, 2017).

4.1.1.3 Population and Abundance

Widespread whaling over the last century is believed to have decreased the global blue whale population to approximately 1 percent of its pre-whaling population size at its lowest point (Branch, 2007; Monnahan, 2013; Monnahan et al., 2014; Rocha et al., 2014; Širović et al., 2004). Off the Pacific Coast, there was a documented increase in the blue whale population size between 1979–80 and 1991 (Barlow, 1994) and between 1991 and 1996 (Barlow, 1997). Calambokidis et al. (2009a) suggested that when feeding conditions off California are not optimal, blue whales may move to other regions to feed, including waters further north. In 2005–2006, during a period of cooler ocean temperatures, blue whales were found distributed more widely throughout Southern California waters than in previous years (Peterson et al., 2006). There had been a northward shift in blue whale distribution within waters off California, Oregon, and Washington (Abrahms et al., 2019a; Bailey et al., 2009; Barlow, 2010, 2016; Calambokidis et al., 2009a; Irvine et al., 2014; Širović et al., 2015).

Mark-recapture estimates reported on by Calambokidis et al. (2009a), "indicated a significant upward trend in abundance of blue whales" at a rate of increase just under 3 percent per year for the U.S. West Coast blue whale population in the Pacific (see also Calambokidis and Barlow (2013)). The most current information suggests that the population in the PMSR Study Area may have recovered and has been at a stable level following the cessation of commercial whaling in 1971, 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., 2015; Carretta et al., 2018b; International Whaling Commission, 2016; Monnahan, 2013; Monnahan et al., 2014; National Marine Fisheries Service, 2018a; Širović et al., 2015; Valdivia et al., 2019). Based on a comparison of sighting records from the 1950s to 2012 in the SOCAL Range Complex that is immediately south of the PMSR Study Area, Smultea (2014) determined that blue whales ranked sixth in occurrence among cetaceans which, "…represents a clear relative increase from historical records."

4.1.2 BRYDE'S WHALE (*BALAENOPTERA BRYDEI/EDENI*)

4.1.2.1 Status and Management

This species is not listed under the ESA. Bryde's whales occurring off the U.S. West Coast are assigned to the Eastern Tropical Pacific stock (Carretta et al., 2019b).

4.1.2.2 Geographic Range and Distribution

Bryde's whales occur primarily in offshore oceanic waters of the north Pacific (Barlow et al., 2006; Bradford et al., 2017). Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Baker & Madon, 2007; Best, 1996). Long migrations are not typical of Bryde's whales, although limited shifts in distribution toward and away from the equator, in winter and summer, have been observed (Best, 1996; Cummings, 1985). Bryde's whales have been only occasionally sighted in the waters off Southern California (Barlow, 2016; Carretta et al., 2010; Jefferson et al., 2014; Smultea, 2012; Smultea et al., 2011), but sightings and acoustic monitoring indicate an increase in the area so that the presence of the species is no longer considered anomalous (Carretta et al., 2017a; Carretta et al., 2019b; Debich et al., 2015a; Kerosky et al., 2012; Smultea, 2014; Smultea et al., 2010; Smultea et al., 2012). The peak in recorded Bryde's whale vocalizations has varied but generally occurs between late July and November in the Southern California portion of the Hawaii-Southern California Training and Testing Study Area (Debich et al., 2015a; Debich et al., 2015b; Kerosky et al., 2012).

4.1.2.3 Population and Abundance

Although there are no data on population trends or current estimate of abundance for Bryde's whale abundance along the U.S. West Coast (Carretta et al., 2019b). The species has not been detected in NMFS surveys off California for over 20 years (Barlow, 2016). Acoustic data suggests that the seasonal presence (summer to early winter) of Bryde’s whale in the Southern California Bight has been increasing over the last decade (Kerosky et al., 2012), which is consistent with aerial surveys around San Clemente Island between August 2006 and September 2010 having encountered five individual Bryde’s whales (Smultea, 2012).

4.1.3 Fin Whale (*Balaenoptera physalus*)

4.1.3.1 Status and Management

The fin whale is listed as depleted under the MMPA and endangered under the ESA throughout its range, but there is no designated critical habitat for this species. Fin whale population structure in the Pacific Ocean is not well known, although there are some hypotheses suggesting a population structure and connectivity across the north Pacific (Archer et al., 2018; Archer et al., 2019). During the 20th century more fin whale were taken by industrialized whaling than any other species (Rocha et al., 2014). In the North Pacific, NMFS recognizes three fin whale stocks: (1) a Northeast Pacific stock in Alaska; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock. Although some fin whales migrate seasonally (Falcone et al., 2011; Mate et al., 2015b; Mate et al., 2016), NMFS does not recognize fin whales from the Northeast Pacific stock as being present in Southern California.

4.1.3.2 Geographic Range and Distribution

The fin whale is found in all the world’s oceans and is the second-largest species of whale (Jefferson et al., 2015). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al., 2002a). This species has been documented from 60° North (N) to 23° N, and those tagged in and around Navy ranges with satellite tracking devices ranged from northern British Columbia, Canada to as far south as Baja California, Mexico (Mate et al., 2018). Fin whales have frequently been recorded in waters within Southern California and are present year-round (Barlow & Forney, 2007; Campbell et al., 2015; Jefferson et al., 2014; Mate et al., 2016, 2017; Mizroch et al., 2009; Rice et al., 2019; Širović et al., 2004; Širović et al., 2015; Širović et al., 2016; Širović et al., 2017; Smultea, 2014; Varga et al., 2018). As demonstrated by satellite tags and discovery tags,[3] fin whales make long-range movements along the entire U.S. West Coast (Falcone et al., 2011; Mate et al., 2015b; Mate et al., 2018; Mizroch et al., 2009). However, photo-identification studies of fin whales off the U.S. West Coast as well as satellite tagging data suggest that not all fin whales undergo long-range seasonal migrations, but instead make short-range seasonal movements in spring and fall (Falcone et al., 2011; Falcone & Schorr, 2011; Mate et al., 2018). Six tags were deployed on fin whales in Southern California in August 2014 (Mate et al., 2015b). The movements of these whales were highly variable, ranging from nearshore waters less than 1 km from the California coast to approximately 232 km offshore, and moving as far north as the Oregon border with California and as far south as Central Baja Mexico (Mate et al., 2015b). Satellite tags deployed on 13 fin whales off Central California in 2016 had only three of those individuals

[3] As a means of data collection starting in the 1930s, discovery tags having a serial number and return address were shot into the blubber of the whale by scientists. If that whale was later harvested by the whaling industry and the tag “discovered” during flensing, it could be sent back to the researchers, providing data on the movement of individual whales.

move into the PMSR for a period of time lasting approximately one day, eight days, and 44 days for each (Mate et al., 2017). Only one fin whale was tagged in 2017, and its tracks remained generally along the continental shelf break in waters off the central California Coast and north of the PMSR, between Santa Cruz and Point Reyes off Monterey, over 42 days of tracking (Mate et al., 2018).

Fin whales are not known to have a specific habitat and are highly adaptable, following prey, typically off the continental shelf (Azzellino et al., 2008; Panigada et al., 2008; Scales et al., 2017). Off the U.S. West Coast, fin whales typically congregate in areas of high productivity, allowing for extended periods of localized residency that are not consistent with the general baleen whale migration model (Mate et al., 2018; Scales et al., 2017).

Based on predictive habitat-based density models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, relatively high densities of fin whales are predicted off Southern California during the summer and fall (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2012a; Becker et al., 2016; Forney et al., 2012). Aggregations of fin whales are present year-round in Southern and central California (Campbell et al., 2015; Douglas et al., 2014; Forney et al., 1995; Forney & Barlow, 1998; Jefferson et al., 2014; Mate et al., 2018; Rice et al., 2019; Scales et al., 2017), although their distribution shows seasonal shifts. In 2005–2006, during a period of cooler ocean temperatures, fin whales were encountered more frequently than during normal years (Peterson et al., 2006). Sightings from year-round surveys off Southern California from 2004 to 2013 show fin whales farther offshore in summer and fall and closer to shore in winter and spring (Campbell et al., 2015; Douglas et al., 2014).

As was done for other species, a scientific review process (Ferguson et al., 2015b) was undertaken to identify BIAs for fin whales occurring along the U.S. West Coast. Survey and acoustic data indicates that fin whale distributions shift both seasonally as well as annually (Calambokidis et al., 2015; Douglas et al., 2014; Jefferson et al., 2014; Peterson et al., 2006; Širović et al., 2015; Širović et al., 2017). Definitive areas of biological importance for fin whales have not yet been identified due to poor knowledge of fin whale population structure and biases inherent in different sampling methods that revealed high concentrations of fin whales in both coastal and offshore regions (Calambokidis et al., 2015).

4.1.3.3 Population and Abundance

For the U.S. West Coast, Moore and Barlow (2011) predict continued increases in fin whale numbers over the next decade and suggest that fin whale densities are reaching “current ecosystem limits.” Based on a comparison of sighting records from the 1950s to 2012, Smultea and Jefferson (2014) also showed an increase in the relative abundance of fin whales inhabiting Southern California. Širović et al. (2015) used passive acoustic monitoring of fin whale calls to estimate the spatial and seasonal distribution of fin whales in the Southern California Bight. An increase in the number of calls detected between 2006 and 2012 also suggests that the population of fin whales off the U.S. West Coast may be increasing. Based on 18 aerial surveys conducted between 2008 and 2013, fin whales were one of the most common large whales in the SOCAL Range Complex, which is adjacent to the southern boundary of the PMSR Study Area (Jefferson et al., 2014). Increasing numbers of fin whales documented in coastal waters between Vancouver Island and Washington State may reflect recovery of populations in the North Pacific (Towers et al., 2018). These findings, and the trend for an increase in population, appear consistent with the highest-yet abundances of fin whales in the 2014 NMFS survey of the U.S. West Coast (Barlow, 2016).

4.1.4 GRAY WHALE (*ESCHRICHTIUS ROBUSTUS*)

4.1.4.1 Status and Management

There are two north Pacific populations of gray whales: the Western subpopulation and the Eastern subpopulation designated in the Pacific SAR (Carretta et al., 2017a; Cooke, 2019; Muto et al., 2017; Weller et al., 2013). Both populations (stocks) could be present in the PMSR Study Area during their northward and southward migration (Calambokidis et al., 2015; Carretta et al., 2017a; Carretta et al., 2018b; Cooke et al., 2015; Sumich & Show, 2011). The current stock structure for gray whales in the Pacific has been in the process of being re-examined for a number of years; that work has been scheduled for completion in 2018–2019 (Carretta et al., 2018b).

The Western subpopulation, which was previously also known as the western north Pacific or the Korean-Okhotsk population, has been designated the Western North Pacific stock and is considered depleted (Carretta et al., 2017a; Cooke, 2019; Cooke et al., 2015; Weller et al., 2002; Weller et al., 2013). This subpopulation is endangered and should be very few in number in the Study Area, given the small population and their known wintering areas in waters off Russia and Asia (Moore & Weller, 2013; Weller et al., 2013). Recent analysis of the data available for 2005 through 2016 estimates the combined Sakhalin Island and Kamchatka populations are increasing (Cooke, 2019). There has been no designated critical habitat for this species.

The Eastern North Pacific subpopulation (also known as the California-Chukchi population) has recovered from whaling exploitation and was delisted under the ESA in 1994 (Swartz et al., 2006). This population has been designated the Eastern North Pacific stock and is not considered depleted (Carretta et al., 2017a).

A few hundred gray whales that feed along the Pacific coast between southeastern Alaska and Northern California throughout the summer and fall are known as the Pacific Coast Feeding Group (Calambokidis et al., 2002; Carretta et al., 2017a; Mate et al., 2013; Weller et al., 2013). The group has been identified as far north as Kodiak Island, Alaska (Gosho et al., 2011) and has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al., 2017a; Weller et al., 2012; Weller et al., 2013). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is demographically distinct from the Eastern North Pacific population (Calambokidis et al., 2010; Frasier et al., 2011; Mate et al., 2010). In 2012–2013, the Navy funded a satellite tracking study of Pacific Coast Feeding Group gray whales (Mate, 2013). Tags were attached to 11 gray whales near Crescent City, California in fall 2012. Good track histories were received from 9 of the 11 tags, which confirmed an exclusive nearshore (< 19 km) distribution and movement along the Northern California, Oregon, and Washington coasts (Mate, 2013). Although the duration of the tags was limited, none of the Pacific Coast Feeding Group whales moved south beyond Northern California, and so individuals from this group are not expected to be present in the PMSR Study Area. The Pacific Coast Feeding Group is not currently managed as a distinct stock in NMFS SARs, but this may change in the future if new information supports such a designation (Carretta et al., 2015; Carretta et al., 2018b).

4.1.4.2 Geographic Range and Distribution

Most of the science dealing with gray whale migrations and distribution is not specific to either of the two recognized gray whale sub-populations, but where possible that distinction has been specified in the following sections.

Gray whales of the Western North Pacific stock primarily occur in shallow waters over the U.S. West Coast, Russian, and Asian continental shelves and are considered to be one of the most coastal of the great whales (Jefferson et al., 2015; Jones & Swartz, 2009). Feeding grounds for the population are the Okhotsk Sea off Sakhalin Island, Russia, and in the southeastern Kamchatka Peninsula (in the southwestern Bering Sea) in nearshore waters generally less than 225 ft. deep (Jones & Swartz, 2009; Weller & Brownell, 2012). The breeding grounds consist of subtropical lagoons in Baja California, Mexico, and suspected wintering areas in southeast Asia (Alter et al., 2009; Jones & Swartz, 2009; Mate et al., 2015a; Urban-Ramirez et al., 2003; Weller et al., 2012). In surveys of the northern feeding grounds, the largest number of Western North Pacific gray whales was observed in late August and early September (Meier et al., 2007), suggesting those few gray whales that may migrate down the U.S. West Coast will not be in PMSR or California in general during those months.

Whales of the Eastern North Pacific stock primarily occur in shallow waters over the continental shelf of North America and Mexico and are considered to be one of the most coastal of the great whales (Jefferson et al., 2015; Jones & Swartz, 2009). Feeding grounds are generally less than 225 ft. deep (Jones & Swartz, 2009), and the main feeding areas are located in the Chukchi Sea, Bering Sea, Gulf of Alaska, the Pacific Northwest, and Northern California. The main breeding grounds consist of subtropical lagoons in Baja California, Mexico (Alter et al., 2009; Jones & Swartz, 2009; Urban-Ramirez et al., 2003).

Some gray whales make the longest annual migration of any mammal (15,000–20,000 km roundtrip; (Jefferson et al., 2015; Jones & Swartz, 2009; Mate et al., 2010; Mate, 2013; Mate & Urban-Ramirez, 2003; Mate et al., 2015a; Muir et al., 2015; Weller et al., 2002; Weller et al., 2012; Weller et al., 2013)). Gray whales migrate along the Pacific coast twice a year between October and July (Calambokidis et al., 2015) and are generally only present in the PMSR Study Area while migrating through those waters. Although they generally remain mostly over the shelf during migration, some gray whales may be found in more offshore waters to the west of San Clemente Island and the Channel Islands (Calambokidis et al., 2015; Guazzo et al., 2019; Smultea, 2014; Sumich & Show, 2011).

The timing of the October–July gray whale migrations that pass through the PMSR Study Area can be loosely categorized into three phases (Calambokidis et al., 2015; Rugh et al., 2008). Calambokidis et al. (2015) note these migration phases are not distinct, the timing for a phase may vary based on environmental variables, and a migration phase typically begins with a rapid increase in migrating whales, followed by moderate numbers over a period of weeks, and then slowly tapering off. A southward migration from summer feeding areas in the Chukchi Sea, Bering Sea, Gulf of Alaska, and the Pacific Northwest begins in the fall (Calambokidis et al., 2015; Mate et al., 2013; Mate et al., 2015a). This Southbound Phase includes all age classes as they migrate primarily to the nearshore waters and lagoons of Baja, Mexico as a destination. During this southward migration from October through March, the whales generally are within 10 km of the coast (Calambokidis et al., 2015), although there are documented exceptions where migrating gray whales have bypassed the coast by crossing sections of the open ocean (Mate, 2013; Mate & Urban-Ramirez, 2003; Mate et al., 2015a; Rice & Wolman, 1971).

In the PMSR Study Area, migrating gray whales may transit much farther offshore from the mainland as some are routinely seen offshore the Channel Islands, including to the west of San Nicolas and San Clemente Islands (Aquatic Mammals, 2015; Ferguson et al., 2015b; Guazzo et al., 2019; Sumich, 1984; Van Parijs et al., 2015). The northward migration for the Eastern North Pacific stock to the feeding grounds in Arctic waters, Alaska, the Pacific Northwest, and Northern California occurs in two phases (Calambokidis et al., 2015). Northbound Phase A consists mainly of adults and juveniles that lead the beginning of the north-bound migration from late January through July, peaking in April through July. Newly pregnant females go first to maximize feeding time, followed by adult females and males, then juveniles (Jones & Swartz, 2009). The Northbound Phase B consists primarily of cow-calf pairs that begin their northward migration later (March to July) remaining on the reproductive grounds longer to allow calves to strengthen and rapidly increase in size before the northward migration (Jones & Swartz, 2009; Urban-Ramirez et al., 2003).

The gray whale migration area (south of Point Conception), the migration corridors (north of Point Conception), the potential presence buffer area, and the months (October through July) these sections of the Pacific coastal waters are cumulatively in use were identified by Calambokidis et al. (2015) as important for gray whales. A portion of the gray whale migration area and routes off Southern California pass through the waters of the PMSR (Figure 4-2). It is important to note that these designated gray migration corridors extend along the entire length of the North America U.S. EEZ in the Pacific and exclude the continuation of those migration corridors outside of the U.S. EEZ that are equally as important (such the migration corridor segments continuing into Russian, Canadian, and Mexican waters (see Aquatic Mammals (2015); (Ferguson et al., 2015a); Ferguson et al. (2015b); Van Parijs et al. (2015) regarding the limits to the areas identified).

Unlike the remainder of the U.S. West Coast areas where phases of migration occur within specific distances from the shore, in waters south of Point Conception the entire migration corridor is used during each migration phase (Calambokidis et al., 2015). The following bullets summarize the applicable seasons for the gray whale migration (as detailed in Calambokidis et al. (2015)) along the U.S. West Coast, including the PMSR Study Area:

- Southbound corridor – October–March
- Northbound Phase A corridor – January–July; peaking April–July
- Northbound Phase B corridor – March–July
- Potential presence area – October–July

These identified migratory months presented by Calambokidis et al. (2015) characterize the majority of a gray whale migration phase start from feeding locations in northern waters or from breeding locations in Mexico. For example, the first whales departing northern waters (on the Southbound Phase) have been documented as showing up off Granite Canyon, California (the shore-based counting location south of Carmel) in early December for decades (Durban et al., 2017; Laake et al., 2012). A year-long (2013–2014) survey effort in the nearshore waters off San Diego, south of the PMSR Study Area encountered gray whales in January, February, and in the April–June timeframe (Graham & Saunders, 2015). In December and April each year, gray whales are the third-most encountered large cetacean in Southern California (Smultea, 2014). Sightings from a shore based station and acoustic recordings during seven migration seasons (2008−2009 to 2014−2015) detected whales migrating southbound off Southern California from the first of December (at the start of data collection) and overlapping with the return migration northward peaking in March and the end of April/start of May, but with some individuals still detected in June when the data collection ended (Guazzo et al., 2019). Additionally, the National Oceanic and Atmospheric Administration's website containing data records for marine mammals from the Cetacean Density and Distribution Mapping Working Group (see Ferguson et al. (2015b) and National Oceanic and Atmospheric Administration (2019)) shows the recorded presence of gray whales in the Southern California Bight in every month of the year except June, October, and November, but other area-specific investigations have cumulatively documented gray whale presence in all but October (Durban et al., 2017; Guazzo et al., 2017; Hildebrand et al., 2018; Soldevilla et al., 2006).

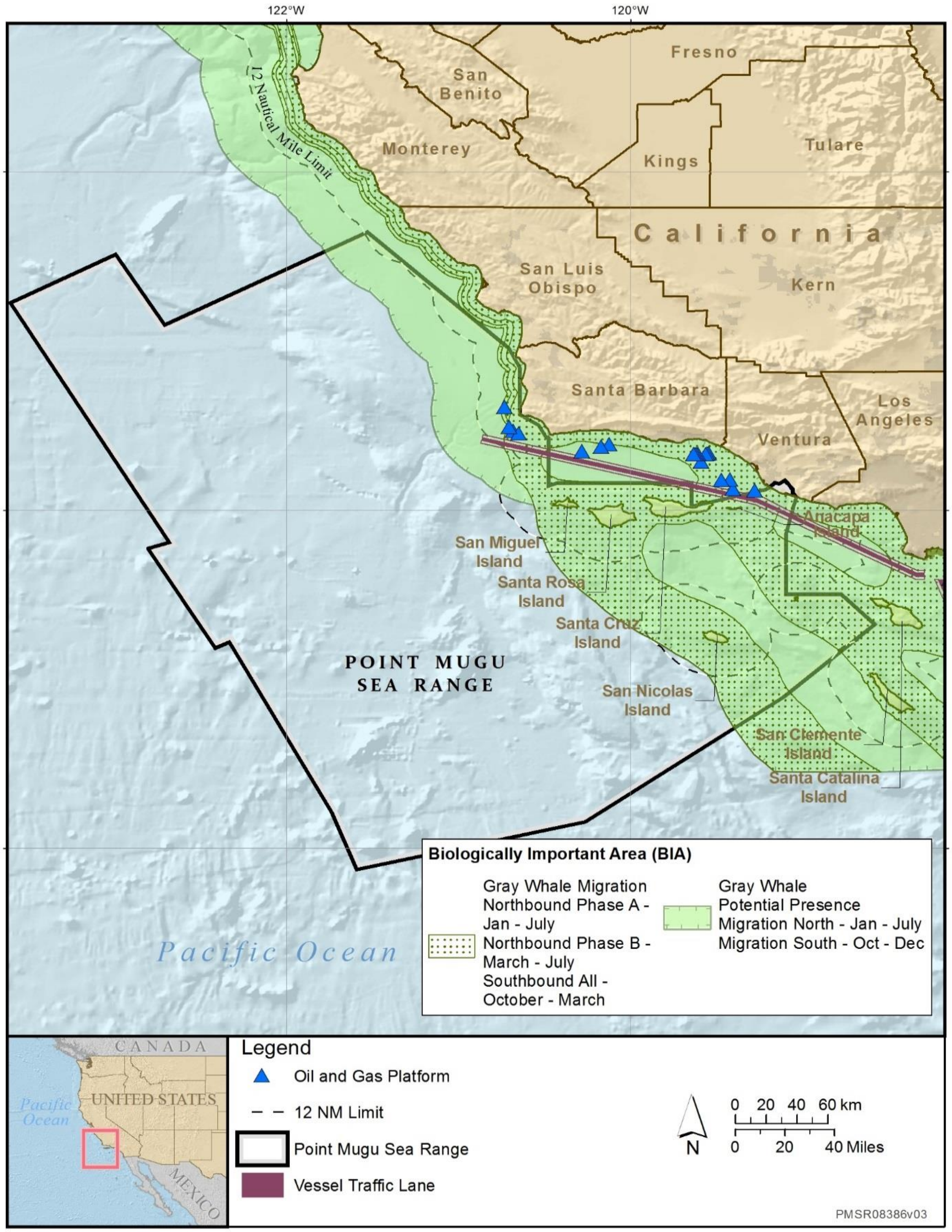

Figure 4-2: Gray Whale Biologically Important Area Migration Corridors Identified in the Vicinity of the PMSR Study Area (per Calambokidis et al., 2015)

These gray whales, which are present in the PMSR area outside the normal or main migration period patterns, are likely transient non-breeding juveniles and not a significant portion of any gray whale the population. Therefore, and for purposes of the analysis presented in this document, the Navy assumes that small numbers of gray whales may be present year round and that larger numbers would be migrating through the PMSR Study Area in the winter and spring.

Recordings from a hydrophone array deployed offshore of central California (near Monterey) show that gray whales are acoustically active while migrating and that this acoustic behavior and their swimming behavior during migration changes on daily and seasonal time scales (Guazzo et al., 2017). Mate and Urban-Ramirez (2003) reported an average gray whale speed of approximately 5.2 kilometers per hour (km/hr) based on a tagged migrating animal. Subsequent satellite tag data from seven additional gray whales provided by Mate et al. (2015a) showed migration swim speeds ranged from 0.6 km/hr. to 6.6 km/hr, which remains within the average previously suggested. At this average swim speed, and based on data in Sumich and Show (2011) for migrating gray whales in the PMSR Study Area, it should take approximately 58 hours for a gray whale to cross through the PMSR Study Area (approximately 300 km). It is assumed they will do this twice a year during their annual southbound and northbound migration legs.

Most of the Eastern North Pacific stock summers in the shallow waters of the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Mate et al., 2010; Weller et al., 2013), except for approximately 200 individuals collectively known as the "Pacific Coast Feeding Group" (Calambokidis et al., 2002; Mate et al., 2013; Weller et al., 2013). The Pacific Coast Feeding Group is not currently treated as a distinct stock or population segment (Carretta et al., 2015; Carretta et al., 2017a; Carretta et al., 2018b; Mate et al., 2010). Eastern North Pacific Gray Whales and some Western North Pacific gray whales return to locations off Mexico in the fall to winter in sheltered warmer waters (Carretta et al., 2018b; Mate et al., 2010; Weller et al., 2013).

4.1.4.3 Population and Abundance

The Western North Pacific stock of gray whales was once considered extinct, but now small numbers are known to exist (Carretta et al., 2017a; Carretta et al., 2018b; Cooke et al., 2015; International Union for Conservation of Nature (IUCN), 2012; International Whaling Commission, 2014; Mate et al., 2015a; Nakamura et al., 2017; Weller et al., 2013). The combined Sakhalin Island and Kamchatka populations are estimated to be increasing from 2005 through 2016 at an average rate between 2 and 4 percent annually (Cooke, 2019; Cooke et al., 2015). A recent increase in the occurrence of gray whales off Japan (Nakamura et al., 2017), is also consistent with a positive population growth for Western North Pacific gray whales. At least 12 members of the Western North Pacific stock have been detected in waters off the Pacific Northwest (Mate et al., 2013; Weller & Brownell, 2012). NMFS reported that 18 Western North Pacific gray whales have been identified in waters far enough south to have passed through Southern California waters (National Marine Fisheries Service, 2014b), and although some gray whales have been shown to make mid-ocean migrations (Mate et al., 2015a), the Navy assumes migration to and from Southern California would include passage through the PMSR Study Area for both gray whale subpopulations.

The eastern population has increased over several decades despite the 1999 and 2000 Unusual Mortality Events (UMEs) in which an unusually large number of gray whales stranded along the coast, from Mexico to Alaska (Gulland et al., 2005), when many scientists thought the population had reached "carrying capacity" (Carretta et al., 2017a; Carretta et al., 2018b; Durban et al., 2016). Monitoring over the last 30 years has provided data that have indicated the Eastern North Pacific population and stock is within range of its optimum sustainable population, which is consistent with a population approaching the carrying capacity of the environment (Carretta et al., 2017a). Starting in January of 2019, an elevated number of gray whale strandings occurred along the west coast of North America from Mexico through Alaska, which prompted NMFS to declare those strandings an UME (National Marine Fisheries Service, 2019c; National Oceanic and Atmospheric Administration, 2020). From the start of the UME in January 2019 and as of February 2020, the strandings totaled 236 known individual gray whales along their migratory corridor (National Oceanic and Atmospheric Administration, 2020). Preliminary findings for several of the whales indicated signs of emaciation although the findings were not consistent across the subset of the whales examined and additional future research will be needed to better identify factors resulting in the UME (National Marine Fisheries Service, 2019c; National Oceanic and Atmospheric Administration, 2020).

4.1.5 HUMPBACK WHALE (*MEGAPTERA NOVAEANGLIAE*)

4.1.5.1 Status and Management

Humpback whales that are seasonally present in the PMSR Study Area are from two DPSs given they represent populations that are both discrete from other conspecific populations and significant to the species of humpback whales to which they belong (National Marine Fisheries Service, 2016a). These DPSs are based on animals identified in breeding areas in Mexico, and Central America (Bettridge et al., 2015; Calambokidis et al., 2017; Carretta et al., 2017a; Carretta et al., 2018a; Muto et al., 2017; National Marine Fisheries Service, 2016b; Wade et al., 2016). Presentation of information is provided in the following subsections for the Mexico DPS and the Central America DPS, which are both seasonally present in the PMSR Study Area. Humpback whales of the Mexico DPS are listed as threatened, and those from the Central America DPS are listed as endangered under the ESA (National Marine Fisheries Service, 2016a). Critical habitat has not been designated for any ESA-listed humpback whales.

In the PMSR Study Area, the California, Oregon, Washington stock of humpback whales is assumed to consist of only animals from the Mexico DPS and the Central America DPS (National Marine Fisheries Service, 2016c, 2016d). The stock is considered depleted under the MMPA (Carretta et al., 2017a; Carretta et al., 2017b; Carretta et al., 2018b; National Marine Fisheries Service, 2016a, 2016d).

4.1.5.2 Geographic Range and Distribution

The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75–80 degrees Fahrenheit [°F] or 24–28 degrees Celsius [°C]) and relatively shallow, low-relief ocean bottom in protected areas, nearshore, or created by islands or reefs (Clapham, 2000; Craig & Herman, 2000; Smultea, 1994). In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper, more offshore waters (Ersts & Rosenbaum, 2003; Smultea, 1994). Breeding and calving areas for the Mexico DPS and for the Central America DPS are both located far to the south of the PMSR Study Area in waters off Mexico and Central America.

Off the U.S. West Coast, humpback whales are more abundant in shelf and slope waters (<2,000 m deep) and are often associated with areas of high productivity (Becker et al., 2010; Becker et al., 2012a; Becker et al., 2016; Campbell et al., 2015; Forney et al., 2012; Redfern et al., 2013). While most humpback whales migrate, data has demonstrated that humpback whales occur year-round off Southern California (Campbell et al., 2015; Dohl et al., 1983; Forney & Barlow, 1998).

Humpback migrations are complex and cover long distances (Barlow et al., 2011; Calambokidis et al., 2009b; Calambokidis et al., 2017; Lagerquist et al., 2008; Mate et al., 1998; Mate et al., 2017). Although the majority of humpback whale sightings are in nearshore and continental shelf waters, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al., 2001; Clapham & Mattila, 1990; Clapham, 2000; Mate et al., 1998). Humpback whales migrating from breeding grounds in Mexico and Central America on their way to feeding grounds at higher latitudes may cross the PMSR Study Area farther offshore (Lagerquist et al., 2008; Mate et al., 2017). Some of the California, Oregon, and Washington stock of humpback whales is expected to use portions of the waters within the PMSR Study Area as a summer feeding ground (Calambokidis et al., 2015). Peak occurrence during migration occurs in the PMSR Study Area from December through June (Calambokidis et al., 2015). In quarterly surveys undertaken in the 10-year period between 2004 and 2013 off Southern California, humpback whales were generally encountered in coastal and shelf waters with the largest concentration occurring in relatively shallow waters, north of Point Conception (Campbell et al., 2015). During winter and spring, a substantially greater proportion of the humpback whale population is found farther offshore than during the summer, with the majority of the population (in all seasons) found north of the Channel Islands (Becker et al., 2017; Calambokidis et al., 2017; Campbell et al., 2015; Forney & Barlow, 1998). Based on aerial survey data collected between 2008 and 2012 in the SOCAL Range Complex, Smultea and Jefferson (2014) determined that humpback whales ranked eighth in relative occurrence of cetaceans and concluded that this species has clearly increased their representation in the Navy's SOCAL Range Complex over the last several decades.

There are two biologically important humpback whale feeding areas that have been identified as overlapping a portion of the PMSR Study Area (Calambokidis et al., 2015). In their designation, these feeding areas (Figure 4-3) were identified as the Morro Bay to Point Sal feeding area (in use from April to November) and the Santa Barbara Channel–San Miguel feeding area (in use from March to September) (Calambokidis et al., 2015).

On October 9, 2019, in the Federal Register (84 FR 54378), NMFS issued a proposed rule to designate critical habitat for the humpback whales within the U.S. EEZ for the endangered Western North Pacific DPS and Central America DPS, and the threatened Mexico DPS pursuant to section 4 of the ESA. In the proposal, NMFS considered 19 Regions/Units of habitat as critical habitat for the listed humpback whale DPSs. These 19 areas include almost all coastal waters off California, Oregon, Washington, and Alaska in the Pacific. The NMFS designated, named and numbered habitat "regions/units" are shown on Figure 4-4. As shown on that figure, there is overlap between the PMSR Study Area and portions of the habitat designated Regions/Units 17, 18, and 19.

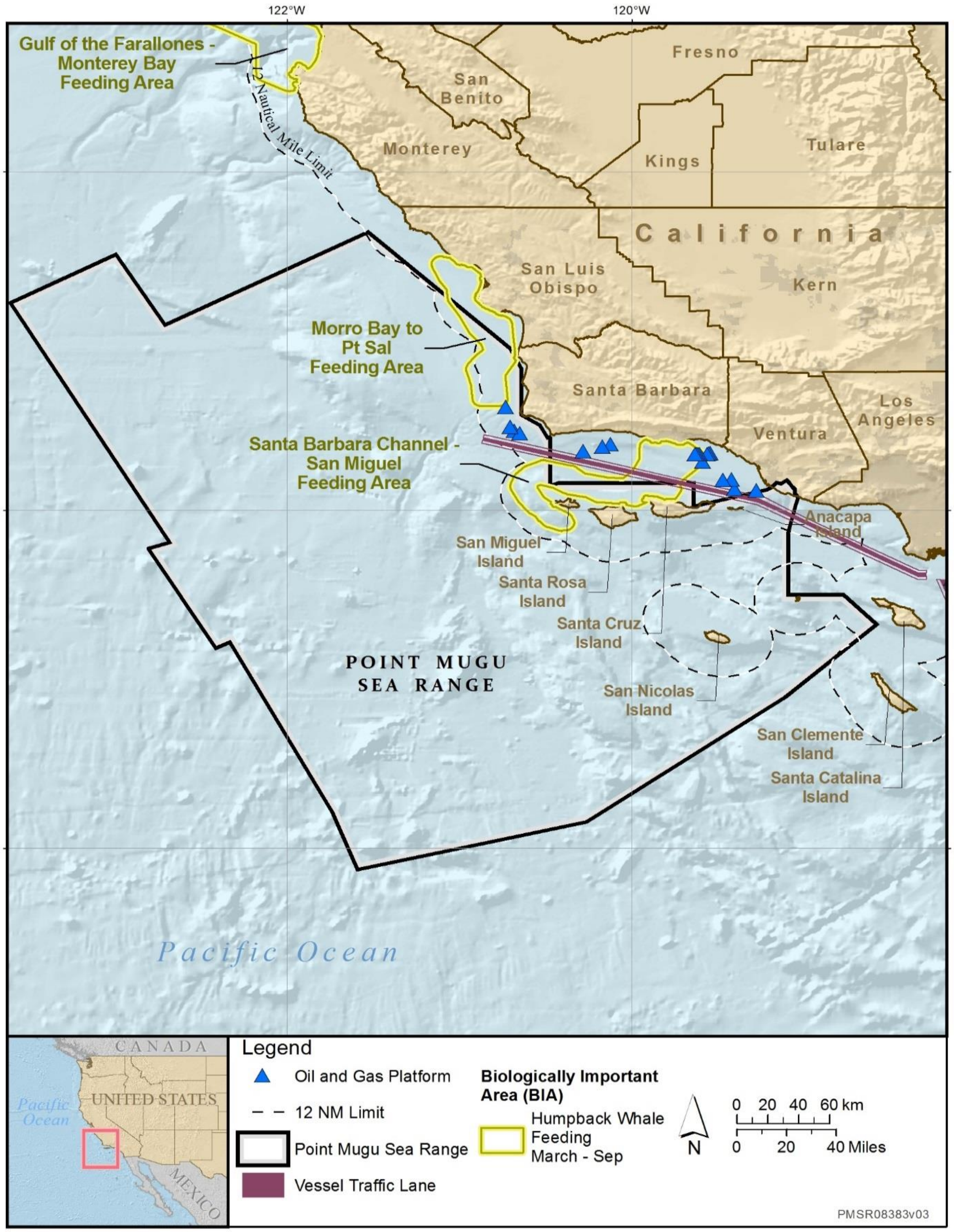

Figure 4-3: Humpback Whale Biologically Important Feeding Areas Identified in the Vicinity of the PMSR Study Area (per Calambokidis et al. 2015)

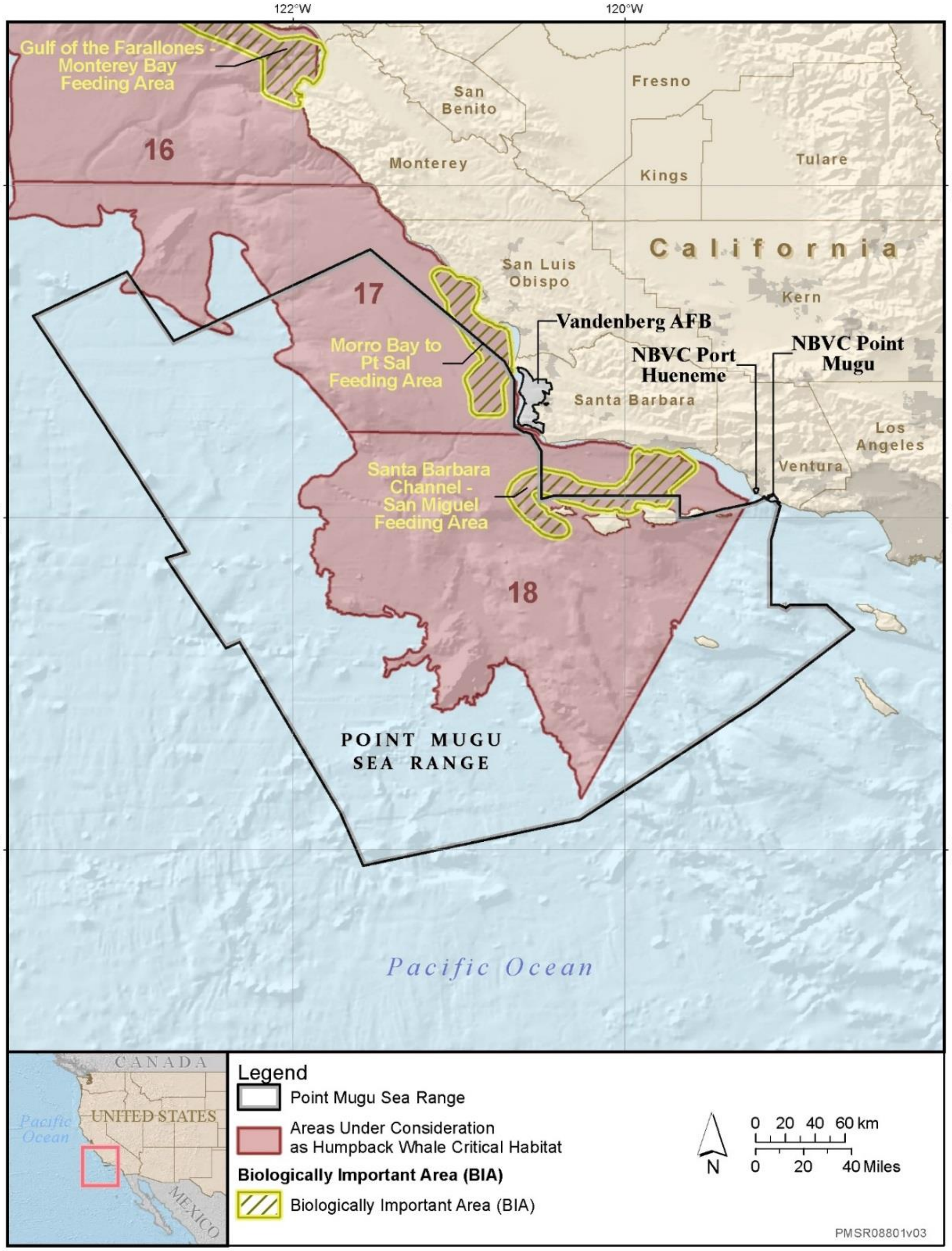

Figure 4-4: Areas Under Consideration by NMFS as Humpback Whale Critical Habitat within and in the Vicinity of the PMSR Study Area and in Relationship to the Previously Designated Humpback Whale Biologically Important Areas

Region/Unit 17 has been referred to by NMFS as the "Central California Coast Area," which covers an area of 6,697 NM^2 extending from 36° 00' to 34° 30' north latitude. Within those north and south boundaries, Region/Unit 19 begins at the 30 m depth contour out to the 3,700 m depth contour. This region's area includes waters off of southern Monterey county, San Luis Obispo, and Santa Barbara counties. This is the northernmost portion of proposed humpback whale critical habitat overlapping with the PMSR and includes the Morro Bay to Point Sal feeding area described above. This region/unit of habitat is characterized by NMFS as having a very high conservation value (84 FR 54378).

Region/Unit 18 has been referred to by NMFS as the "Channel Islands Area," which covers an area of 9,799 NM^2 extending from 34° 30' north latitude, south to a boundary line seaward to the southeast from Oxnard, CA. This region's area includes waters off of Santa Barbara and Ventura counties. Within those boundaries extending from the coast, Region/Unit 19 begins at the 50 m depth contour and includes the waters out to the 3,700 m depth contour. Coastal waters managed by the Navy[4], as addressed within the NBVC Point Mugu INRMP and SNI INRMP, are not included in the proposed designation as these areas were determined by NMFS to be ineligible for designation as critical habitat under section 4(a)(3)(B)(i) of the ESA (84 FR 54378). The Navy does not anticipate national security impacts resulting from a critical habitat destination in the portion of Region/Unit 18 that overlaps with the PMSR. This region/unit of habitat is characterized by NMFS as having a high conservation value (84 FR 54378).

Region/Unit 19 has been referred to by NMFS as the "California South Coast Area," which covers 12,966 NM^2 extending from the southern boundary of Region 18 (at Oxnard, CA), south to the border between the U.S. and Mexico EEZs. Within those north and south boundaries, Region/Unit 19 begins at the 50 m depth contour out to the 3,700 m depth contour. This unit includes waters off of Los Angeles, Orange, and San Diego counties. This region/unit of habitat is characterized by NMFS as having a low conservation value and therefore exclude from further consideration as critical habitat for both the Mexico DPS and the Central America DPS (84 FR 54378). The Navy has also concluded that designation of Region/Unit 19 as critical habitat could lead to requirements for additional mitigations (avoidance, limitations, etc.) that could hinder Navy activities, and thereby impact military readiness and national security and therefore requested that exclusion of Region/Unit 19 from any critical habitat designation. NMFS agreed that designation of Region/Unit 19 would likely have national security impacts that outweigh the benefits of designating this low conservation value area and so based on consideration of national security and economic impacts, NMFS has excluded this area from further consideration as critical habitat (84 FR 54378).

4.1.5.3 Population and Abundance

Although recent estimates show variable trends in the number of humpback whales along the U.S. West Coast, the overall trend is consistent with a growth rate of 6–7 percent for the California, Oregon, and Washington stock and appears consistent with the highest-yet abundance estimates of humpback whales based on a recent 2014 survey (Barlow, 2016; Calambokidis et al., 2017; Carretta et al., 2017a;

[4] The relevant areas addressed under the NBVC Point Mugu INRMP are submerged lands and resources 3 NM seaward from Point Mugu and a zone that extends 0.25 NM offshore around San Miguel and Prince Islands. Relevant areas within the footprint of the SNI INRMP are the waters surrounding SNI and Begg Rock within the 300-foot (91 m) depth contour or 1 NM from shore; whichever is greater.

Carretta et al., 2018b; Smultea, 2014). In 2014, 2015, and 2016, humpback whales were more commonly sighted in coastal waters of Santa Monica Bay, and from Long Beach south to waters off Dana Point (Calambokidis et al., 2017), which are locations farther south and nearer to shore than the waters within the PMSR. For the DPSs in Mexico and Central America, photo-identification data collected between 2004 and 2006 are the main basis for the estimates specific to those populations (Bettridge et al., 2015; National Marine Fisheries Service, 2016a; Wade et al., 2016). However, because the data are greater than eight years old, they do not provide reliable estimates of current abundance for the individual DPSs (Carretta et al., 2018b). There are no population trend data for the Mexico DPS or the Central America DPS since there have been no subsequent data collected for comparison (Bettridge et al., 2015; Carretta et al., 2018b; National Marine Fisheries Service, 2016a; Wade et al., 2016).

4.1.6 MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*)

4.1.6.1 Status and Management

The minke whale is not listed under the ESA. Minke whales in the PMSR Study Area are part of the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.6.2 Geographic Range and Distribution

The minke whale's range is known to extend from open ocean and coastal waters to subarctic and arctic waters (Kuker et al., 2005).

Minke whales occur year-round off California (Forney et al., 1995; Forney & Barlow, 1998), mainly in nearshore areas (Barlow & Forney, 2007; Hamilton et al., 2009b; Smultea, 2014). During systematic ship surveys conducted in summer and fall off the U.S. West Coast between 1991 and 2014, there were 28 minke whale sightings (Barlow, 2016). During year-round aerial surveys conducted in the SOCAL Range Complex from 2008 through 2013 minke whales were sighted 19 times (Jefferson et al., 2014).

The migration paths of the minke whale include travel between breeding and feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al., 2015; Towers et al., 2013). Minke whales generally participate in annual migrations between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Kuker et al., 2005). There is insufficient information to determine if the year-round low numbers of minke whales detected in Southern California suggest there may be resident animals, although acoustic monitoring data indicating only occasional minke "boing" presence in spring and late fall (Debich et al., 2015a; Hildebrand et al., 2012) would be consistent with a general seasonal migration pattern.

4.1.6.3 Population and Abundance

There are no data on population trends for minke whales in the California, Oregon, and Washington stock (Carretta et al., 2017a; Carretta et al., 2018a).

4.1.7 SEI WHALE (*BALAENOPTERA BOREALIS*)

4.1.7.1 Status and Management

The sei 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. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (National

Marine Fisheries Service, 2011). Sei whales along the U.S. West Coast are assigned to the Eastern North Pacific stock within the U.S. EEZ (Carretta et al., 2017a; Carretta et al., 2018a, 2018b).

4.1.7.2 Geographic Range and Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found in warm tropical waters. Sei whales are also encountered during the summer off California and the North America coast from approximately the latitude of the Mexican border to as far north as Vancouver Island, Canada (Horwood, 2009; Masaki, 1976, 1977; Smultea et al., 2010). Although sei whales have been observed south of 20° N in the winter (Fulling et al., 2011; Horwood, 2009; Horwood, 1987), they are considered absent or at very low densities in most equatorial areas. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood, 1987; Perry et al., 1999).

Sei whales are distributed in offshore waters in the PMSR Study Area (Carretta et al., 2017a). A total of 10 sei whale sightings were made during systematic ship surveys conducted off the U.S. West Coast in summer and fall between 1991 and 2008 (Barlow, 2010), with an additional 14 groups sighted during a 2014 survey (Barlow, 2016). Sei whales were not seen in the larger Southern California Bight during 15 aerial surveys conducted from 2008 to 2012 (Smultea et al., 2014) or during any systematic ship surveys conducted by NMFS (Barlow, 2010, 2016).

4.1.7.3 Population and Abundance

NMFS has determined that an assessment of the sei whale population trend will likely require additional survey data and reanalysis of all datasets using comparable methods (Carretta et al., 2017b). There are no data on Eastern North Pacific sei whale trends in abundance (Carretta et al., 2018b).

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

4.1.8.1 Status and Management

Baird's beaked whale is not listed under the ESA. Baird's beaked whale stocks are defined for the two separate areas within Pacific U.S. waters where they are found: (1) Alaska; and (2) California, Oregon, and Washington (Carretta et al., 2010; Carretta et al., 2018a).

4.1.8.2 Geographic Range and Distribution

Baird's beaked whale occurs mainly in deep waters over the continental slope, near oceanic seamounts, and areas with submarine escarpments, although they may be seen close to shore where deep water approaches the coast (Jefferson et al., 2008; Kasuya, 2009). This species is generally found throughout the colder waters of the North Pacific, ranging from off Baja California, Mexico, to the Aleutian Islands of Alaska (Jefferson et al., 2008; MacLeod & D'Amico, 2006).

The continental shelf margins from the California coast to 125° W longitude have been identified as key areas for beaked whales (MacLeod & D'Amico, 2006). Baird's beaked whale is found mainly north of 28° N in the eastern Pacific (Kasuya & Miyashita, 1997; Reeves et al., 2003). Along the west coast of North America, Baird's beaked whales are seen primarily along the continental slope, from late spring to early fall (Carretta et al., 2010; Green et al., 1992; Hamilton et al., 2009b). Baird's beaked whales are sighted less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al., 2010). Based on habitat models developed using 1991–2008 survey data collected off the west coast of North America during summer and fall, Becker et al. (2012b) found that encounters of Baird's beaked whale increased in waters near the 2,000 m isobath. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al., 2009; Forney et al., 2012). During ship surveys conducted quarterly off Southern California from 2004 to 2008, there was a single sighting of a group of 20 Baird's beaked whales near the shelf break during a summer survey (Douglas et al., 2014). Baird's beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 to 2012 (Smultea, 2014).

Although it is unknown if the species migrates, Baird's beaked whales in the western north Pacific are known to move between waters of depths ranging from 1,000 to 3,000 m, where fish that live on or near the bottom of the ocean are abundant (Ohizumi et al., 2003). Data from a satellite tagged Baird's beaked whale off Southern California recently documented movement north along the shelf-edge for more than 400 NM over a six and one-half day period (Schorr et. al., Unpublished).

4.1.8.3 Population and Abundance

A trend-based analysis of data from line transect surveys conducted off the U.S West Coast between 1991 and 2014 yielded an abundance estimate of 2,697 (coefficient of variation = 0.60) Baird's beaked whales and an indication that the population has remained stable or increased slightly (Carretta et al., 2017a; Moore & Barlow, 2017).

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

4.1.9.1 Status and Management

Blainville's beaked whale is not listed under the ESA. Due to the difficulty in distinguishing different *Mesoplodon* species from one another at sea during visual surveys, the United States management unit is usually defined to include all *Mesoplodon* species that occur in an area. This is the case in the PMSR Study Area, where the six species of *Mesoplodon* beaked whales present along the U.S. West Coast is a single stock for all *Mesoplodon* in the California/Oregon/Washington region waters, including Blainville's beaked whale (Carretta et al., 2015; Carretta et al., 2018a).

4.1.9.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (Jefferson et al., 2008; MacLeod & Mitchell, 2006). They are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al., 2005; MacLeod & Mitchell, 2006; Mead, 1989).

There are a handful of known records of Blainville's beaked whale from the coast of California and Baja California, Mexico, but the species does not appear to be common in the PMSR Study Area (Hamilton et al., 2009b; Mead, 1989; Pitman et al., 1988). *Mesoplodon* beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea, 2014).

4.1.9.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent survey in 2014 (Barlow, 2016), and a new analysis incorporating information from all surveys between 1991 and 2014, suggests an increasing abundance for the U.S.

West Coast trend over that time, which is a reversal of the previously reported population decline (Carretta et al., 2017b; Moore & Barlow, 2017).

4.1.10 BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

4.1.10.1 Status and Management

The common bottlenose dolphin is not listed under the ESA. The bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks, two of which occur in the PMSR Study Area—the California Coastal stock; and the California, Oregon and Washington Offshore stock (Carretta et al., 2017a; Carretta et al., 2018a).

4.1.10.2 Geographic Range and Distribution

Common bottlenose dolphins typically are found in coastal and continental shelf waters of tropical and temperate regions of the world (Jefferson et al., 2008; Wells et al., 2009); (Baird, 2013a; Baird et al., 2003; Baird et al., 2015; Barlow, 2006; Barlow et al., 2008; Becker et al., 2012b; Bradford et al., 2013; Forney et al., 2015; Maldini, 2003; Maldini et al., 2005; Martien et al., 2012; Mobley et al., 2000; Richie et al., 2012; Shallenberger, 1981; Shannon et al., 2016).

Common bottlenose dolphins are known to occur year round in both coastal and offshore waters of Monterey Bay, Santa Monica Bay, Anaheim Bay, San Diego Bay, and San Clemente Island, California (Bearzi, 2005a, 2005b; Bearzi et al., 2009; Carretta et al., 2000; Graham & Saunders, 2015; Henkel & Harvey, 2008; Naval Facilities Engineering Command Southwest, 2017). The dolphins in the nearshore waters of Southern California differ somewhat from other coastal populations of this species in distribution, site fidelity, and pod size (Bearzi, 2005a, 2005b; Carretta et al., 2017a; Defran & Weller, 1999; Defran et al., 2015).

During surveys off California, offshore common bottlenose dolphins were generally found at distances greater than 1.9 miles from the coast and throughout the waters of Southern California (Barlow & Forney, 2007; Barlow, 2016; Bearzi et al., 2009; Hamilton et al., 2009b). Sighting records off California and Baja California suggest a continuous distribution of offshore common bottlenose dolphins in these regions (Mangels & Gerrodette, 1994). Analyses of sighting data collected during winter aerial surveys in 1991–1992 and summer shipboard surveys in 1991 indicated no significant seasonal shifts in distribution (Forney & Barlow, 1998). Based on habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, offshore common bottlenose dolphins exhibit a disjunctive longitudinal distribution, suggesting that there may be two separate populations in this area, although additional genetic data are required for confirmation (Becker et al., 2016).

Off Southern California, animals from the California Coastal stock are found within 500 m of the shoreline 99 percent of the time and within 250 m of the shoreline 90 percent of the time (Hanson & Defran, 1993; Hwang et al., 2014). California Coastal bottlenose dolphins are found generally from Point Conception to as far south as San Quintin, Mexico (Carretta et al., 1998; Defran & Weller, 1999; Hwang et al., 2014), but have also been consistently sighted off central California and as far north as San Francisco since the 1983 El Niño. It has been suggested that as a result of that event, these dolphins traveled further north tracking prey when warmer waters expanded northward and then continued using these more northern waters after that El Niño had ended (Hwang et al., 2014). One photo-identified dolphin that was first sighted in Southern California in 1983, belonging to the Coastal stock of bottlenose dolphins, has been part of a group incrementally expanding the northern range of the stock and has been identified in the waters of Puget Sound (Cascadia Research, 2017).

Photo identification analyses suggest that there may be two separate stocks of coastal bottlenose dolphins that exhibit limited integration, a California Coastal stock and a Northern Baja California stock (Defran et al., 2015), but they are not yet managed by NMFS as two stocks (Carretta et al., 2017a). The results from relatively contemporaneous surveys at Ensenada, San Diego, Santa Monica Bay, and Santa Barbara between 1996 and 2001 provided samples of the speed and distances individual coastal bottlenose dolphins routinely traveled (Hwang et al., 2014). The minimum travel speed was observed as 53 km per day, and the maximum was 95 km per day, with the total distances traveled between points between 104 km and 965 km (Hwang et al., 2014).

4.1.10.3 Population and Abundance

The California Coastal stock population size has remained stable over the period for which data are available (Carretta et al., 2017a; Dudzik et al., 2006). For the California, Oregon, and Washington Offshore stock, there has been no trend analysis for the population (Carretta et al., 2017a).

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

4.1.11.1 Status and Management

The Cuvier's beaked whale is not listed under the ESA. There are two stocks of Cuvier's beaked whales in the Pacific, one of which occurs in the PMSR Study Area—the California, Oregon, and Washington stock (Carretta et al., 2017a; Carretta et al., 2018a).

4.1.11.2 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. Cuvier's beaked whales have been encountered in almost all areas of the Pacific, including the open mid-ocean, wherever surveys have occurred (Hamilton et al., 2009b). Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 200 m and are frequently recorded in waters with bottom depths greater than 1,000 m (Bradford et al., 2013; Falcone et al., 2009; Jefferson et al., 2015). Acoustic sampling of bathymetrically featureless areas off Southern California detected many beaked whales over an abyssal plain, which counters a common misperception that beaked whales are primarily found over slope waters, in deep basins, or over seamounts (Griffiths & Barlow, 2016).

Adjacent to the southern boundary of the PMSR Study Area, research involving tagged Cuvier's beaked whales in the SOCAL Range Complex has documented movements in excess of hundreds of kilometers. Schorr et al. (2014) reported that five out of eight tagged whales journeyed approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km to the south to Mexico and back (Falcone et al., 2009; Falcone & Schorr, 2011, 2012, 2013, 2014). Acoustic data indicates a regional and seasonal (August and September) dip in Cuvier's echolocation clicks during the fall (DiMarzio et al., 2018; DiMarzio et al., 2019; Moretti, 2017; Rice et al., 2019), which may be tied to some as yet unknown population dynamic or oceanographic and prey availability dynamics (Schorr et al., 2018).

The Cuvier's beaked whale is the most commonly encountered beaked whale off the U.S. West Coast in surveys (Carretta et al., 2017a) and in acoustic monitoring in the waters off Southern California (Rice et al., 2019). This species is found from Alaska to Baja California, Mexico (Mead, 1989; Pitman et al., 1988). During ship surveys conducted quarterly off Southern California from 2004 to 2008, there were only six beaked whale sightings, and half of these were Cuvier's beaked whales (Douglas et al., 2014). During 18 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2013, Cuvier's beaked whales were sighted on two occasions (Jefferson et al., 2014). Repeated sightings of the same individuals have been reported off San Clemente Island in Southern California, which indicates some level of site fidelity (Falcone et al., 2009; Schorr et al., 2018). This species has also frequently been heard on passive acoustic recording devices in Southern California (Griffiths & Barlow, 2016; Rice et al., 2019; Širović et al., 2016). In a test of drifting passive acoustic recorders off California in fall 2014, Griffiths and Barlow (2016) reported beaked whale detections over slopes and seamounts, which was not unexpected, and also over deep-ocean abyssal plains, which was a novel finding.

4.1.11.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 had suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent study (Barlow, 2016) included data from an additional survey conducted in 2014 and indicated that the pattern seen for the U.S. West Coast from 1996 to 2014 may indicate a change in that downward trend. More recently, incorporation of information from the entire 1991–2014 time series has suggested an increasing abundance trend and a reversal of the previously indicated declining trend along the U.S. West Coast (Moore & Barlow, 2017). Multiple studies have indicated that in waters surrounding Navy testing and training areas in Southern California, the abundance of beaked whales remains high, including specifically where Navy has been testing and training for decades (see for example, DiMarzio et al. (2019)). Results from passive acoustic monitoring and other research have estimated regional Cuvier's beaked whale densities that were higher than indicated by NMFS's broad-scale visual surveys for the U.S. West Coast (Debich et al., 2015a; Debich et al., 2015b; Falcone & Schorr, 2012, 2014; Hildebrand et al., 2009; Moretti, 2016; Rice et al., 2019; Širović et al., 2016; Smultea, 2014). In a series of surveys from 2006 to 2008, Falcone et al. (2009) proposed that the ocean basin west of San Clemente Island (adjacent to the PMSR Study Area) may be an important region for Cuvier's beaked whales. Archived acoustic data gathered over the seven-year interval from 2010 to 2017 found the annual Cuvier's beaked whale abundance for the Navy's range adjacent to San Clemente Islands have no observed decline and potentially a slight increase (DiMarzio et al., 2018; DiMarzio et al., 2019).

These location-specific results have continuously demonstrated higher abundances observed on the Navy's testing and training areas in Southern California compared to the remainder of the U.S. West Coast. Adjacent to the southern boundary of the PMSR Study Area, research at the Navy's instrumented Southern California Anti-Submarine Warfare Range also indicates a higher-than-expected residency by the species (Falcone & Schorr, 2012; Schorr et al., 2018). Photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, of which as many as 57 percent having been seen in one or more prior years, with re-sightings up to 10 years apart (Falcone & Schorr, 2014; Schorr et al., 2018). The documented residency by many Cuvier's beaked whales over multiple years indicate that a stable population may exist in that small portion of the stock's overall range (Falcone et al., 2009; Falcone & Schorr, 2014; Schorr et al., 2017; Schorr et al., 2018). Resightings of 45 known reproductive females both with and without calves over time have also provided critically needed calving and weaning rate data that will serve as the basis for future population modeling for the species (Schorr et al., 2018).

4.1.12 Dall's Porpoise (*Phocoenoides dalli*)

4.1.12.1 Status and Management

This species is not listed under the ESA. Dall's porpoise is managed by NMFS in U.S. Pacific waters as two stocks: (1) a California, Oregon, and Washington stock; and (2) an Alaskan stock (Allen & Angliss, 2010; Carretta et al., 2010; Carretta et al., 2017a). The Alaska stock does not occur in the PMSR Study Area.

4.1.12.2 Geographic Range and Distribution

The Dall's porpoise is one of the most common odontocete species in north Pacific waters (Calambokidis & Barlow, 2004; Ferrero & Walker, 1999; Houck & Jefferson, 1999; Jefferson, 1991; Jefferson et al., 2008; Williams & Thomas, 2007; Zagzebski et al., 2006). Dall's porpoise is found from northern Baja California, Mexico, north to the northern Bering Sea, and south to southern Japan (Jefferson et al., 1993). However, the species is only common between 32° N and 62° N in the eastern North Pacific (Houck & Jefferson, 1999; Morejohn, 1979). It is typically found in waters at temperatures less than 63°F (17°C) with depths of more than 180 m (Houck & Jefferson, 1999; Reeves et al., 2002b).

Dall's porpoise distribution off the U.S. West Coast is highly variable between years, most likely due to changes in oceanographic conditions (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2012b; Boyd et al., 2017; Forney & Barlow, 1998; Forney et al., 2012; Peterson et al., 2006). North-south movements in California, Oregon, and Washington have been observed, with Dall's porpoises shifting their distribution southward during cooler-water periods on both interannual and seasonal time scales (Forney & Barlow, 1998; Peterson et al., 2006). Based on habitat models developed using 1991–2009 survey data collected during summer and fall, Becker et al. (2016) found that encounters of Dall's porpoise increased in shelf and slope waters in the Study Area, and encounters decreased substantially in waters warmer than approximately 63°F (17°C). These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2012b; Becker et al., 2014; Forney et al., 2012; Henderson et al., 2014).

During ship surveys conducted quarterly off Southern California from 2004 to 2013, Dall's porpoise was encountered year round, with highest encounters during the cold-water months (Campbell et al., 2015; Douglas et al., 2014; Peterson et al., 2006). As a cold-temperate species, Dall's porpoise showed distributional shifts to the north years with elevated water temperatures (Barlow, 2016). In the PMSR, Dall's porpoise distribution extended from nearshore waters out to approximately 250 km from the coast. Fewer animals were encountered farther south because of a preference for cooler water temperatures (Boyd et al., 2017; Campbell et al., 2015). This distribution for Dall's porpoise is also reflective of the biogeographic boundary at approximately Point Conception (Boyd et al., 2017; Campbell et al., 2015; Forney & Barlow, 1998; Hamilton et al., 2009a; Sanford et al., 2019; Santora et al., 2017a) as discussed in greater detail in Section 3.2 (Sediments and Water Quality) of the PMSR Draft EIS/OEIS. Distribution patterns based on summer/fall habitat models were substantially different, predicting very low densities in the Southern California Bight and offshore, and highest predicted densities in a more concentrated band closer to shore, starting at approximately Point Mugu and extending north to San Francisco (Becker et al., 2017).

4.1.12.3 Population and Abundance

No data are available regarding population trends for the stock of Dall's porpoises in California, Oregon, and Washington (Carretta et al., 2015). Examination of sighting and stranding data from the 1950s through 2012 suggest that the relative occurrence of this species in the Southern California Bight has not changed substantially over this time period (Smultea, 2014).

4.1.13 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the dwarf sperm whale, which is described in the following subsections, and the pygmy sperm whale. Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

4.1.13.1 Status and Management

The dwarf sperm whale is not listed under the ESA. Dwarf sperm whales within the Pacific U.S. EEZ are divided into two separate stocks, one of which occurs in the Study Area—the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.13.2 Geographic Range and Distribution

Dwarf sperm whales tend to occur over the outer continental shelf, and they may be relatively coastal in some areas with deep waters nearshore (MacLeod et al., 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of the species are not well understood. Records of this species from both the western Pacific (Taiwan) and eastern Pacific (California) suggest that its range includes the waters off Southern California (Carretta et al., 2017a; Jefferson et al., 2008; Wang et al., 2001; Wang & Yang, 2006).

Along the U.S. Pacific coast, no reported sightings of this species during surveys have been confirmed as dwarf sperm whales, and it is likely that most *Kogia* species off California are pygmy sperm whale (*Kogia breviceps*) (Barlow, 2016; Carretta et al., 2015; Nagorsen & Stewart, 1983). There were no *Kogia* detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea et al., 2014), which is immediately south of the PMSR Study Area. This may be somewhat due to their pelagic distribution, cryptic behavior (i.e., “hidden” because they are not very active at the surface and do not have a conspicuous blow), and physical similarity to the pygmy sperm whale (Jefferson et al., 2008; McAlpine, 2009). However, the presence of dwarf sperm whales off the coast of California has been demonstrated by at least five dwarf sperm whale strandings in California between 1967 and 2000 (Carretta et al., 2010).

4.1.13.3 Population and Abundance

There is no information available to estimate the population size of dwarf sperm whales off the U.S. West Coast (Carretta et al., 2017a). There are no known sighting records of this species despite many vessel surveys along the West Coast, and sightings of unidentified *Kogia* species are likely to be pygmy sperm whales (Carretta et al., 2015).

4.1.14 Ginkgo-Toothed Beaked Whale (*Mesoplodon ginkgodens*)

4.1.14.1 Status and Management

The ginkgo-toothed beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another at sea during visual surveys, the United States management unit is defined to include all *Mesoplodon* species that occur in the area (Carretta et al., 2015; Jefferson et al., 2008). The ginkgo-toothed beaked whale has been combined with five other

Mesoplodon species to make up the California, Oregon, and Washington stock (Carretta et al., 2015; Carretta et al., 2018a).

4.1.14.2 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., 2006; MacLeod & Mitchell, 2006; Pitman, 2009; Waring et al., 2001).

The distribution of the ginkgo-toothed beaked whale likely includes deep waters off the Pacific coast of North America. The handful of known records of the ginkgo-toothed beaked whale are from strandings, one of which occurred in California (Jefferson et al., 2015; MacLeod & D'Amico, 2006). *Mesoplodon* beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea, 2014).

4.1.14.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 had previously suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent survey in 2014 (Barlow, 2016), and a new analysis incorporating information from all surveys between 1991 and 2014, suggests an increasing abundance for the U.S. West Coast trend over that time, which is a reversal of the previously reported population decline (Carretta et al., 2017b; Moore & Barlow, 2017).

4.1.15 Harbor Porpoise (*Phocoena phocoena*)

4.1.15.1 Status and Management

Harbor porpoise are not considered a threatened or endangered species under the ESA. The Morro Bay stock overlaps the northern extent of the PMSR Study Area (Carretta et al., 2017a). This stock is not considered depleted under the MMPA.

4.1.15.2 Geographic Range and Distribution

The southern extent of the Morro Bay stock is Point Conception, while the northern extent, to the north of and outside the PMSR Study Area, is at Point Sur (approximately 30 km south of Monterey Bay (Carretta et al., 2017a; Forney et al., 2014). The harbor porpoise distribution is reflective of the biogeographic boundary at approximately Point Conception (Forney & Barlow, 1998; Hamilton et al., 2009a; Sanford et al., 2019; Santora et al., 2017a) as discussed in greater detail in Section 3.7 (Marine Mammals) of the PMSR Draft EIS/OEIS. Harbor porpoise is a nearshore species, although the outer range of the Morro Bay stock is the 200 m isobath (Carretta et al., 2017a; Forney et al., 2014). Harbor porpoise are expected to be present in these waters year round. Surveys including shallow and deep waters north of Point Conception have encountered very few harbor porpoise in the offshore area (Campbell et al., 2015; Douglas et al., 2014; Forney et al., 2014). In the waters north of Point Conception the 200 m isobath can be up to approximately 10 NM from the coast, but a large portion of the PMSR is beyond 12 NM from the coast in that part of the Study Area.

Aerial surveys that included the Morro Bay harbor porpoise population between 2002 and 2007 indicated a core area of higher density between Point Estero (north of Cayucos), and Point Arguello (north of Point Conception), with density decreasing toward the edges of their range (Calambokidis et al., 2015). It was argued that the small core range of this small and resident Morro Bay harbor porpoise

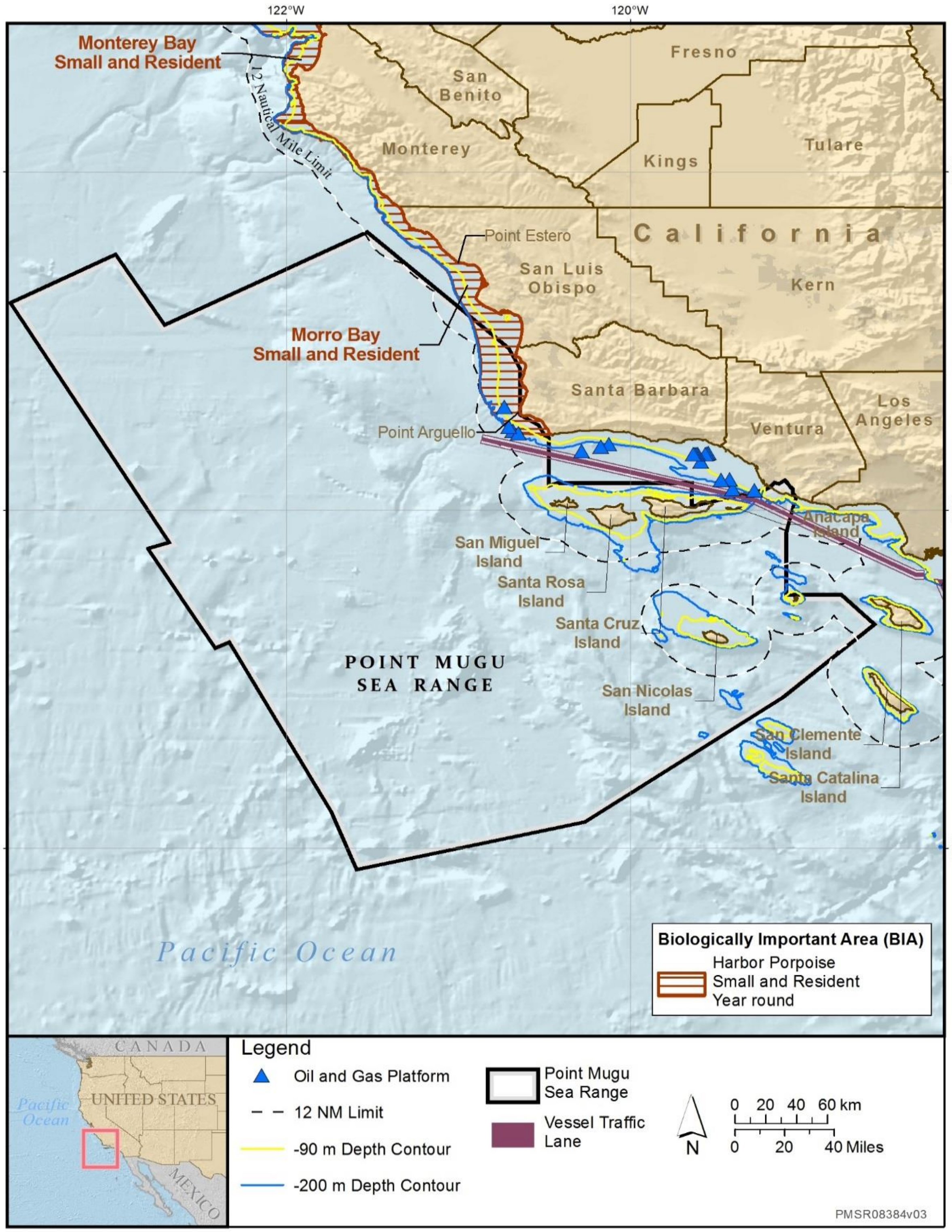

Figure 4-5: Morro Bay Harbor Porpoise Biologically Important Small and Resident Population Area Identified in the Vicinity of the PMSR Study Area (per Calambokidis et al. 2015)

population made it particularly vulnerable to anthropogenic impacts (Calambokidis et al., 2015). As a result, the entire range of the Morro Bay harbor porpoise population was identified by Calambokidis et al. (2015) as a BIA for that small and resident population. A portion of the identified Morro Bay harbor porpoise small and resident population area overlaps with the nearshore boundary of waters within the northern portion of the PMSR Study Area (Figure 4-5).

4.1.15.3 Population and Abundance

No data are available regarding population trends for the stock of harbor porpoises in the Morro Bay stock (Carretta et al., 2017a; Carretta et al., 2018a, 2018b; Forney et al., 2014) because they are not surveyed often, although the most recent abundance estimate based on aerial surveys from 2007 to 2012 are greater than the previous 2002–2007 estimates (Forney et al., 2014).

4.1.16 Hubbs' Beaked Whale (*Mesoplodon carlhubbsi*)

4.1.16.1 Status and Management

Hubbs' beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another at sea during visual surveys, the United States management unit is defined to include all *Mesoplodon* species that occur in the area. Hubbs' beaked whale has been combined with five other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al., 2015; Carretta et al., 2018a).

4.1.16.2 Geographic Range and Distribution

The distribution of Hubbs' beaked whale is generally associated with the deep subarctic current system along the Pacific coast of North America (Mead et al., 1982; Mead, 1989). MacLeod et al. (2006) speculated that the distribution of Hubbs' beaked whale might be continuous across the north Pacific between about 30° N and 45° N, but this remains to be confirmed.(Baumann-Pickering et al., 2014; MacLeod & Mitchell, 2006; Mead, 1989)

Mead (1989) speculated that the range of Hubbs' beaked whale includes the PMSR Study Area off California. During systematic surveys conducted from 1986 to 2005 in the eastern Pacific, there was one confirmed sighting of Hubbs' beaked whale in offshore waters off the state of Washington (Hamilton et al., 2009b). *Mesoplodon* beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea, 2014). Passive acoustic monitoring has documented a beaked whale-like frequency modulated echolocation pulse type recorded off Southern California over multiple years that may possibly be produced by Hubbs' beaked whale (Baumann-Pickering et al., 2014; Debich et al., 2015b; Rice et al., 2019).

4.1.16.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent survey in 2014 (Barlow, 2016), and a new analysis incorporating information from all surveys between 1991 and 2014, suggests an increasing abundance for the U.S. West Coast trend over that time, which is a reversal of the previously reported population decline (Carretta et al., 2017b; Carretta et al., 2018a; Moore & Barlow, 2017).

4.1.17 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called "ecotypes" (Ford, 2008). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits. In the north Pacific, these recognizable geographic forms are variously known as ''residents," "transients," and "offshore" ecotypes (Hoelzel et al., 2007). Both the transient and offshore ecotypes are known to occur in the PMSR Study Area (Carretta et al., 2018b).

4.1.17.1 Status and Management

Five killer whale stocks are recognized within the Pacific U.S. EEZs. Both the West Coast Transient stock and the Eastern North Pacific Offshore stock are present in the PMSR Study Area (Carretta et al., 2017a; Carretta et al., 2018a, 2018b). The stocks present in the PMSR Study Area are not species or DPS listed under the ESA.

4.1.17.2 Geographic Range and Distribution

Killer whales are found in all marine habitats, from the coastal zone (including most bays and inshore channels) to deep oceanic basins, and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim & Heyning, 1999). Forney and Wade (2006) found that killer whale densities increased by one to two orders of magnitude from the tropics to the poles.

In the PMSR Study Area, only the transient and offshore ecotypes may be present (Carretta et al., 2017a). During seven systematic ship surveys of waters off the U.S. West Coast between 1991 and 2014, there were 37 killer whale sightings, only five of which were off Southern California (Henderson et al., 2016). Based on two sightings from 15 aerial surveys conducted in the SOCAL Range Complex from 2008 to 2012, killer whales were ranked 12th in occurrence compared to other cetaceans (Jefferson et al., 2014; Smultea et al., 2014).

4.1.17.3 Population and Abundance

No data are available on current population trends for the West Coast Transient stock of killer whales (Carretta et al., 2017a; Carretta et al., 2017b; Carretta et al., 2018b; Muto et al., 2017). NMFS considers the population trajectory for Eastern North Pacific Offshore killer whales to be stable (Carretta et al., 2018b).

4.1.18 Long-beaked Common Dolphin (*Delphinus capensis*)

Common dolphins are represented by two species for management purposes in the NMFS Pacific SAR (Carretta et al., 2017a), the long-beaked common dolphin (*Delphinus capensis*) and the short-beaked common dolphin (*Delphinus delphis*). There is scientific disagreement regarding the common dolphin taxonomy (Committee on Taxonomy, 2016), but the Navy is following the NMFS naming convention as presented in the most recent stock assessment (Carretta et al., 2017a; Carretta et al., 2018b).

4.1.18.1 Status and Management

This species is not listed under the ESA. For the NMFS SARs, there is a single Pacific management stock for long-beaked common dolphins found within the U.S. EEZ off the U.S. West Coast, which is called the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.18.2 Geographic Range and Distribution

The long-beaked common dolphin appears to be restricted to waters relatively close to shore (Jefferson & Van Waerebeek, 2002; Perrin, 2009), apparently preferring shallower and warmer water than the short-beaked common dolphin (Becker et al., 2016; Perrin, 2009). Off California and Baja California, Mexico, long-beaked common dolphins are commonly found within 50 NM of the coast (Carretta et al., 2011; Gerrodette & Eguchi, 2011). This species is found off Southern California year round, but it may be more abundant there during the warm-water months (May–October) (Barlow & Forney, 2007; Bearzi, 2005a; Douglas et al., 2014; Henderson et al., 2014; Heyning & Perrin, 1994). Stranding data and sighting records suggest that this species' abundance fluctuates seasonally and from year to year off California (Carretta et al., 2011; Douglas et al., 2014; Henderson et al., 2014). Southern California waters represent the northern limit to this species' range, and the seasonal and inter-annual changes in abundance off California are assumed to reflect the shifts in the movements of animals between U.S. and Mexican waters (Carretta et al., 2017a).

4.1.18.3 Population and Abundance

There appears to be an increasing trend in the abundance of long-beaked common dolphin in Southern California waters over the last 30 years (Carretta et al., 2017a; Jefferson et al., 2014).

4.1.19 NORTHERN RIGHT WHALE DOLPHIN (*LISSODELPHIS BOREALIS*)

4.1.19.1 Status and Management

This species is not listed under the ESA but is protected by the MMPA. The management stock in U.S. waters consists of a single California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.19.2 Geographic Range and Distribution

The northern right whale dolphin occurs in cool and temperate to subarctic waters of the North Pacific, from the west coast of North America to Japan and Russia. This oceanic species is distributed from approximately 30° N to 50° N, 145° W to 118° E and generally not as far north as the Bering Sea (Jefferson et al., 2015). Occasional movements south of 30° N are associated with unusually cold water temperatures (Jefferson & Lynn, 1994). This species tends to occur along the outer continental shelf and slope, normally in waters colder than 68°F (20°C) (Jefferson & Lynn, 1994). Northern right whale dolphins generally move nearshore only in areas where the continental shelf is narrow or where productivity on the shelf is especially high (Smith et al., 1986).

Off California, the northern right whale dolphin is known to occur year round, but abundance and distribution vary seasonally (Becker et al., 2014; Dohl et al., 1983; Douglas et al., 2014; Forney & Barlow, 1998). Northern right whale dolphins are primarily found off California during the colder water months, with distribution shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Barlow, 1995; Forney et al., 1995; Forney & Barlow, 1998; Henderson et al., 2014). In the cool water period, the peak abundance of northern right whale dolphins in Southern California corresponds closely with the peak abundance of squid (Forney & Barlow, 1998; Jefferson &

Lynn, 1994). Northern right whale dolphins were sighted year round during 16 ship surveys conducted from 2004 to 2008 off Southern California, but the majority of the sightings were in winter and spring (Douglas et al., 2014). There were 16 sightings of northern right whale dolphins during 18 aerial surveys conducted in the Southern California Bight from 2008 to 2013 (Jefferson et al., 2014).

As noted above, in the warm-water periods, the northern right whale dolphin is not as abundant in Southern California due to shifting distributions north into Oregon and Washington (Barlow, 1995; Forney et al., 1995; Forney & Barlow, 1998). Based on habitat models developed with line-transect survey data collected off the U.S. West Coast during summer and fall from 1991 to 2009, Becker et al. (2016) found that encounters of northern right whale dolphin increased in shelf and slope waters, and encounters decreased substantially in waters warmer than approximately 64°F (18°C). These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2012b; Becker et al., 2014; Forney et al., 2012). Northern right whale dolphins also tend to occur further offshore of Southern California during the summer months (Douglas et al., 2014; Forney & Barlow, 1998).

4.1.19.3 Population and Abundance

Examination of sighting and stranding data from the 1950s through 2012 suggest that the relative occurrence of northern right whale dolphins in the Southern California Bight has not changed over that period (Smultea, 2014), and the Pacific SAR states that there is no evidence of a trend in abundance for this stock (Carretta et al., 2017a).

4.1.20 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

4.1.20.1 Status and Management

This species is not listed under the ESA. NMFS recognizes a single stock for the U.S. West Coast—the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.20.2 Geographic Range and Distribution

Pacific white-sided dolphins are found in cold temperate waters across the northern rim of the Pacific Ocean as far north as the southern Bering Sea and as far south as the Gulf of California off Mexico (Ferguson, 2005; Jefferson et al., 2015; Leatherwood et al., 1984; Reeves et al., 2002b). They are also known to inhabit inshore regions of southeast Alaska, British Columbia, and Washington, and occur seasonally off Southern California (Brownell et al., 1999; Forney & Barlow, 1998). Sighting records and captures in open sea driftnets indicate that this species also occurs in oceanic waters well beyond the shelf and slope (Ferrero & Walker, 1996; Leatherwood et al., 1984).

Off California, Forney and Barlow (1998) found significant north/south shifts in the seasonal distribution of Pacific white-sided dolphin, with animals moving north into Oregon and Washington waters during the summer and showing increased abundance in the Southern California Bight in the winter. During ship surveys conducted off the U.S. West Coast in the summer and fall from 1991 to 2005, the number of Pacific white-sided dolphin sightings showed no clear pattern with respect to geographic region, although they were consistently found in larger groups off central California (Barlow & Forney, 2007; Henderson et al., 2014). Based on habitat models developed with survey data collected during summer and fall from 1991 to 2009, Becker et al. (2016) found that encounters of Pacific white-sided dolphin increased in shelf and slope waters and in relatively cooler waters in the Study Area. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al., 2009;

Becker et al., 2010; Becker et al., 2012b; Becker et al., 2014; Forney et al., 2012). Based on ship survey data collected quarterly from 2004 to 2013, Pacific white-sided dolphins occurred year round off Southern California, but the majority of the sightings were in winter and spring, when their distribution was more widespread (Campbell et al., 2015). There were 21 sightings of Pacific white-sided dolphin during 18 aerial surveys conducted in the Southern California Bight from 2008 to 2013 (Jefferson et al., 2014).

4.1.20.3 Population and Abundance

Multiple analyses of sightings and stranding data have indicated a significant decline in abundance over time from the Southern California Bight to the Gulf of California in Mexico (Barlow, 2016; Campbell et al., 2015; Salvadeo et al., 2010; Smultea, 2014).

4.1.21 Perrin's Beaked Whale (*Mesoplodon perrini*)

4.1.21.1 Status and Management

Perrin's beaked whale was described as a new species of marine mammal in 2002 (Dalebout et al., 2002). Perrin's beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the *Mesoplodon* species at sea during visual surveys, the management unit has been defined by NMFS to include all *Mesoplodon* species that occur in the area. Perrin's beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al., 2017a; Carretta et al., 2018a).

4.1.21.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 200 m) and are only occasionally reported in waters over the continental shelf (Cañadas et al., 2002; Ferguson et al., 2006; MacLeod & Mitchell, 2006; Pitman, 2009; Waring et al., 2001).

Perrin's beaked whale is known only from five strandings along the California coastline from 1975 to 1997 (Dalebout et al., 2002; MacLeod & Mitchell, 2006). These strandings include two at U.S. Marine Corps Base Camp Pendleton (33°15' N, 117°26' W), and one each at Carlsbad, (33°07' N, 117°20' W), Torrey Pines State Reserve (32°55' N, 117°15' W), and Monterey (36°37' N, 121°55' W) (Dalebout et al., 2002; Mead, 1981). These stranded animals were previously identified as Hector's beaked whale but have been reclassified as Perrin's beaked whale (Dalebout et al., 2002; Mead, 1981; Mead & Baker, 1987; Mead, 1989). While this stranding pattern suggests an eastern North Pacific Ocean distribution, too few records exist for this to be conclusive (Dalebout et al., 2002). Due to the scarcity of data, the full extent of Perrin's beaked whale distribution is unknown; however, it likely occurs primarily in oceanic waters of the eastern north Pacific with depths exceeding 1,000 m (MacLeod & Mitchell, 2006). *Mesoplodon* beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea, 2014). Acoustic monitoring from devices located at seven sites in the Southern California Bight (across a broad area stretching from Santa Cruz Island to an open ocean area south of San Clemente Island) have documented the presence of a beaked whale-like frequency modulated pulse type over multiple years that may possibly be produced by Perrin's beaked whale, since it is otherwise unidentified (Baumann-Pickering et al., 2014; Baumann-Pickering et al., 2015; Debich et al., 2015b; Rice et al., 2019).

4.1.21.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent survey in 2014 (Barlow, 2016), and a new analysis incorporating information from all surveys between 1991 and 2014, suggests an increasing abundance for the U.S. West Coast trend over that time, which is a reversal of the previously reported population decline (Carretta et al., 2017b; Moore & Barlow, 2017).

4.1.22 PYGMY BEAKED WHALE (*MESOPLODON PERUVIANUS*)

Literature published before the pygmy beaked whale was identified referred to it by the common name "*Mesoplodon* species A" (Pitman & Lynn, 2001). It is also commonly referred to as "Lesser beaked whale" (Carretta et al., 2015). The pygmy beaked whale was first described as a new species in 1991 (Jefferson et al., 2008).

4.1.22.1 Status and Management

The pygmy beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the *Mesoplodon* species at sea during visual surveys, the United States management unit is defined to include all *Mesoplodon* species that occur in the area. The pygmy beaked whale has been combined with five other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al., 2010; Carretta et al., 2018a).

4.1.22.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 200 m) and are only occasionally reported in waters over the continental shelf (Cañadas et al., 2002; Ferguson et al., 2006; MacLeod & Mitchell, 2006; Pitman, 2009; Waring et al., 2001). Based on stranding data from the Pacific coast of Bahia de La Paz, Mexico, this species' range is thought to include deep waters off the Pacific coast of North America (Aurioles-Gamboa & Urban-Ramirez, 1993; Jefferson et al., 2008; Urban-Ramirez & Aurioles-Gamboa, 1992). This species was first described in 1991 from stranded specimens from Peru. Since then, strandings have been recorded along the coasts of Mexico, Peru, and Chile (Pitman & Lynn, 2001; Reyes et al., 1991; Sanino et al., 2007). Based on sightings and strandings, the pygmy beaked whale is presumed to be found only in the eastern tropical Pacific. MacLeod et al. (2006) suggested that the pygmy beaked whale occurs in the eastern Pacific from about 30° N to about 30° South (S) (MacLeod & Mitchell, 2006; Mead, 1989).

Pygmy beaked whales are assumed to be present in the PMSR Study Area. *Mesoplodon* beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea, 2014). Acoustic monitoring has documented the presence of a beaked whale-like frequency modulated pulse type ("BW70") in Southern California that may possibly be produced by pygmy beaked whales (Baumann-Pickering et al., 2014).

4.1.22.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent survey in 2014 (Barlow, 2016), and a new analysis incorporating information from all surveys between 1991 and 2014, suggests an increasing abundance for the U.S.

West Coast trend over that time, which is a reversal of the previously reported population decline (Carretta et al., 2017b; Carretta et al., 2018a; Moore & Barlow, 2017).

4.1.23 Pygmy Killer Whale (*Feresa attenuata*)

4.1.23.1 Status and Management

The pygmy killer whale is not listed under the ESA. The only stock for the species in the Pacific is for animals found within the U.S. EEZ around the Hawaiian Islands. The species has only been sighted in U.S. West Coast waters once, which occurred in 2014 (Barlow, 2016). The Pacific SAR does not include pygmy killer whales as a managed stock in U.S. West Coast waters (Carretta et al., 2019b).

4.1.23.2 Geographic Range and Distribution

This tropical species' range in the open ocean generally extends to the southern regions of the North Pacific Gyre and the southern portions of the North Pacific Transition Zone in deep water areas (Davis et al., 2000; McSweeney et al., 2009; Oleson et al., 2013; Würsig et al., 2000). Many sightings have occurred from cetacean surveys of the eastern tropical Pacific (Au & Perryman, 1985; Barlow & Gisiner, 2006; Wade & Gerrodette, 1993).

During a NMFS 2014 systematic ship survey off the U.S. West Coast in unusually warm water conditions, a group of 27 pygmy killer whales was sighted in deep offshore waters near the southern U.S. EEZ bordering Mexico (Barlow, 2016). This was the first sighting of that tropical species in U.S. West Coast waters. Even with this 2014 sighting, it remains unlikely for this species to routinely be present off the U.S. West Coast.

4.1.23.3 Population and Abundance

The 2014 sighting was the first sighting of this tropical species in U.S. West Coast waters (Barlow, 2016). There are no data available for an analysis of the population trend for pygmy killer whales in U.S. West Coast waters. Lacking any other data for context, surveys in the Eastern Tropical Pacific indicated that population had an abundance of approximately 39,000 (Wade & Gerrodette, 1993).

4.1.24 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia*: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*). Dwarf and pygmy sperm whales are difficult to detect and distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

4.1.24.1 Status and Management

The pygmy sperm whale is not listed under the ESA. Pygmy sperm whales in the Study Area have been designated the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.24.2 Geographic Range and Distribution

The pygmy sperm whale frequents more temperate habitats than the dwarf sperm whale, which is more of a tropical species (Baird, 2013a; Baird et al., 2003; Baird, 2005; Barlow et al., 2004; Maldini et al., 2005; Oleson et al., 2013). Pygmy sperm whales have only rarely been sighted along the U.S. West Coast during surveys, and the limited sightings cannot be used to produce a reliable population estimate (Carretta et al., 2017a). Several studies have suggested that this species generally occurs beyond the continental shelf edge (Bloodworth & Odell, 2008; MacLeod et al., 2004), and all confirmed pygmy sperm whale sightings off the U.S. West Coast have been well offshore (Barlow, 2016; Hamilton et al., 2009b). For California, a total of six pygmy sperm whale sightings have been made in offshore waters along the U.S. West Coast during systematic surveys conducted between 1991 and 2014 (Barlow, 2016; Hamilton et al., 2009b). There were no *Kogia* detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 to 2012 (Smultea, 2014).

Movement patterns for this species are poorly understood. No specific information regarding routes, seasons, or resighting rates in specific areas is available for the PMSR Study Area.

4.1.24.3 Population and Abundance

There are no data available for an analysis of the population trend for pygmy sperm whales in the Pacific (Carretta et al., 2017a).

4.1.25 Risso's Dolphin (*Grampus griseus*)

4.1.25.1 Status and Management

Risso's dolphin is not listed under the ESA. For the NMFS SARs, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate stocks, one of which occurs in the PMSR Study Area—the California, Oregon and Washington stock (Carretta et al., 2017a).

4.1.25.2 Geographic Range and Distribution

Risso's dolphins are found in the waters off the U.S. West Coast (Barlow, 2016). Studies have documented that Risso's dolphins are found along the continental slope, over the outer continental shelf (Baumgartner, 1997; Cañadas et al., 2002; Cetacean and Turtle Assessment Program, 1982; Davis et al., 1998; Green et al., 1992; Kruse et al., 1999; Mignucci-Giannoni, 1998), and over submarine canyons (Mussi et al., 2004). This species is frequently observed in the waters surrounding San Clemente Island, located just south of the PMSR Study Area (Bacon et al., 2017; Carretta et al., 2000; Smultea et al., 2018).

Risso's dolphins exhibit an apparent seasonal shift in distribution off the U.S. West Coast, with movements from California waters north into Oregon and Washington waters in summer (Carretta et al., 2000; Forney & Barlow, 1998; Green et al., 1992; Soldevilla et al., 2008). During ship surveys conducted quarterly off Southern California from 2004 to 2008, Risso's dolphins were encountered year round, with the highest number of encounters during the cold-water months (Douglas et al., 2014), consistent with previously observed seasonal shifts in distribution (Carretta et al., 2000; Forney & Barlow, 1998; Henderson et al., 2014; Soldevilla, 2008). Habitat models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast show that Risso's dolphins exhibit a disjunctive longitudinal distribution, suggesting that there may be two separate populations in this area, although additional genetic data are required for confirmation (Becker et al., 2016). Aerial surveys over a six-year period between 2008 and 2013 found Risso's dolphins to be the most common species among mixed-species associations with other marine mammals in the Southern California Bight (Bacon et al., 2017).

4.1.25.3 Population and Abundance

For Risso's dolphins in California, Oregon, and Washington waters, differences in estimated abundance between survey years is most likely due to the interannual variability in species distribution rather than a true abundance trend (Carretta et al., 2015). However, based on density estimates derived from aerial survey data collected from 2008 to 2013, the abundance of Risso's dolphin in Southern California waters appears to have increased (Jefferson et al., 2014). Further, examination of sighting and stranding data from the 1950s through 2012 also indicated an increase in the relative occurrence of this species in the Southern California Bight (Smultea, 2014).

4.1.26 Short-beaked Common Dolphin (*Delphinus delphis*)

Common dolphins are represented by two species for management purposes in NMFS Pacific SAR (Carretta et al., 2017a), the short-beaked common dolphin (*Delphinus delphis*) and long-beaked common dolphin (*Delphinus capensis*). There is scientific disagreement regarding the common dolphin taxonomy (Committee on Taxonomy, 2016), but the Navy is following NMFS naming convention as presented in the most recent stock assessment (Carretta et al., 2017a; Carretta et al., 2018b).

4.1.26.1 Status and Management

This species is not listed under the ESA. There is a single Pacific management stock for those animals found within the U.S. EEZ off the U.S. West Coast—the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.26.2 Geographic Range and Distribution

Historically along the U.S. West Coast, short-beaked common dolphins were sighted primarily south of Point Conception (Dohl et al., 1983), but now they are commonly encountered as far north as 42° N (Hamilton et al., 2009b), and occasionally as far north as 48° N (Forney, 2007). Seasonal distribution shifts are pronounced, with a significant southerly shift south of Point Arguello, California, in the winter (Becker et al., 2014; Campbell et al., 2015; Forney & Barlow, 1998; Henderson et al., 2014). Short-beaked common dolphins are a warm temperate to tropical species; based on habitat models developed using line-transect survey data collected off the U.S. West Coast, densities are greatest when waters are warmest (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2014; Becker et al., 2016; Forney & Barlow, 1998; Forney et al., 2012). The abundance of short-beaked common dolphins off the U.S. West Coast varies, with seasonal and year-to-year changes in oceanographic conditions; movements may be north-south or inshore-offshore (Barlow et al., 2009; Becker et al., 2014; Becker et al., 2016; Forney & Barlow, 1998; Forney et al., 2012; Henderson et al., 2014). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s, along with a smaller decrease in abundance in the eastern tropical Pacific, suggesting a large-scale northward shift in the distribution of this species in the eastern North Pacific (Carretta et al., 2017a; Forney et al., 1995; Forney & Barlow, 1998).

Short-beaked common dolphins are found in Southern California throughout the year, distributed between the coast and approximately 345 miles from shore (Barlow & Forney, 2007; Barlow, 2016; Forney & Barlow, 1998). Based on multiple line-transect studies conducted by NMFS, the short-beaked common dolphin is the most abundant cetacean species, with a widespread distribution off Southern California (Barlow & Forney, 2007; Barlow, 2016; Campbell et al., 2015; Carretta et al., 2011; Douglas et al., 2014; Forney et al., 1995). From 2004 to 2008 during ship surveys conducted quarterly by the State of California off Southern California, short-beaked common dolphins were encountered year round, with the highest encounters during the summer (Douglas et al., 2014). From 2008 to 2013 during 18 aerial surveys conducted in the Southern California Bight, short-beaked common dolphins were the most frequently observed cetacean species (Jefferson et al., 2014).

4.1.26.3 Population and Abundance

Based on an analysis of sighting data collected during quarterly surveys off Southern California from 2004 to 2013, short-beaked common dolphins showed annual variations in density, but there was no significant trend evident during the period of this study (Campbell et al., 2015) or as a result of any other data (Carretta et al., 2017a). However, Barlow (2016) noted a nearly monotonic increase in the abundance of short-beaked common dolphins from 1991 to 2014 off the U.S. West Coast and suggested that a future trend analysis is appropriate.

4.1.27 Short-finned Pilot Whale (*Globicephala macrorhynchus*)

4.1.27.1 Status and Management

Short-finned pilot whales are not listed under the ESA. For MMPA SARs, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete stocks, one of which occurs in the PMSR Study Area—the California, Oregon, and Washington stock (Carretta et al., 2017a; Carretta et al., 2018a).

4.1.27.2 Geographic Range and Distribution

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world and occurs in waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Baird, 2013a; Olson, 2009). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern United States (Payne & Heinemann, 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Baird, 2013b; Gannier, 2000; Mignucci-Giannoni, 1998). Short-finned pilot whales are not considered a migratory species, although seasonal shifts in abundance have been noted in some portions of the species’ range. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard & Reilly, 1999; Hui, 1985; Payne & Heinemann, 1993).

Short-finned pilot whale distribution off Southern California changed dramatically after El Niño in 1982–1983, when squid did not spawn as usual in the area, and pilot whales virtually disappeared from the area for nine years (Jefferson & Schulman-Janiger, 2018a; Shane, 1995). There were nine short-finned pilot whale sightings during seven systematic ship surveys conducted by NMFS off California, Oregon, and Washington between 1991 and 2014, with three of these off Southern California (Barlow & Forney, 2007; Barlow, 2016). There were two additional short-finned pilot whale sightings during 16 ship surveys conducted by the State of California in the Southern California Bight between 2004 and 2008 (Douglas et al., 2014). Short-finned pilot whales were not sighted during 18 aerial surveys conducted in the Southern California Bight between 2008 and 2013 (Jefferson et al., 2014). A group of approximately 50 individuals was encountered off San Diego in May 2015 and included an individual photo-identified previously off Ensenada, Mexico (Kendall-Bar et al., 2016).

4.1.27.3 Population and Abundance

Pilot whales appear to have returned to California waters, as evidenced by an increase in sighting records as well as by incidental fishery bycatches (Barlow & Forney, 2007; Barlow, 2016; Douglas et al., 2014; Jefferson & Schulman-Janiger, 2018b; Kendall-Bar et al., 2016). Because these changes likely reflect a change in distribution based on a changing environment rather than a change in the population, there can be no assessment of the current population trend for short-finned pilot whales in California (Carretta et al., 2017a).

4.1.28 Sperm Whale (*Physeter macrocephalus*)

4.1.28.1 Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service, 2009), and is depleted under the MMPA throughout its range, but there is no designated critical habitat for this species in the North Pacific. Sperm whales are divided into three stocks in the Pacific; one (California/Oregon/Washington) occurs within the Study Area (Carretta et al., 2018a). Based on genetic analyses, Mesnick et al. (2011) found that sperm whales in the California Current are demographically independent from animals in the rest of the tropical Pacific.

4.1.28.2 Geographic Range and Distribution

Primarily, this species is found in the temperate and tropical waters of the Pacific (Rice, 1989). Their secondary range includes areas of higher latitudes in the PMSR Study Area (Jefferson et al., 2015; Whitehead & Weilgart, 2000; Whitehead et al., 2008; Whitehead et al., 2009). This species appears to have a preference for deep waters and the continental shelf break and slope (Baird, 2013a; Carretta et al., 2017a; Jefferson et al., 2015; Rice, 1989; Whitehead, 2003; Whitehead et al., 2008). Typically, sperm whale concentrations also correlate with areas of high productivity generally near drop offs and areas with strong currents and steep topography (Gannier & Praca, 2007; Jefferson et al., 2015).

Sperm whales are found year round in California waters, but their abundance is temporally variable, most likely due to variation in the availability of prey species (Barlow, 1995; Barlow & Forney, 2007; Forney & Barlow, 1993; Smultea, 2014). Based on habitat models derived from line-transect survey data collected between 1991 and 2008 off the U.S. West Coast, sperm whales show an apparent preference for deep waters (Barlow et al., 2009; Becker et al., 2010; Becker et al., 2012a; Forney et al., 2012). During quarterly ship surveys conducted off Southern California between 2004 and 2008, there were a total of 20 sperm whale sightings, the majority (12) occurring in summer in waters greater than 2,000 m deep (Douglas et al., 2014). Only one sperm whale group was observed during 18 aerial surveys conducted in the Southern California Bight from 2008 through 2012 (Smultea et al., 2014).

Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice, 1989; Whitehead, 2003; Whitehead et al., 2008; Whitehead et al., 2009). Pods of females with calves remain on breeding grounds throughout the year, between 40° N and 45° N (Rice, 1989; Whitehead, 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al., 2007). In the northern hemisphere, "bachelor" groups (males typically 15–21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al., 2007).

4.1.28.3 Population and Abundance

Sperm whale population abundance and trends based on line-transect surveys conducted off the U.S. West Coast from 1991 to 2014 include a high level of uncertainty but indicate that sperm whale abundance has appeared stable (Carretta et al., 2017b; Moore & Barlow, 2017; Moore & Barlow, 2014).

4.1.29 STRIPED DOLPHIN (*STENELLA COERULEOALBA*)

4.1.29.1 Status and Management

This species is not listed under the ESA. In the eastern north Pacific, NMFS identifies two striped dolphin management stocks within the U.S. EEZ, one of which occurs in the PMSR Study Area—the California, Oregon, and Washington stock (Carretta et al., 2017a).

4.1.29.2 Geographic Range and Distribution

Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than that of any other species in the genus *Stenella*. Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au & Perryman, 1985; Reilly, 1990). The northern limits are the Sea of Japan, Hokkaido, Washington State, and along roughly 40° N across the western and central Pacific (Reeves et al., 2002b). 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). In some areas, this species appears to avoid waters with sea temperatures less than 68°F (20°C) (Van Waerebeek et al., 1998).

Based on sighting records, striped dolphins appear to have a continuous distribution in offshore waters from California to Mexico (Mangels & Gerrodette, 1994). The striped dolphin also occurs far offshore, in waters affected by the warm Davidson Current as it flows northward (Archer, 2009; Jefferson et al., 2008). During ship surveys conducted off the U.S. West Coast in the summer and fall from 1991 to 2005, striped dolphins were sighted primarily from 100 to 300 NM offshore of the California coast (Barlow & Forney, 2007). Striped dolphin encounters increase in deep, relatively warmer waters off the U.S. West Coast (Becker et al., 2012a; Becker et al., 2016; Henderson et al., 2014), and their abudance decreases north of about 42° N (Barlow et al., 2009; Becker et al., 2012a; Becker et al., 2016; Forney et al., 2012). There were only three striped dolphin encounters during 16 ship surveys off Southern California from 2004 to 2008 (Douglas et al., 2014), and they were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 to 2012 (Smultea, 2014).

4.1.29.3 Population and Abundance

No long-term trends in abundance have been identified for the California, Oregon, and Washington stock of striped dolphins (Carretta et al., 2017a).

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

Stejneger's beaked whale was initially described in 1885 from a skull, and nothing more of the species was known for nearly a century. The late 1970s saw several strandings, but it was not until 1994 that the external appearance was well described from fresh (stranded) specimens.

4.1.30.1 Status and Management

Stejneger's beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the *Mesoplodon* species at sea during visual surveys, the United States management unit is defined to include all *Mesoplodon* species that occur in the area. Stejneger's beaked whale has been combined with five other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al., 2015; Carretta et al., 2018a).

4.1.30.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 200 m) (Cañadas et al., 2002; Ferguson et al., 2006; MacLeod & Mitchell, 2006; Pitman, 2009; Waring et al., 2001). They are occasionally reported in waters over the continental shelf (Pitman & Stinchcomb, 2002).

Stejneger's beaked whale appears to prefer cold to temperate and subpolar waters (MacLeod & Mitchell, 2006). This species has been observed in waters ranging from 730 to 1,560 m deep on the steep slope of the continental shelf (Loughlin & Perez, 1985). The southern limit in the central Pacific is unknown but is likely to range between 60° N and 30° N (Baumann-Pickering et al., 2014; Loughlin & Perez, 1985; MacLeod & Mitchell, 2006). Specific movement patterns of this species are not known, but high stranding rates in the winter and spring along the Pacific coast suggest that Stejneger's beaked whales migrate north during summer (Jefferson et al., 2008; Pitman, 2009). Stejneger's beaked whales are not considered to regularly occur in Southern California coastal waters (Jefferson et al., 2008; MacLeod & Mitchell, 2006). The farthest south this species has been observed in the eastern Pacific is Cardiff, California (33° N), but this is considered an extralimital occurrence (Loughlin & Perez, 1985; MacLeod & Mitchell, 2006; Mead, 1989). *Mesoplodon* beaked whales were not detected during 15 aerial surveys conducted in the SOCAL Range Complex from 2008 through 2012 (Smultea, 2014). Beaked whales produce species-specific frequency modulated echolocation pulses. Acoustic monitoring at a site (Site "M") located south of the PMSR Study Area recorded the presence of sounds from Stejneger's beaked whales once in July 2009 and again in July 2010 (Baumann-Pickering et al., 2014).

4.1.30.3 Population and Abundance

A Bayesian trend analysis of systematic survey data collected from 1991 to 2008 suggested a decline in the abundance of beaked whales found in waters off California, Oregon, and Washington (Moore & Barlow, 2013). However, a more recent survey in 2014 (Barlow, 2016) and a new analysis incorporating information from all surveys between 1991 and 2014 suggest an increasing abundance for the U.S. West Coast trend over that time, which is a reversal of the previously reported population decline (Carretta et al., 2017a; Carretta et al., 2017b; Carretta et al., 2018a; Moore & Barlow, 2017).

4.1.31 California Sea Lion (*Zalophus californianus*)

4.1.31.1 Status and Management

The California sea lion is not listed under the ESA. The California sea lion is managed by NMFS as the U.S. stock in all areas where they occur along the U.S. West Coast and in Alaska (Carretta et al., 2017a).

4.1.31.2 Geographic Range and Distribution

The California sea lion occurs in the eastern north Pacific from Puerto Vallarta, Mexico, through the Gulf of California and north along the west coast of North America to the Gulf of Alaska (Barlow et al., 2008; DeLong et al., 2017b; Jefferson et al., 2008; Maniscalco et al., 2004). Typically, during the summer, California sea lions congregate near rookery islands and specific open-water areas. The primary rookeries off the coast of the United States are on San Nicolas, San Miguel, Santa Barbara, and San Clemente Islands (Carretta et al., 2000; Le Boeuf & Bonnell, 1980; Lowry et al., 1992; Lowry & Forney, 2005; Lowry et al., 2017). Haulout sites are also found on Anacapa Island, Richardson Rock, Santa Catalina Island, Santa Cruz Island, and Santa Rosa Island in the Southern California Bight (Le Boeuf, 2002;

Lowry et al., 2017). This species is prone to invade human-modified coastal sites that provide good haulout substrate, such as marinas, buoys, bait barges, and rip-rap tidal control structures.

In the nonbreeding season, beginning in late summer, adult and subadult males migrate northward along the coast of California to Washington and return south the following spring (Laake, 2017; Lowry & Forney, 2005). Females and juveniles also disperse somewhat but tend to stay in the Southern California area, although north and west of the Channel Islands (Lowry & Forney, 2005; Melin & DeLong, 2000; Thomas et al., 2010). California sea lions from the west coast of the Baja California peninsula also migrate to Southern California during the fall and winter (Lowry & Forney, 2005), and sea lions from San Clemente Island tend to remain in Southern California (Melin, 2015). There is a general distribution shift northwest in fall and southeast during winter and spring, probably in response to changes in prey availability (DeLong et al., 2017a; DeLong et al., 2017b; Lowry et al., 2017).

California sea lions can be found in California open ocean and coastal waters (Barlow et al., 2008; Jefferson et al., 2008; Lander et al., 2010). California sea lions are usually found in waters over the continental shelf and slope; however, they are also known to occupy locations far offshore in deep, oceanic waters, such as Guadalupe Island and Alijos Rocks off Baja California (Jefferson et al., 2008; Melin et al., 2008; Urrutia & Dziendzielewski, 2012; Zavala-Gonzalez & Mellink, 2000). California sea lions are the most frequently sighted pinnipeds offshore of Southern California during the spring, and peak abundance is during the May through August breeding season (Green et al., 1992; Keiper et al., 2005; Lowry et al., 2017).

Tagged California sea lions from Monterey Bay and SNI, California, demonstrated that adult males can travel more than 450 km from shore during longer foraging bouts (Weise et al., 2006; Weise et al., 2010); however, rehabilitated females and subadults normally stay within 65 km of the coast (Thomas et al., 2010). Most individuals stay within 50 km of the rookery islands during the breeding season (Melin & DeLong, 2000). In the PMSR Study Area, females breeding and pupping on the Channel Islands typically feed over the continental shelf and generally remain within 150 km north and west of the islands (Kuhn & Costa, 2014; Melin & DeLong, 2000; Melin et al., 2008; Melin et al., 2012). Tagging results showed that lactating females foraging along the coast would travel as far north as Monterey Bay and offshore to the 1,000 m isobath (Henkel & Harvey, 2008; Kuhn & Costa, 2014; McHuron et al., 2017; Melin & DeLong, 2000; Melin et al., 2008). Data from satellite tags and time-depth recorders on nine females at SNI indicated they primarily foraged around the northern Channel Islands, while six tagged females at San Miguel Island foraged north of the Channel Islands along or just off the mainland coast (McHuron et al., 2017). During the nonbreeding season, they occur most often over the slope or offshore; during the breeding season, they occur most often over the continental shelf (Melin & DeLong, 2000; Melin et al., 2008). Lowry and Forney (2005) estimated that 47 percent of sea lions would potentially be at-sea during the cold seasons.

Dive durations range from 1.4 to 5.0 minutes, with longer dives during El Niño events; surface intervals range from 0.7 to 17.0 minutes, with sea lions diving about 32–47 percent of the time at sea (Feldkamp et al., 1989; Kuhn & Costa, 2014; Melin et al., 2008; Melin et al., 2012). Adult females alternate between nursing their pup on shore and foraging at sea, spending approximately 67–77 percent of time at sea (Kuhn & Costa, 2014; Melin & DeLong, 2000). Data from satellite tags and time-depth recorders on 15 California sea lions at (nine at SNI and six at San Miguel Island) indicated different foraging strategies with some individuals spending energy at almost twice the rate of other individuals (McHuron et al., 2017).

4.1.31.3 Population and Abundance

The California sea lion is the most abundant pinniped along the California coast. Overall, the California sea lion population is abundant and generally increasing (Carretta et al., 2010; Jefferson et al., 2008; Lowry et al., 2017). In spite of the robustness of the overall species population, in Mexican waters in the Gulf of California, the abundance of California sea lions has declined over the last decade (Urrutia & Dziendzielewski, 2012). A time-series data analysis supported the hypothesis that the Gulf of California has four subpopulations of California sea lions, three of which exhibit lower-than-expected growth rates and two of which have high probabilities of extinction within the next 50 years (Ward et al., 2010).

Using count and resighting data gathered between 1975 and 2015, NMFS researchers showed that California sea lion population growth was above the maximum net productivity level and within the range of the optimal sustainable population (Laake et al., 2018). This research also noted that the species abundance can be dramatically decreased by increasing sea surface temperature associated with El Niño events or similar regional ocean temperature anomalies (Laake et al., 2018).

4.1.32 NORTHERN FUR SEAL (*CALLORHINUS URSINUS*)

4.1.32.1 Status and Management

Two stocks of northern fur seals are recognized in United States waters: an Eastern Pacific stock that breeds in southern Bering Sea, and a California stock (Carretta et al., 2017a; Muto et al., 2018b). The California stock is present in the PMSR Study Area, is not considered depleted under the MMPA, and is not listed under the ESA (Carretta et al., 2017a).

4.1.32.2 Geographic Range and Distribution

Northern fur seals range throughout the north Pacific along the west coast of North America, from California (32° N) to the Bering Sea, and west to the Sea of Okhotsk and Honshu Island, Japan (36° N) (Baird & Hanson, 1997; Carretta et al., 2010; Gentry, 2009; Jefferson et al., 2008; Ream et al., 2005). Olesiuk (2012) characterized northern fur seals as ubiquitous in the North Pacific between 60° N and 40° N latitude, with their distribution at sea driven by prey concentrations associated with oceanographic features such as the boundary of the sub-arctic–sub-tropical transition zone near 42° N latitude (Polovina et al., 2001). Migrating seals and those along the U.S. West Coast are typically found over the edge of the continental shelf and slope (Adams et al., 2014; Gentry, 2009; Kenyon & Wilke, 1953; Sterling & Ream, 2004), although two fur seals were tracked over 2,000 km offshore into the central North Pacific Ocean (Ream et al., 2005). Their offshore distribution has been correlated with oceanographic features (e.g., eddies and fronts) where prey may be concentrated (Ream et al., 2005; Sterling et al., 2014). Northern fur seals are found throughout their Pacific offshore range throughout the year, although seasonal peaks are known to occur. The small breeding population from San Miguel Island migrates north into the north Pacific after the breeding season, arriving in the region in November and December. Females and subadult males are often observed off Canada's west coast during winter (Adams et al., 2014; Baird & Hanson, 1997).

Northern fur seal colonies are present at Adams Cove on San Miguel Island and on Castle Rock, an offshore island 1.1 km northwest of San Miguel Island (Baird & Hanson, 1997; Carretta et al., 2017a; Melin et al., 2012; Pyle et al., 2001; Stewart & Huber, 1993). Northern fur seal can also occasionally be present on SNI during summer (Baird & Hanson, 1997; Carretta et al., 2017a; Melin et al., 2012; Pyle et al., 2001). In aerial surveys of the Channel Islands between 2011 and 2015, the species was only observed at San Miguel Island (Lowry et al., 2017). Animals from the California stock may remain in or near the area throughout the year but generally move to the North Pacific in waters off Washington, Oregon, and Northern California to forage (Carretta et al., 2017a; Koski et al., 1998; Melin et al., 2012; Sterling et al., 2014). In 2005–2006, during a period of cooler ocean temperatures, northern fur seals shifted their distribution from their common occurrence at least 50 km from coast, to being unusually abundant within 10 km of the central California coast (Carretta et al., 2017a; Peterson et al., 2006).

Most northern fur seals, excluding those of the California stock, migrate along continental margins from low-latitude winter foraging areas to northern breeding islands (Gentry, 2009; Ragen et al., 1995). They leave the breeding islands in November and concentrate around the continental margins of the north Pacific Ocean in January and February, where they have access to vast, predictable food supplies and where the Eastern Pacific and the California stocks overlap (Gentry, 2009; Loughlin et al., 1994; Newsome et al., 2007; Ream et al., 2005). Juveniles have been known to conduct trips between 8 and 29 days in duration, ranging from 171 to 680 km (Sterling & Ream, 2004). Adult female fur seals equipped with radio transmitters have been recorded conducting roundtrip foraging trips of up to 740 km (National Marine Fisheries Service, 2007; Robson et al., 2004).

4.1.32.3 Population and Abundance

The abundance of northern fur seals at San Miguel Island, the primary rookery for the California stock, has increased steadily over the past four decades, except for two severe declines associated with El Niño-southern Oscillation events in 1993 and 1998 (Carretta et al., 2015; Carretta et al., 2017a; DeLong & Stewart, 1991; Melin et al., 2006; Melin et al., 2008; Orr et al., 2012). The San Miguel Island population makes up 96 percent of the California stock of northern fur seals (Carretta et al., 2015; Carretta et al., 2017a).

4.1.33 GUADALUPE FUR SEAL (*ARCTOCEPHALUS TOWNSENDI*)

4.1.33.1 Status and Management

The Guadalupe fur seal is listed as threatened under the ESA and depleted under the MMPA throughout its range. Critical habitat for the Guadalupe fur seal has not been designated given that the only areas that meet the definition for critical habitat are outside of U.S. jurisdiction (National Oceanic and Atmospheric Administration, 1985). Guadalupe fur seals were hunted nearly to extinction during the 1800s. The last NMFS status review of the Guadalupe fur seals was conducted in 1984, but with the recent population growth and increase in distribution NMFS has initiated a new status review (Fahy, 2015). All individuals alive today are recent descendants from one breeding colony at Isla Guadalupe and Isla San Benito off Mexico and are considered a single stock (Carretta et al., 2017a; Pablo-Rodríguez et al., 2016).

4.1.33.2 Geographic Range and Distribution

The Guadalupe fur seal is typically found on shores with abundant large rocks, often at the base of large cliffs. They are also known to inhabit caves, which provide protection and cooler temperatures, especially during the warm breeding season (Belcher & Lee, 2002). Adult males, juveniles, and nonbreeding females may live at sea during some seasons or for part of a season (Reeves et al., 1992). Several observations suggest that this species travels alone or in small groups of fewer than five (Belcher & Lee, 2002; Seagars, 1984).

Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa et al., 2010). Guadalupe fur seals are most common at their primary breeding ground of Guadalupe Island, Mexico (Melin & DeLong, 1999). A second rookery was found in 1997 at the San Benito Islands off Baja California (Aurioles-Gamboa et al., 2010; Esperon-Rodriguez & Gallo-Reynoso, 2012; Maravilla-Chavez & Lowry, 1999), and they have also been found in La Paz Bay in the southern Gulf of California (Elorriaga-Verplancken et al., 2016a). Adult and juvenile males have been observed at San Miguel Island, California, since the mid-1960s, and in the late 1990s, a pup was born on the island. Sightings have also occurred at Santa Barbara, San Nicolas, and San Clemente Islands (Stewart, 1981). Other than their occurrence at San Miguel Island, Guadalupe fur seals were not observed at the other Channel Islands in NMFS aerial surveys between 2011 and 2015 (Lowry et al., 2017). Documentation of apparently healthy Guadalupe fur seals in offshore waters of Washington and British Columbia, the increased number of strandings in the Pacific Northwest, the increase in ocean temperature of the Northeastern Pacific, and their increasing population suggest that Guadalupe fur seals may be reinhabiting the northern extent of their previous range (Etnier, 2002; Lambourn et al., 2012). Satellite tracking data from Guadalupe fur seals tagged at Guadalupe Island demonstrating movements into the offshore waters of the Pacific Northwest also support this suggestion (Norris et al., 2015; Norris, 2017a, 2017b). Guadalupe fur seals can be expected to occur in both deeper waters of the open ocean and coastal waters within the PMSR Study Area (Hanni et al., 1997; Jefferson et al., 2015; Norris, 2017b, 2019). Up to 2017, animals from Guadalupe Island affixed with data recording tags (n=39) included adult females, juvenile/sub-adult males and females, and weaned pups/yearlings. Satellite tags (n=26) were placed on rehabilitated pups/yearlings that had stranded in California and were released from central California (Gallo-Reynoso et al., 2008; Norris et al., 2015; Norris, 2017a, 2017b). In 2018, an additional 35 satellite tags were deployed on adult females, juvenile females, and juvenile males. Data from animals leaving Guadalupe Island indicate that Guadalupe fur seals primarily use habitats offshore of the continental shelf between 50 and 300 km from the U.S. West Coast, with approximately one-quarter of the population foraging farther out and up to 700 km offshore (Norris, 2017a, 2019). Females with pups are generally restricted to rookery areas because they must return to nurse their pups (Gallo-Reynoso et al., 2008). Satellite tags have documented the movement of females without pups at least as far as 1,300 km north of Guadalupe Island (approximately Point Cabrillo in Mendocino County, California) (Norris, 2019). Adult males have not been tagged but typically undertake some form of seasonal movement either after the breeding season or during the winter, when prey availability is reduced (Arnould, 2009). Satellite-tagged juvenile males appear to have more variable movement patterns than females. Although most remained within 600 km of Guadalupe Island, only one of 10 satellite tagged males traveled north of Point Cabrillo, California (Norris, 2017a).

4.1.33.3 Population and Abundance

The most recent SARs (Carretta et al., 2017a; Carretta et al., 2017b) reflect the population of Guadalupe fur seals from a survey in 2010, which indicated a total estimated population size of approximately 20,000 animals. Although the estimated growth rate over the period between 1955 and 2010 was approximately 10 percent annually (Carretta et al., 2017a), the ongoing UME involving Guadalupe fur seals (National Marine Fisheries Service, 2019b; National Oceanic and Atmospheric Administration, 2018a) is likely to have impacted that trend (Elorriaga-Verplancken et al., 2016a; Elorriaga-Verplancken et al., 2016b; Ortega-Ortiz et al., 2019). Valdivia et al. (2019) has noted that since being ESA-listed in 1985, the population of the Guadalupe fur seal increased about ninefold at a rate of approximately 15 percent per year.

4.1.34 Harbor Seal (*Phoca vitulina*)

4.1.34.1 Status and Management

The harbor seal is not listed under the ESA. The Society of Marine Mammalogy's Committee on Taxonomy (2016) has determined that all harbor seals in the north Pacific should be recognized as a single subspecies (*Phoca vitulina richardii*) until the subspecies limits of various populations are better known. There are 17 stocks of harbor seal along the U.S. West Coast (Carretta et al., 2017a; Muto et al., 2016); the California stock of harbor seals is the only stock present within the PMSR Study Area.

4.1.34.2 Geographic Range and Distribution

The harbor seal is one of the most widely distributed seals, found in nearly all temperate coastal waters of the northern hemisphere (Jefferson et al., 2008). Harbor seals are generally not present in the deep waters of the open ocean. Harbor seals, while primarily aquatic, also use the coastal terrestrial environment, where they haul out of the water periodically. Harbor seals are a coastal species, rarely found more than 20 km from shore, and frequently occupying bays, estuaries, and inlets (Baird, 2001; Harvey & Goley, 2011; Jefferson et al., 2014). Individual seals have been observed several kilometers upstream in coastal rivers (Baird, 2001). Harbor seals are not considered migratory (Burns, 2009; Carretta et al., 2018a; Harvey & Goley, 2011; Jefferson et al., 2008), and data from 180 radio-tagged harbor seals in California indicated most remained within 10 km of the location where they were captured and tagged (Harvey & Goley, 2011).

Ideal harbor seal habitat includes suitable haulout sites, shelter from high surf during the breeding periods, and sufficient food near haulout sites to sustain the population throughout the year (Bjorge, 2002). Haulout sites vary but include intertidal and subtidal rock outcrops, sandbars, sandy beaches, estuaries, and even peat banks in salt marshes (Burns, 2009; Gilbert & Guldager, 1998; Prescott, 1982; Schneider & Payne, 1983; Wilson, 1978).

Small numbers of harbor seals are found hauled out on coastal and island sites and forage in the nearshore waters off Southern California (Jefferson et al., 2014; Lowry et al., 2008; Lowry et al., 2017). Haulout counts for harbor seals in Southern California are scheduled to occur during the late May to early June to correspond with the peak molt season when the maximum number of harbor seals are onshore (Lowry et al., 2017). In California, approximately 400–600 harbor seal haulout sites are widely distributed along the mainland and on offshore (Lowry et al., 2008; Lowry et al., 2017). The harbor seal haulout sites include mainland beaches and all of the Channel Islands (Lowry et al., 2008; Lowry et al., 2017). There were 1,367 harbor seals counted in the Channel Islands during aerial surveys in July 2015 (Lowry et al., 2017). A total of 15 harbor seals were sighted at sea in waters south of Santa Catalina and to the west and south of San Clemente Island during 18 aerial surveys conducted between 2008 and 2013 in Southern California (Jefferson et al., 2014).

4.1.34.3 Population and Abundance

The most recent (2012) statewide survey of California harbor seal rookeries has indicated that in the Channel Islands the count has been stable or trending as a slight increase since 1995 (Carretta et al., 2015; Carretta et al., 2017a). As noted above, a survey of the Channel Islands in July 2015 counted 1,367 harbor seals in that subset of the California population (Lowry et al., 2017), but there was not comparative information from 2012 to 2015 to allow for examination of the trend over that period.

4.1.35 Northern Elephant Seal (*Mirounga angustirostris*)

4.1.35.1 Status and Management

The northern elephant seal is not listed under the ESA. The northern elephant seal population has recovered dramatically after being reduced to perhaps no more than 10–100 animals surviving in Mexico in the 1890s (Carretta et al., 2010; Hoelzel, 1999; Stewart et al., 1994). Movement and some genetic interchange occur between rookeries, but most elephant seals return to the rookeries where they were born to breed and thus may have limited genetic differentiation (Carretta et al., 2010). There are two distinct populations of northern elephant seals: one that breeds in Baja, Mexico; and a population that breeds in California (Garcia-Aguilar et al., 2018). NMFS considers northern elephant seals in the Study Area to be from the California Breeding Stock, although elephant seals from Baja Mexico frequently migrate north through the PMSR Study Area (Aurioles-Gamboa & Camacho-Rios, 2007; Carretta et al., 2017a).

4.1.35.2 Geographic Range and Distribution

Northern elephant seals are found in both coastal and deep waters of the eastern and central north Pacific. Elephant seals spend more than 80 percent of their annual cycle at sea, making long migrations to offshore foraging areas and feeding intensively to build up the blubber stores required to support them during breeding and molting haulouts (Hindell & Perrin, 2009; Le Boeuf & Laws, 1994; Worthy et al., 1992). Breeding and pupping take place on offshore islands and mainland rookeries (Carretta et al., 2010; Le Boeuf & Laws, 1994; Lowry et al., 2014; Lowry et al., 2017). Small colonies of northern elephant seals breed and haul out on Santa Barbara Island and San Clemente Island, while large colonies are found on San Nicolas, Santa, Rosa, and San Miguel Islands (Lowry et al., 2014; Lowry et al., 2017; Stewart et al., 1993; Stewart et al., 1994); peak abundance in California is during the January–February breeding season (Lowry et al., 2017). Aerial survey that included all the Channel Islands in July 2015 found the majority (approximately 61 percent) of elephant seals at San Miguel Island, approximately 21 percent at SNI, and 18 percent at Santa Rosa Island (Lowry et al., 2017). Elephant seals use these islands as rookeries from late December to February, and to molt from April to July. Northern elephant seals spend little time nearshore and migrate through offshore waters four times a year as they travel to and from breeding/pupping and molting areas on various islands and mainland sites along the Mexico and California coasts.

With most of their prey found in open oceans, northern elephant seal juveniles and females are often found in deepwater zones, while males also engage in benthic foraging and travel as far north as seamounts in the Gulf of Alaska (Le Boeuf et al., 1996; Le Boeuf et al., 2000; Robinson et al., 2012; Simmons et al., 2007; Simmons et al., 2010; Stewart & DeLong, 1995). Northern elephant seals are found in both coastal areas and deeper waters off Southern California (Carretta et al., 2010; Jefferson et al., 2008; Robinson et al., 2012). The foraging range of northern elephant seals extends thousands of kilometers offshore from the breeding range into the central North Pacific Transition Zone well to the north of Hawaii; however, their range is not considered to be continuous across the Pacific (Simmons et al., 2010; Stewart & Huber, 1993). Adult males and females segregate while foraging and migrating (Simmons et al., 2010; Stewart & DeLong, 1995; Stewart, 1997). Adult females mostly range west to about 173° W, between the latitudes of 40° N and 45° N, whereas adult males range farther north into the Gulf of Alaska and along the Aleutian Islands to between 47° N and 58° N (Le Boeuf et al., 2000; Robinson et al., 2012; Stewart et al., 1993; Stewart & DeLong, 1995). Adults stay offshore during migration, while juveniles are often seen along the coasts of Oregon, Washington, and British Columbia (Le Boeuf et al., 1996; Stewart & Huber, 1993). The most far-ranging individual appeared on Nijima

Island off the Pacific coast of Japan in 1989 (Kiyota et al., 1992). This demonstrates the great distances that these animals are capable of covering.

4.1.35.3 Population and Abundance

The population in California continues to increase, but the Mexican stock appears to be stable or slowly decreasing (Carretta et al., 2015; Lowry et al., 2014; Lowry et al., 2017; Stewart & DeLong, 1994). The two most productive elephant seal rookeries as of 2010 have been on San Miguel Island and SNI (Lowry et al., 2014; Lowry et al., 2017). Elephant seals have expanded their pupping range northward in response to continued population growth, and this trend is expected to continue (Hodder et al., 1998; Lowry et al., 2014); there are rookeries as far north as Northern California at the Farallon Islands, Point Reyes, and Castle Rock off Crescent City. Other rookeries within or in the vicinity of the PMSR Study Area are at Cape Martin/Gorda, Piedras Blancas, Point Conception, Santa Rosa Island, Santa Barbara, and San Clemente Island (Lowry et al., 2014; Lowry et al., 2017; Stewart et al., 1994).

5 Type of Incidental Taking Authorization Requested

The Navy requests regulations and a LOA for the take of marine mammals incidental to proposed activities in the PMSR Study Area for the period from 2021 through 2028. 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 behavioral 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) of the MMPA]. 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 testing and training activities within the PMSR Study Area are composed of military readiness activities as that term is defined in Public Law 107-314, because testing and training 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. Most behavioral responses estimated using the Navy's quantitative analysis are not likely to disrupt normal daily variations in behavior such as feeding, reproduction, resting, migration/movement, or social cohesion.

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 verses non-significant behavioral reactions for Cetaceans are currently impossible to quantify. There is a high likelihood that many marine mammals exposed to explosive acoustic sources at or near the surface are not significantly altering or abandoning their natural behavior patterns.

Pinniped reactions to target and missile launches at San Nicolas Island have been monitored consistently since 2001. Reactions to launches are now well documented and predictable. Based on nearly 20 years of monitoring data, NMFS has previously determined that proposed activity on San Nicolas Island from launch events would have a negligible impact on pinnipeds (84 FR 28462 June 19, 2019). As such, the overall impact of target and missile launches on pinnipeds are not expected to affect the species or stocks through effects on annual rates of recruitment or survival of these species.

The PMSR Draft EIS/ OEIS considered all testing and training 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 two stressors could result in the incidental taking of marine mammals:

- **Explosives** (explosive shock wave and sound)
- **Target and missile launches from SNI** (disturbance at haul out sites)

The quantitative analysis process used for the PMSR Draft EIS/OEIS and this request for an LOA to estimate potential exposures to marine mammals resulting from explosive stressors is detailed in the technical report titled *Quantifying Acoustic Impacts on Marine Species: Methods and Analytical Approach for Activities at the Point Mugu Sea Range* (U.S. Department of the Navy, 2019a). The Navy Acoustic Effects Model estimates acoustic and explosive effects without taking mitigation into account; therefore, the model overestimates predicted impacts on marine mammals that may be within mitigation zones. 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 EXPLOSIVE SOURCES AND LAUNCH OF TARGETS AND MISSILES FROM SAN NICOLAS ISLAND

A detailed presentation of effects due to marine mammal exposures resulting from explosives detonated at or near the water's surface in the PMSR Study Area and from target and missile launches from San Nicolas is presented in Chapter 6 (Take Estimates for Marine Mammals). There are no non-acoustic injuries or mortalities expected as demonstrated by the Navy's analysis. Based on the quantitative analysis of explosive sources and target and missile launches from SNI, Table 5-1 summarizes the Navy's take request from testing and training activities annually and the summation of the take requested over a seven-year period. There are no non-acoustic injuries or mortality requested or predicted by the analysis for explosive sources; only acoustic injury as PTS (Level A) and behavioral disturbance (Level B). Analysis of launches monitored at SNI has indicated only Level B behavioral disturbances are expected to occur. As shown, the Navy's quantitative analysis for explosive sources and launches of targets and missiles from SNI estimates 1,087 Level A exposures, and 93,353 Level B exposures to marine mammals in the PMSR over the 7-year LOA period being requested.

Table 5-1: Summary of Annual and 7-Year Take Request from Explosive Sources and Launches of Targets and Missiles from San Nicolas Island

MMPA Category	Source	Annual Authorization Sought	7-Year Authorization Sought
Level A	Explosives	155	1,087
Level B	Explosives and Launches from SNI	13,335	93,353

Chapter 6 (Take Estimates for Marine Mammals) contains descriptions of species-specific results of the quantitative analysis of potential exposures resulting from explosive sources used during testing and

training activities within the PMSR Study Area. A summary of the species-specific takes requested are provided in Table 5-2, listing the annual and seven-year periods.

Table 5-2: Species-Specific Annual and 7-Year Take Request from Explosive Sources

Common Name	Stock/DPS	Annual			7-Year Period**		
		Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS
Blue whale*	Eastern North Pacific	7	4	0	52	27	0
Bryde's whale	Eastern Tropical Pacific	0	0	0	0	0	0
Fin whale*	California, Oregon, and Washington	14	7	1	101	46	7
Gray whale	Eastern North Pacific	9	5	0	65	37	0
	Western North Pacific†	0	0	0	0	0	0
Humpback whale*	California, Oregon, and Washington/Mexico DPS	7	4	0	52	29	0
	California, Oregon, and Washington/Central America DPS	1	0	0	6	0	0
Minke whale	California, Oregon, and Washington	2	1	0	15	6	0
Sei whale*	Eastern North Pacific	0	0	0	0	0	0
Baird's beaked whale	California, Oregon, and Washington	0	0	0	0	0	0
Bottlenose dolphin	California Coastal	0	0	0	0	0	0
	California, Oregon, and Washington Offshore	5	5	1	37	36	4
Cuvier's beaked whale	California, Oregon, and Washington	0	0	0	0	0	0
Dall's porpoise	California, Oregon, and Washington	261	406	49	1,824	2,845	341
Dwarf sperm whale	California, Oregon, and Washington	20	31	6	142	217	43
Harbor Porpoise	Morro Bay	0	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore	0	0	0	0	0	0
	Eastern North Pacific Transient or West Coast Transient[6]	0	0	0	0	0	0
Long-beaked common dolphin	California	66	44	9	454	310	65

Common Name	Stock/DPS	Annual			7-Year Period**		
		Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS
Mesoplodont spp.	California, Oregon, and Washington	0	0	0	0	0	0
Northern right whale dolphin	California, Oregon, and Washington	3	2	1	22	16	4
Pacific white-sided dolphin	California, Oregon, and Washington	11	8	2	76	58	14
Pygmy killer whale	NSD	0	0	0	0	0	0
Pygmy sperm whale	California, Oregon, and Washington	20	31	6	141	219	44
Risso's dolphins	California, Oregon, and Washington	6	3	1	39	24	6
Short-beaked common dolphin	California, Oregon, and Washington	90	65	15	630	456	103
Short-finned pilot whale	California, Oregon, and Washington	0	0	0	0	0	0
Sperm whale*	California, Oregon, and Washington	1	1	0	7	8	0
Striped dolphin	California, Oregon, and Washington	1	1	0	5	4	0
Harbor seal	California	202	120	14	1,415	842	99
Northern elephant seal	California	37	63	22	258	444	152
California sea lion	U.S. Stock	8	12	2	58	81	16
Guadalupe fur seal*	Mexico to California	1	1	0	5	7	0
Northern fur seal	California	0	0	0	0	0	0

*ESA-listed species in PMSR
**7-year total impacts may differ from the annual total times seven as a result of standard rounding
†Only the indicated DPS is ESA-listed
Note: NSD = No stock designation

5.2 Incidental Take of Marine Mammals from Launch Activities at San Nicolas Island

Pinnipeds hauled out on the shoreline of SNI have been observed to behaviorally react to the sound of launches of targets and missiles from launch pads on the island (Naval Air Warfare Center Weapons Division, 2018). Based on discussions with NMFS, current regulations, (see 84 FR 18809) and in light of the monitoring results from past launches (Burke, 2017; Ugoretz, 2016), the estimation of the number of harassments that would be expected to occur as a result of launch events has been based on the total take by species observed for three previous monitoring seasons (2015–2017) divided by the number of launch events over that time period. The Navy has determined that the numbers presented in Table 5-3 represent the number of pinnipeds expected to be hauled out at SNI based on surveys in the five-year period between 2011 and 2015 (Lowry et al., 2017) and the average number of takes observed per launch event (Burke, 2017; Naval Air Warfare Center Weapons Division, 2018; Ugoretz, 2016).

Table 5-3: Species-Specific Level B Take Requests for Pinnipeds from Launches of Targets and Missiles from San Nicolas Island

Species	Stock	Annual	7-Year Total
Family Otariidae (eared seals)			
California sea lion	U.S.	11,000	77,000
Family Phocidae (true seals)			
Harbor seal	California	480	3,360
Northern elephant seal	California	40	280

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6 Take Estimates for Marine Mammals

6.1 ESTIMATED TAKE OF MARINE MAMMALS BY USE OF EXPLOSIVES AT OR NEAR THE SURFACE AND LAUNCH ACTIVITIES AT SAN NICOLAS ISLAND

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 many of the various species of marine mammals predicted to be taken as a result of the proposed Navy testing and training. 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. As detailed in the following sections, separate methods have been used to quantifying exposures resulting from the detonation of explosives at or near the surface and for the potential disturbance of pinnipeds hauled out at SNI during launch events based on years of monitoring results.

6.2 CONCEPTUAL FRAMEWORK FOR ASSESSING EFFECTS FROM EXPLOSIVES AT OR NEAR THE SURFACE AND LAUNCH ACTIVITIES AT SAN NICOLAS ISLAND

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). Sections 6.4 and 6.5 (Acoustic Stressors and Explosive Stressors, respectively) provide background data specific to marine mammals based on best available science and follow this conceptual framework for explosive stressors and launches of targets and missiles from SNI respectively.

As noted previously in this request, there are no explosives proposed to detonate underwater as part of the Proposed Action, only those that detonate at or near the surface of the water. For explosives detonating at or near the surface, 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 have the potential to result from exposure to explosive activities. The categories of potential effects resulting from the use of explosives are:

Injury *- Injury to organs or tissues of an animal.*
Decrease in hearing sensitivity *- 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; although, 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.*

For launches of targets and missiles from SNI, years of monitoring have demonstrated that sound levels at the nearest pinniped haulout sites are not sufficiently high for there to be effects beyond a behavioral reaction (National Marine Fisheries Service, 2019a; Naval Air Warfare Center Weapons Division, 2018). NMFS determined that "…the effects of these military readiness activities will be limited to short-term, localized changes in behavior, including temporarily vacating haul-outs, and possible temporary threshold shift in the hearing of any pinnipeds that are in close proximity to a launch pad at the time of a launch. These effects are not likely to have a significant or long-term impact on feeding, breeding, or other important biological functions. No take by injury or mortality is anticipated, and the potential for permanent hearing impairment is unlikely" (National Marine Fisheries Service, 2019c). Pinnipeds that may be behaviorally harassed by launches of targets and missiles from SNI include California sea lions, harbor seals, and elephant seals, which if they react, may leave a haulout for variable periods of time from minutes to hours. Furthermore, over almost 20 years of monitoring, there is no evidence of injury, mortality, pup abandonment, or other significant impact beyond behavioral harassment during or immediately succeeding any of the SNI launches. No known pinniped injuries or mortalities have occurred since monitoring began in 2001, and few, if any, pinnipeds are believed to have received sound levels strong enough to elicit TTS.

Figure 6-1 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 pressure 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.

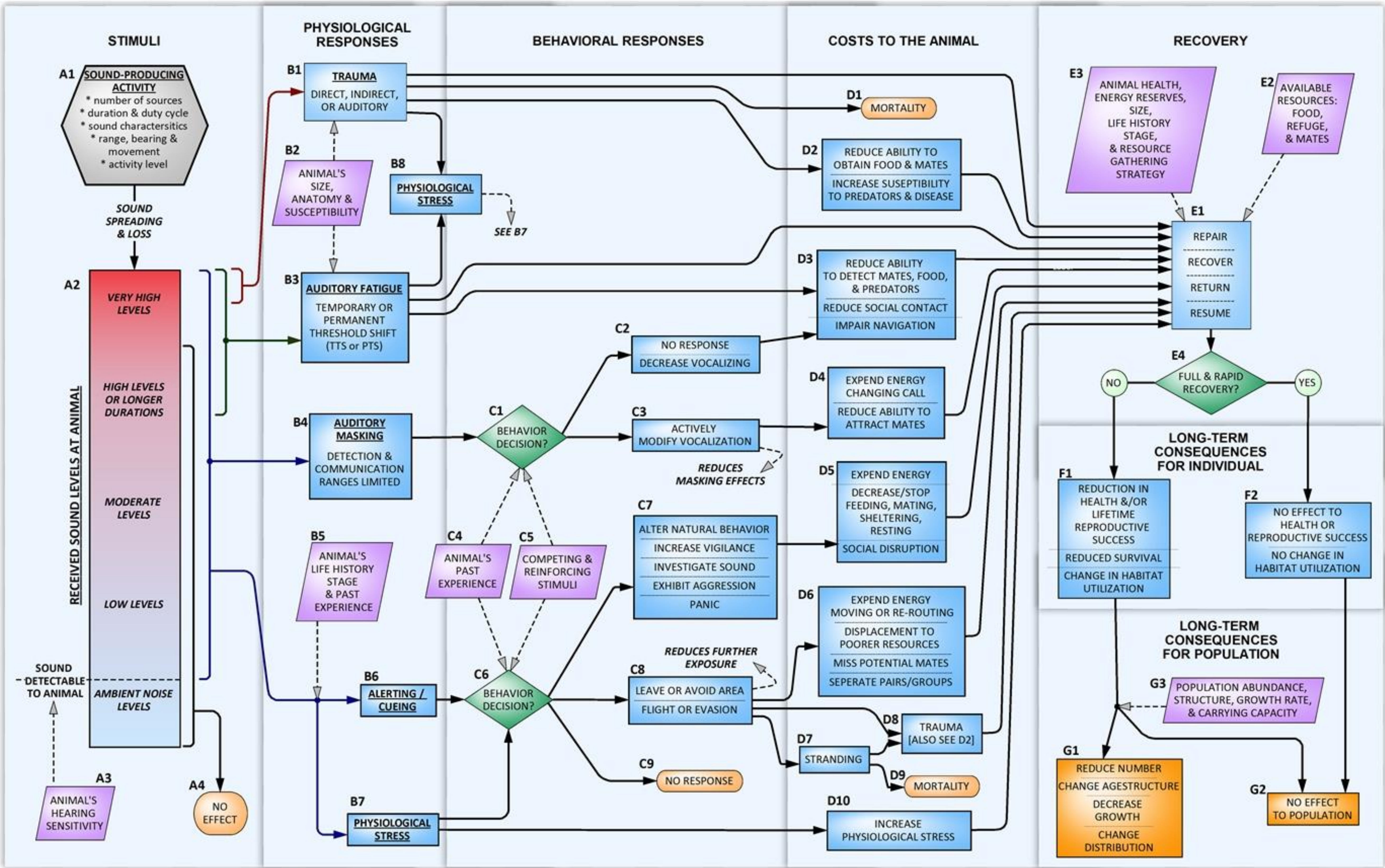

Figure 6-1: Flow Chart of the Evaluation Process of Sound-Producing Activities

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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) use bone and fat channels in the head to conduct sound to the ear; while the auditory canal still exists in pinnipeds, it is narrow and sealed with wax and debris, and external pinnae are absent (Houser & Mulsow, 2016; 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., 2004a; 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 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). However, the thresholds provided by auditory evoked potential methods are 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 et al., 2016). For marine mammal species for which access is limited and therefore psychophysical or Audio-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 6-1 summarizes hearing capabilities for marine mammal species in the study area.

Table 6-1: Species Within Marine Mammal Hearing Groups Likely Found in the Study Area

Hearing Group	Species within the Study Area
High-frequency cetaceans	Dall's porpoise
	Dwarf sperm whale
	Harbor porpoise
	Pygmy sperm whale
Mid-frequency cetaceans	Baird's beaked whale
	Common bottlenose dolphin
	Cuvier's beaked whale
	Ginkgo-toothed beaked whale
	Hubbs' beaked whale
	Killer whale
	Long-beaked common dolphin
	Melon-headed whale
	Northern right whale dolphin
	Pacific white-sided dolphin
	Pantropical spotted dolphin
	Perrin's beaked whale
	Pygmy beaked whale
	Pygmy killer whale
	Risso's dolphin
	Short-beaked common dolphin
	Short-finned pilot whale
	Sperm whale
	Striped dolphin
	Stejneger's beaked whale
Low-frequency cetaceans	Blue whale
	Bryde's whale
	Fin whale
	Gray whale
	Humpback whale
	Minke whale
	Sei whale
Otariids	California sea lion
	Northern fur seal
	Guadalupe fur seal
Phocids	Harbor seal
	Northern elephant seal

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), low-frequency cetaceans (group LF: mysticetes), otariids and other non-phocid marine carnivores in water and air (groups OW and OA: sea lions, walruses, otters, polar bears), and phocids in water and air (group PW and PA: true seals). 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.

In previous Navy analyses, a single representative composite audiogram (Figure 6-2) 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, 2017e).

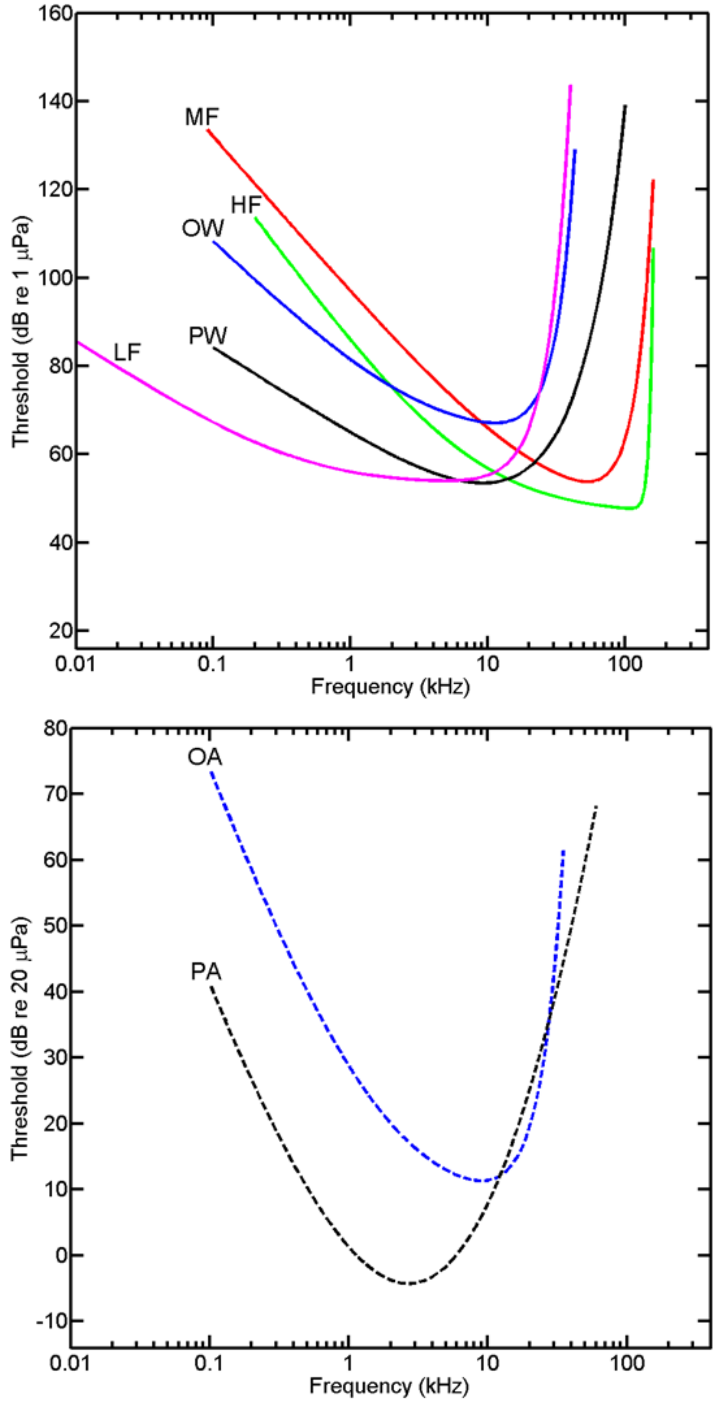
The mid-frequency cetacean composite audiogram is consistent with recently published behavioral audiograms of killer whales (Branstetter et al., 2017). The mid-frequency cetacean composite audiogram is consistent with recently published behavioral audiograms of killer whales (Branstetter et al., 2017). The otariid and phocid composite audiograms are consistent with recently published behavioral audiograms of pinnipeds; these behavioral audiograms also show that pinniped hearing sensitivity at frequencies and thresholds far above the range of best hearing may drop off at a slower rate than previously predicted (Cunningham & Reichmuth, 2015).

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 kilohertz (kHz) range. Of particular note are the very low-frequency calls of mysticete whales that range from tens of hertz (Hz) to several kilohertz 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 and pinnipeds use underwater communicative signals that, while not as low in frequency as those of many mysticetes, likely serve similar functions. These include tonal whistles in some odontocetes, the calls of manatees and dugongs, and the wide variety of barks, grunts, clicks, sweeps, and pulses of pinnipeds. Of additional note are the aerial vocalizations that are produced by pinnipeds, otters, and polar bears. Again, the acoustic characteristics of these signals are quite diverse among species, but they 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 (200–500 microseconds), 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).



For hearing in water (top) and in air (bottom, phocids and otariids only). LF = low frequency, MF = mid-frequency, HF = high frequency, OW = otariids and other non-phocid marine carnivores in water, PW = phocids in water, OA = otariids and other non-phocid marine carnivores in air, PA = phocids in air. Source: Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) (U.S. Department of the Navy, 2017e)

Figure 6-2: Composite Audiograms for Hearing Groups Likely Found in the Study Area

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 (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 (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., 2007b; Southall et al., 2007b). Furthermore, 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 Section 6.2 (Conceptual Framework for Assessing Effects from Explosives at or Near the Surface and Launch Activities at San Nicolas Island). 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, Loss of Hearing Sensitivity and Auditory Injury) 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 result in 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 reduce or avoid as many of these impacts as possible, the Navy implements marine mammal mitigation measures during most Navy testing and training activities (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. The analysis and modeling of activities involving the use of explosives indicates no non-auditory injury would occur; the only injury expected is permanent threshold shift (PTS) as auditory injury. Therefore, non-auditory injury is not discussed or considered further in this analysis.

6.4.1.1.1 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 could 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 has demonstrated that nitrogen bubble formation can occur once animals are brought to the surface and tissues are supersaturated with nitrogen (Bernaldo de Quiros et al., 2013; Moore et al., 2009). Deep diving whales, such as beaked whales, normally have higher nitrogen loads in body tissues, which may make them more susceptible to decompression for certain modeled changes in dive behavior (Fahlman et al., 2014b; Fernández 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 (Fernández 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 (Fernández et al., 2005; Jepson et al., 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (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). However, Costidis and Rommel (Costidis & 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. 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. Researchers have also considered the role of accumulation of carbon dioxide 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).

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 may 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.

Dennison et al. (2011) 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 liver 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.

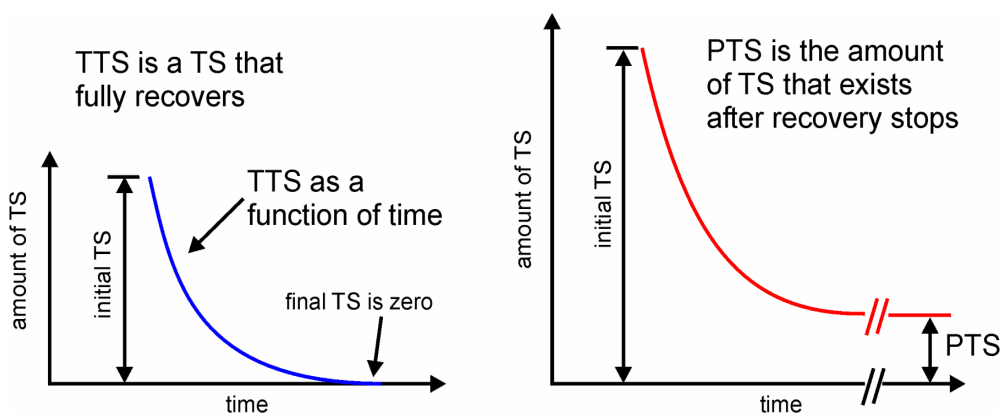
The appearance of extensive bubble and fat emboli in beaked whales is unique to strandings associated with certain high-intensity sonar events; the phenomenon has not been observed in other stranded marine mammals, including other beaked whale strandings not associated with sonar use. Thus, it is uncertain 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). Because of the lack of evidence for extensive nitrogen bubble formation while diving, the Navy believes that the potential for marine mammals to get “the bends” following acoustic exposure to be unlikely and does not consider it in its effect analysis.

6.4.1.2 Loss of Hearing Sensitivity and Auditory Injury

Exposure to intense sound may result in noise-induced loss in hearing sensitivity that persists after cessation of the noise exposure. Loss of hearing sensitivity 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 decibels [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 temporary threshold shift (TTS). If the TS does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining TS is a PTS. Figure 6-3 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, comparing the severity of noise exposures based on the amount of induced TTS can only be done if the 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 2 minutes after exposure; if the TTS is 20 dB after 24 hours, the TTS measured after 2 minutes would likely be much higher. Conversely, if 20 dB of TTS was measured after 2 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 in neural thresholds of 40 dB, measured 24 hours post-exposure, 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 to 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 6-3: 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 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 will 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 to 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., 2005; Finneran, 2015; Ketten, 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured ~4 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 ~4 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., 2010a; Kastelein et al., 2014a; 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., 2014a, 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).

6.4.1.2.1 Threshold Shift due to Explosives as 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 Audio-evoked Potential measured TTS of 7–20 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 decibels referenced to 1 micropascal squared seconds (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 = 193–195 dB re 1 µPa^2s, peak SPL =196–210 dB re 1 µPa) without measurable TTS. Finneran et al. (2003) exposed two sea lions to single impulses from an arc-gap transducer with no measurable TTS (maximum unweighted SEL = 163 dB re 1 µPa^2s, peak SPL = 183 dB re 1 µPa).

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 to 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, 2001b)). 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). 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. 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.

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 noted response to handling stress (St. Aubin & Geraci, 1989; St. Aubin & Dierauf, 2001b).

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). However, this response may have been in part due to the conditions during testing and the young age of the animal, and therefore heart rate may not be a good predictor of a stress response in cetaceans. Along the same lines, a young, recently captured beluga whale exposed to broadband high frequency noise demonstrated a two-stage heart rate response, with an initial tachycardia (increased heart rate) followed by a decreased heart rate (Bakhchina et al., 2017). However, 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 likely acclimated to its surroundings and was familiar with this type of noise. 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) found a non-linear increase in oxygen consumption with both stroke rate and heart rate in swimming and diving bottlenose dolphins, and found that the average energy expended per stroke increased from 2.81 joules per kilogram per stroke during preferred swim speeds to a maximum cost of 6.41 joules per kilogram per stroke when freely following a boat. Collectively, these results demonstrate the difficulty in interpreting the sparse amount of available information on acute stress responses to sound in marine mammals.

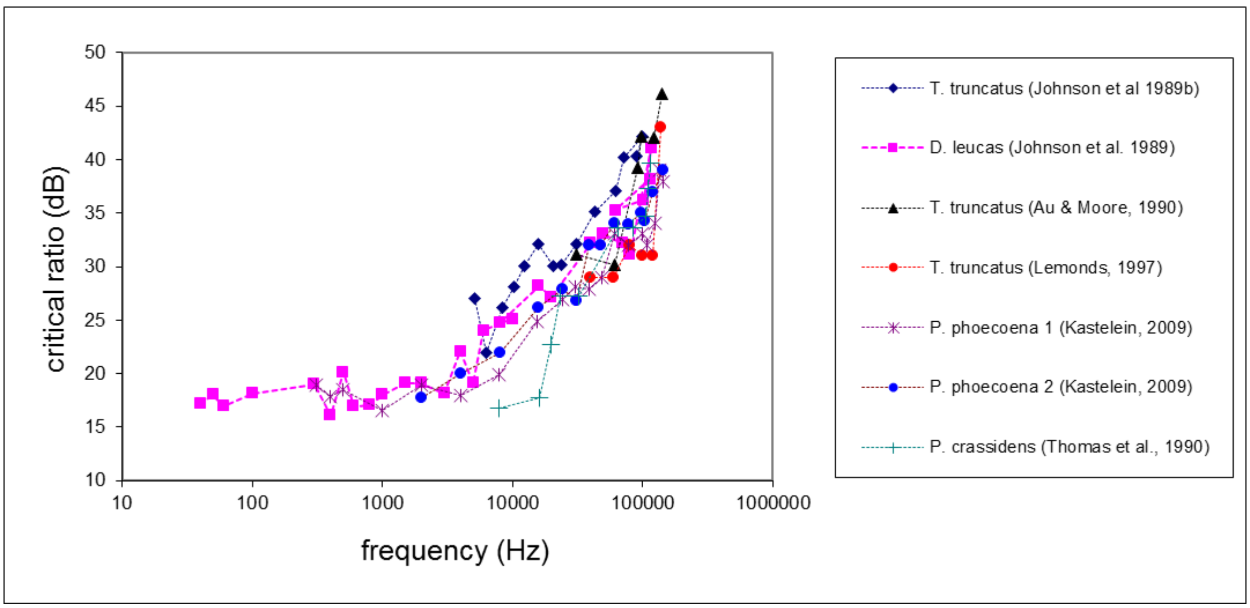
Whereas a limited amount of work has addressed the potential for acute sound exposures to produce a stress response, almost nothing is known about how chronic exposure to acoustic stressors affect stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably 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.

Navy-funded efforts are underway to try and improve our understanding and ability to predict how stressors ultimately affect marine mammal populations (King et al., 2015; e.g., New et al., 2013a; New et al., 2013b; Pirotta et al., 2015a), 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 (St. Aubin & Dierauf, 2001b).

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., 2015). 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., 2015).

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 µPa^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 (from Finneran & Branstetter, 2013, Figure 6-4) (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: 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 (2015) 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, and 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). 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 lead to increase 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).

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, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al., 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, 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 indicating 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 Impulsive Noise

Masking could occur in mysticetes due to the overlap between their low-frequency vocalizations and the dominant frequencies of underwater detonations, however, masking in odontocetes or pinnipeds is less likely unless the animal is close to the detonation. 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 μPa^2s cumulative SEL), but once the received level rose above 127 dB re 1 μPa^2s cumulative SEL the call rate began decreasing, and stopped altogether once received levels reached 170 dB re 1 μPa^2s 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 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 ms 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 1 μPa 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).

6.4.1.5 Behavioral Reactions

As discussed in Section 6.2 (Conceptual Framework for Assessing Effects from Explosives at or Near the Surface and Launch Activities at San Nicolas Island), any stimuli in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels, explosions, 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 a sound such as 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). Factors also 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, 2001a).

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., 2007a; Southall et al., 2007b) 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. (2007b) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al., 2007b; 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, 2017e), Harris et al. (2019), and Henderson et al. (2019)). 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.

6.4.1.5.1 Behavioral Reactions to Impulsive Sound Sources

Impulsive sound sources like underwater detonations, 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. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that responses to seismic sources represent a worst-case scenario compared to responses to Navy explosives, which are the impulsive sources analyzed in this document.

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., 2007b). 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. 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 6–8 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 affect 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 116–129 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).

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. These response patterns are likely to hold true for Navy impulsive sources; however, Navy impulsive sources would largely be stationary (e.g., pile driving), short term (on the order of hours rather than days or weeks), and lower source level (e.g., air guns) than were found in these studies and so responses would likely occur in closer proximity or not at all.

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. (2006) 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). Although the whales showed no horizontal avoidance, 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. 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 and 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.

Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995) and Southall et al. (2007b). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa and in air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an underwater impulsive source at levels of 165–170 dB re 1 µPa (Finneran et al., 2003). Harbor and grey seals were also observed to avoid a seismic air gun by rapidly swimming away, and ceased foraging during exposure, but returned to normal behavior afterwards (Thompson et al. 1998, cited in Gordon et al., 2003). In another study, few responses were observed by New Zealand fur seals to a towed air gun array operating at full power; rather, when responses were observed it seemed to be to the physical presence of the vessel and tow apparatus, and these only occurred when the vessel was within 200 m and sometimes as close as 5 m (Lalas & McConnell, 2016). Captive Steller sea lions were exposed to a variety of tonal, sweep, impulsive and broadband sounds to determine what might work as a deterrent from fishing nets. The impulsive sound had a source level of 120 dB re 1 µPa at 1 m, and caused the animals to haul out and refuse to eat fish presented in a net (Akamatsu et al., 1996). Steller sea lions exposed to in-air explosive blasts increased their activity levels and often re-entered the water when hauled out (Demarchi et al., 2012). However, these responses were short-lived; within minutes, the animals had hauled out again, and there were no lasting behavioral impacts in the days following the blasts.

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

Pinnipeds may be the least-sensitive taxonomic group to most noise sources, although some species may be more sensitive than others, and are likely to only respond to loud impulsive sound sources at close ranges by startling, jumping into the water when hauled out, or even cease foraging, but only for brief periods before returning to their previous behavior (e.g., Southall et al. 2007). Pinnipeds may even experience TTS (Section 6.4.1.2, Loss of Hearing Sensitivity and Auditory Injury) before exhibiting a behavioral response (Southall et al., 2007b).

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; Moore et al., 2018; Redfern et al., 2020), fisheries interactions (Read et al., 2006), entanglement (Baird & Gorgone, 2005; Saez et al., 2012; 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.

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 12,545 cetacean strandings and 39,104 pinniped strandings (51,649 total) per year (National Marine Fisheries Service, 2016e). 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, 2017b).

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).

Data were gathered from stranding networks that operate within and adjacent to the PMSR Study Area and reviewed in an attempt to better understand the frequency that marine mammal strandings occur and what major causes of stranding's (both human-related and natural) exist in areas around the PMSR Study Area (Carretta et al., 2019a). Many marine mammals strand due to natural or anthropogenic causes, the majority of reported type of occurrences in marine mammal strandings in the Study Area 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. For additional information on the determination of long-term consequences, see documents (U.S. Department of the Navy, 2018a, 2018b), regulations, and a Letter of Authorization from NMFS (83 FR 66849; 27 December 2018), and a recent Biological Opinion (National Marine Fisheries Service, 2018b) involving the same types of Navy activities and the same populations of protected marine mammals occurring in the PMSR Study Area. Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury; however, no such mortality or injury is expected to occur based on the standard modeling. Modeling for the PMSR activities does predict both permanent and temporary hearing impairment may occur (see Table 5-1). These effects on marine mammal hearing could range from impairing an animal's navigation, foraging, predator avoidance, or communication to having no meaningful consequences to an individual animal's routine. Most of the impacts on marine mammals from the analysis of Navy testing and training are predicted to be behavioral reactions to an activity. 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 under the various alternatives.

The best assessment of long-term consequences from Navy testing and training 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 testing and training activities on marine species and the effectiveness of the Navy's current mitigation practices. 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 PMRF indicate no changes in detection rates for several species over the past decade. Continued monitoring efforts over time will be necessary to begin to evaluate the long-term consequences of exposure to noise sources.

6.5 Explosive Stressors

6.5.1 Background

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 Explosives at or Near the Surface and Launch Activities at San Nicolas Island (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 in the lungs or GI tract. Large pressure changes at tissue-air interfaces in the lungs and GI 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 GI 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. The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involved the use of explosives in an underwater demolitions training event in 2011 (Danil & St. Ledger, 2011). The Proposed Action does not include this type of training event nor the use of underwater explosives.

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 and Auditory Injury).

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 GI 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.

6.5.1.1.2 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 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 psi-ms (40 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 GI tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25–27 psi-ms (170–90 Pa-s). Lung injuries were found to be slightly more prevalent than GI 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 phocid 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., phocid seals (Kooyman et al., 1973)).

6.5.1.1.3 Peak Pressure as a Predictor of Explosive Injury

High instantaneous peak pressures can cause damaging tissue distortion. Goertner (1982) suggested a peak overpressure GI tract injury criterion because the size of gas bubbles in the GI tract are variable, and their oscillation period could be short relative to primary blast wave exposure duration. The potential for GI 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 GI 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 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 GI tract contusions after exposures up to 1147 psi peak pressure, while exposures of up to 588 psi peak pressure resulted in many instances of no observed GI tract effects. The lowest exposure for which slight contusions to the GI tract were reported was 237 dB re 1 µPa peak. As a vulnerable gas-containing organ, the GI 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 and Auditory Injury

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 Explosives at or Near the Surface and Launch Activities at San Nicolas Island (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. General research findings regarding TTS and PTS in marine mammals, as well as findings specific to exposure to other impulsive sound sources, are discussed in Section 6.4.1.2, (Loss of Hearing Sensitivity and Auditory Injury).

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 Explosives at or Near the Surface and Launch Activities at San Nicolas Island (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 (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., 2015). As discussed in the Conceptual Framework for Assessing Effects from Explosives at or Near the Surface and Launch Activities at San Nicolas Island (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 (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.

6.5.1.5 Reactions

As discussed in Conceptual Framework for Assessing Effects from Explosives at or Near the Surface and Launch Activities at San Nicolas Island (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. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds such as those produced by air guns. 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 has 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 6.4.1.5.1, 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 (Section 6.4.1.5).

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).

Starting in January 2013, an elevated number of strandings of California sea lion pups were observed in five Southern California counties. Additional California counties experiencing elevated California sea lion strandings include Santa Barbara County, Ventura County, Los Angeles County, and Orange County. This unusual number of strandings, continuing into 2016, were declared an UME by NMFS (National Oceanic and Atmospheric Administration, 2018a, 2018b). Although this UME was still considered as "ongoing" through 2017, the number of strandings recorded in 2017 were at or below average (National Oceanic and Atmospheric Administration, 2018b). This is the sixth UME involving California sea lions that has occurred in California since 1991. For this 2013–2015 event, NMFS biologists indicated that warmer ocean temperatures have shifted the location of prey species that are no longer adjacent to the rookeries, which thereby impacted the female sea lions' ability to find food and supply milk to their pups (National Oceanic and Atmospheric Administration, 2018b). As a result, this confluence of natural events causes the pups to be undernourished, and many are subsequently found stranded dead or emaciated due to starvation. In 2015, an UME was declared for Guadalupe fur seals along the entire California coast because of an eight-fold increase over the average historical number of strandings (approximately 12 per year) (National Marine Fisheries Service, 2019b; National Oceanic and Atmospheric Administration, 2018a). This event continued into 2017, although the number of animals involved declined in 2017; in April 2017 an additional seven Guadalupe fur seals stranded associated with this UME, with these latest strandings still being investigated. The initial assumption was that the cause for the increase in strandings was a change in the prey base due to warming conditions, but to date there has been no subsequent cause or other information in that regard provided by NMFS (National Oceanic and Atmospheric Administration, 2015, 2018a). In a similar occurrence for gray whales and since January 2019, an elevated number of gray whale strandings has occurred along the west coast of North America from Mexico through Alaska resulting in NMFS declaring a UME for this species (National Marine Fisheries Service, 2019c). This is similar to a previous UME for gray whales that occurred in 1999–2000.

Use of explosives in the ocean also have the potential to result in injuries or strandings. The use of seal bombs as fishery deterrents has resulting in at least three known marine mammal injuries in the past (Carretta et al., 2019a). For Navy activities, such occurrences are rare given there has been only one known occurrence. During a Navy training event on March 4, 2011, at the Silver Strand Training Complex in San Diego, California, four long-beaked common dolphins were killed by an underwater detonation. Further details are provided above. Modified procedures were instituted as a result of that incident to avoid or reduce it from happening in the future; the type of training activity that was underway when that incident occurred is not part of the PMSR Proposed Action. Details of procedures associated with testing and training activities at PMSR are presented in Chapter 11 (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 Conceptual Framework for Assessing Effects from Explosives at or Near the Surface and Launch Activities at San Nicolas Island (Section 6.2). 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, but these are not expected to occur as a result of the Proposed Action at PMSR. Permanent loss of hearing sensitivity (PTS) could potentially impact navigation, foraging, predator avoidance, or communication or may go unnoticed as it does in most older mammal species. 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. As noted previously in Section 1.1 (Introduction), there are no explosives detonated underwater in the Proposed Action, and those that detonate at or near the surface of the water are unlikely to transfer energy underwater sufficient to result in non-auditory injury or mortality. Exposures that result in 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 explosions 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 basis for the analysis of impacts are the criteria and thresholds presented in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a). Detailed information presented includes on how the criteria and thresholds were derived. Using the established the criteria and thresholds (Table 6-2 and Table 6-3), the Navy performed a quantitative analysis to estimate the probability that marine mammals could be exposed to the sound and energy from explosions during Navy testing and training activities and the effects of those exposures. Because no injury or mortality are expected these estimates of probability did not consider animal avoidance of sound-producing activities (leaving the area before the detonation) or the implementation of mitigation meant to avoid or reduce exposures. A detailed explanation of this analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Species: Methods and Analytical Approach for Activities at the Point Mugu Sea Range* (U.S. Department of the Navy, 2019a).

Table 6-2: Criteria to Quantitatively Assess Non-Auditory Injury Due to Underwater Explosions

Impact Assessment Criterion	Threshold
50% Mortality (Impulse)	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
50% Injury (Impulse)	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury (Peak Pressure)	243 dB re 1 µPa SPL peak

Notes: dB re 1 µPa = decibels referenced to 1 micropascal; Pa-s = pascal second; SPL= sound pressure level; D = depth of animal (m); M = mass of animal (kg)

Table 6-3: Onset of Effect Threshold for Estimating Ranges to Potential Effect For Establishment Of Mitigation Zones

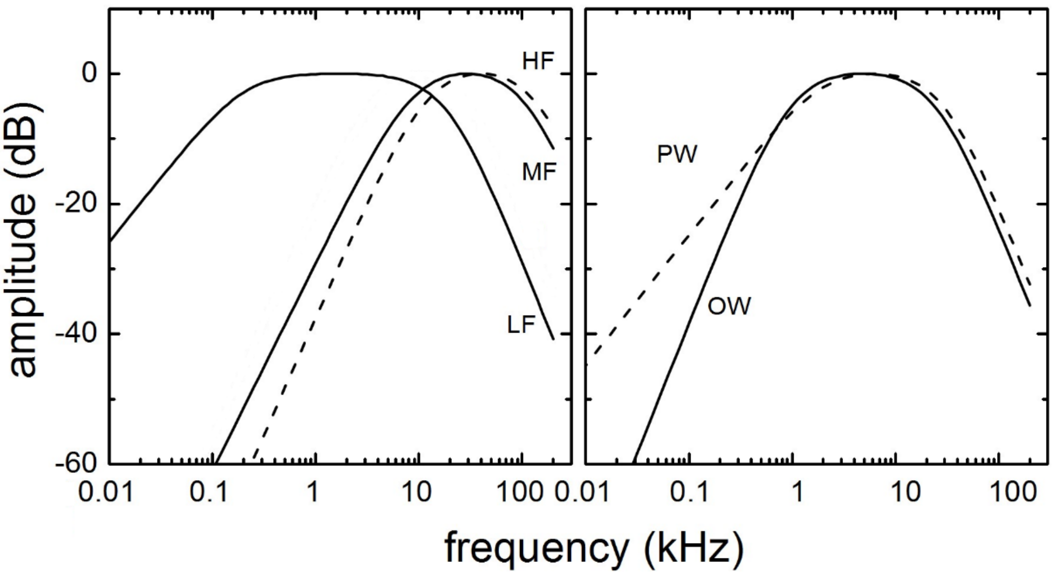
Mitigation Criterion	Threshold
Onset Mortality (Impulse)	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Onset Injury (Impulse)	$47.5M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Onset Injury (Peak Pressure)	237 dB re 1 µPa SPL peak

Notes: dB re 1 µPa = decibels referenced to 1 micropascal; Pa-s = pascal second; SPL = sound pressure level; D = depth of animal (m); M = mass of animal (kg)

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 & Montaro, 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 Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies (Figure 6-5). 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. 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.

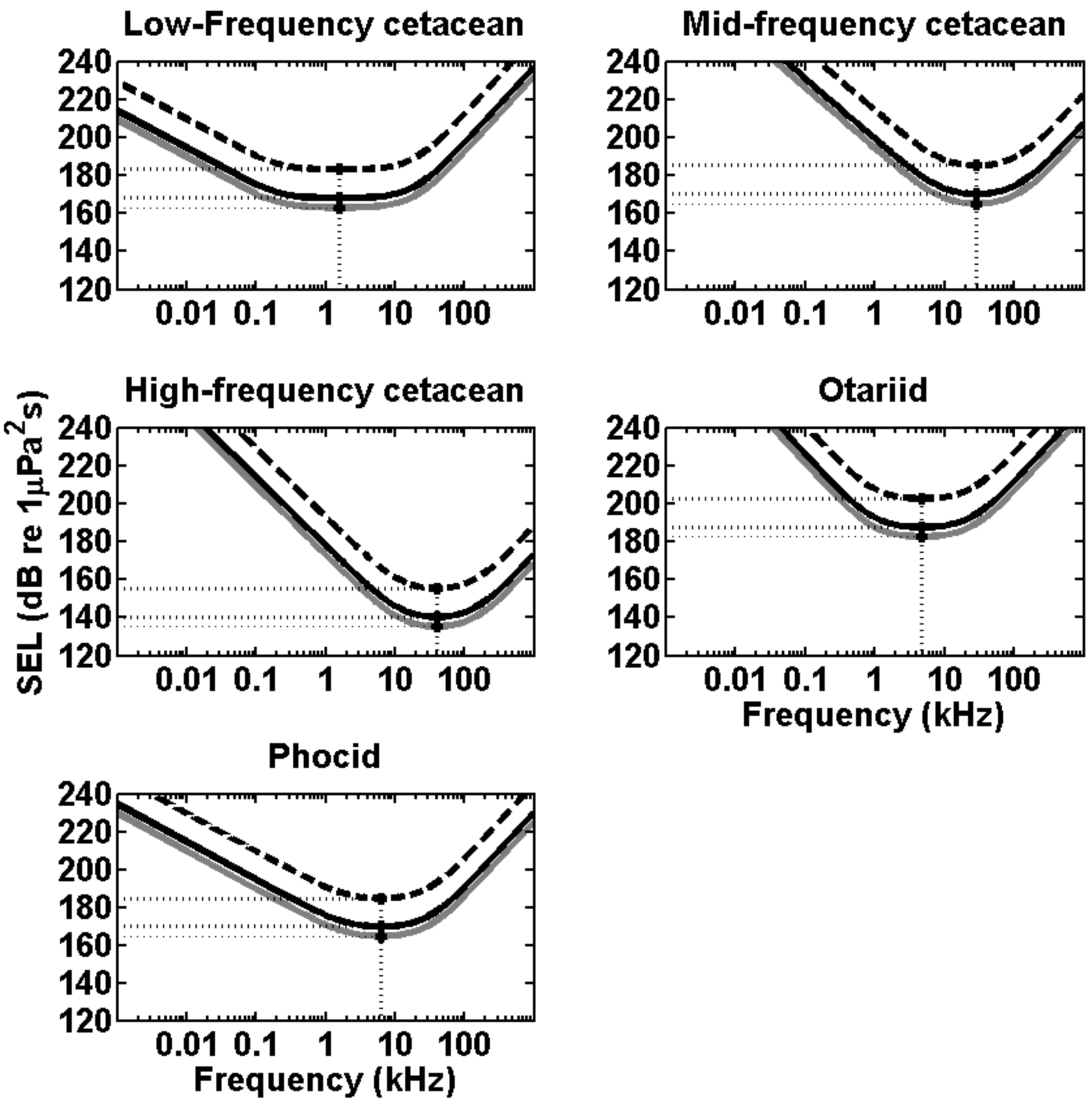


Notes: For parameters used to generate the functions and more information on weighting function derivation see (Finneran, 2015). MF = Mid-Frequency Cetacean; HF = High-Frequency Cetacean; LF = Low-Frequency Cetacean; PW = Phocid (in-water); OW = Otariid (in-water)

Figure 6-5: Navy Weighting Functions for All Species Groups

6.5.2.1.2 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 to 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. (2007b) 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 (Figure 6-6 and Table 6-4).



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 6-6: Navy Behavioral, TTS and PTS Exposure Functions for Explosives

Table 6-4: Navy 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 Thresholds				
	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
Otariids in water	183	188	226	203	232
Phocid seal in water	165	170	212	185	218

Notes: dB = decibels as dB re 1 micropascal; PTS = permanent threshold shift; SEL = sound exposure level; SPL = sound pressure level; TTS = temporary threshold shift

6.5.2.1.3 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 events 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 events, such as certain naval gunnery tests, 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.

As described in Section 1.4.1.1 (Context for Explosives as Acoustic Stressors in the PMSR Study Area), non-Navy underwater detonations associated marine mammal deterrents use by fishermen are a common occurrence in the PMSR (Bland, 2017; Wiggins et al., 2019). Given these deterrents numbering in the thousands in the area are directed towards marine mammals with the intention of causing a behavioral reaction, it is therefore unlikely that Navy detonations occurring at or near the water's surface would constitute a novel acoustic experience for most marine mammals in the area.

6.5.2.1.4 Marine Mammal Density

A quantitative analysis of impacts on a species requires data on their abundance and distribution in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area. To characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. The Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the *Navy Marine Species Density Database* includes seasonal density values for every marine mammal species present within the Study Area (U.S. Department of the Navy, 2017d, 2019a).

6.5.2.1.5 The Navy's Acoustic Effects Model

The Navy's Acoustic Effects Model calculates sound energy propagation from explosions 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 that each record 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 (U.S. Department of the Navy, 2019a).

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 ordnance 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 testing and training events. During any individual modeled event, impacts to 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) (U.S. Department of the Navy, 2019a).

6.5.2.1.6 Accounting for Mitigation

The Navy will implement 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.

The modeling quantifications do not factor in the potential for mitigation to reduce PTS, TTS, or behavioral effects, even though mitigation would 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.

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 Navy Acoustic Effects Model (Section 6.5.2.1.5, The Navy's Acoustic Effects Model). 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 determining adequate mitigation ranges to avoid higher level effects, especially physiological effects to marine mammals.

Ranges to mortality, based on animal mass, are shown in Table 6-5 and Table 6-6, which show 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., net explosive weight; see a detailed discussion of the bins presented in Section 1.5.1.3 [Explosives At or Near the Surface]). These ranges represent the larger of the range to slight lung injury or GI tract injury for representative animal masses ranging from 5 to 72,000 kg and different explosive bins ranging from 0.25 to 1,000 lb. net explosive weight. 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 shows the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 6.5.2.1 (Methods for Analyzing Impacts from Explosives). Ranges are provided for a representative source depth and cluster size for each bin (see description of these bins in Section 1.4.1.2, Explosive Stressors). 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.

Table 6-5: Example Ranges[1] to 50% 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 (2–3)	0 (0–3)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E3	8 (6–10)	4 (2–8)	1 (0–2)	0 (0—0)	0 (0—0)	0 (0–0)
E5	13 (11–45)	7 (4–35)	3 (3–12)	2 (0–8)	0 (0–2)	0 (0–2)
E6	18 (14–55)	10 (5–45)	5 (3–15)	3 (2–10)	0 (0–3)	0 (0–2)
E8	50 (24–110)	27 (9–55)	13 (0–20)	9 (4–13)	4 (0–6)	3 (0–5)
E9	32 (30–35)	20 (13–30)	10 (8–12)	7 (6–9)	4 (3–4)	3 (2–3)
E10	56 (40–190)	25 (16–130)	13 (11–16)	9 (7–11)	5 (4–5)	4 (3–4)

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

Table 6-6: Example Ranges[1] to 50% 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)
E3	25 (25–30)
E5	40 (35–140)
E6	52 (40–120)
E8	117 (75–400)
E9	120 (90–290)
E10	174 (100–480)

Note: All ranges to non-auditory injury within this table are driven by the gastrointestinal (GI) tract injury threshold regardless of animal mass.

The following tables (Table 6-7 through Table 6-16) show the average, minimum, and maximum ranges to onset of auditory and behavioral effects for the various marine mammal hearing groups based on the criteria and thresholds and modeling as cited above. For events with multiple explosions, sound from successive clusters of explosions within a bin (i.e., 25 mm rounds, bin E1; 76 mm rounds, bin E3; and 127 mm (5”) rounds, bin E5) are predicted to accumulate and increase the range to the onset of each type of effect based on the SEL criteria thresholds. Ranges to TTS and PTS are based on the SPL, or peak pressure, for a single explosion, which generally exceeds the corresponding SEL threshold. Ranges to peak pressure thresholds are estimated using the best available science from peer reviewed publications; however, data on peak pressure far from an explosion are very limited. For additional information on how ranges to effects 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* (U.S. Department of the Navy, 2017e). For additional information on the criteria and thresholds for determining behavioral, TTS, or PTS exposures, see the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*.

Table 6-7: Example SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Reaction for High-Frequency Cetaceans

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	353 (130–825)	1,234 (290–3,025)	2,141 (340–4,775)
	25	1,188 (280–3,025)	3,752 (490–8,525)	5,196 (675–12,275)
E3	1	654 (220–1,525)	2,294 (350–4,775)	3,483 (490–7,775)
	12	1,581 (300–3,525)	4,573 (650–10,275)	6,188 (725–14,775)
E5	25	2,892 (440–6,275)	6,633 (725–16,025)	8,925 (800–22,775)
E6	1	1,017 (280–2,525)	3,550 (490–7,775)	4,908 (675–12,275)
E8	1	1,646 (775–2,525)	4,322 (1,525–9,775)	5,710 (1,525–14,275)
E9	1	2,105 (850–4,025)	4,901 (1,525–12,525)	6,700 (1,525–16,775)
E10	1	2,629 (875–5,275)	5,905 (1,525–13,775)	7,996 (1,525–20,025)

[1]Average distance in meters (m) is depicted above the minimum and maximum distances which are in parentheses.
Note: Clusters size refers to ordnance deployed within a short duration, typically within a few minutes. For modeling purposes, counts are modeled as independent sources spaced out in time while clusters are modeled as a group of sources detonating at the same time (i.e., multiple gun bursts).

Table 6-8: Example Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for High-Frequency Cetaceans

Bin	PTS	TTS
E1	660 (170–1,025)	1,054 (270–1,775)
E3	1,261 (290–6,025)	2,068 (480–9,025)
E5	1,869 (410–7,775)	2,751 (600–13,275)
E6	2,177 (525–9,275)	3,136 (625–14,025)
E8	2,986 (925–5,775)	3,806 (1,525–9,775)
E9	3,365 (1,275–8,025)	4,409 (1,525–13,525)
E10	3,791 (1,275–9,775)	5,540 (1,775–26,025)

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

Table 6-9: Example SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Reaction for Low-Frequency Cetaceans

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	51 (40–70)	227 (100–320)	124 (70–160)
	25	205 (95–270)	772 (270–1,275)	476 (190–725)
E3	1	109 (65–150)	503 (190–1,000)	284 (120–430)
	12	338 (130–525)	1,122 (320–7,775)	761 (240–6,025)
E5	25	740 (220–6,025)	2,731 (460–22,275)	1,414 (350–14,275)
E6	1	250 (100–420)	963 (260–7,275)	617 (200–1,275)
E8	1	460 (170–950)	1,146 (380–7,025)	873 (280–3,025)
E9	1	616 (200–1,275)	1,560 (450–12,025)	1,014 (330–5,025)
E10	1	787 (210–2,525)	2,608 (440–18,275)	1,330 (330–9,025)

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

Note: Clusters size refers to ordnance deployed within a short duration, typically within a few minutes. For modeling purposes, counts are modeled as independent sources spaced out in time while clusters are modeled as a group of sources detonating at the same time (i.e., multiple gun bursts).

Table 6-10: Example Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Low-Frequency Cetaceans

Bin	PTS	TTS
E1	126 (55–140)	226 (90–270)
E3	264 (100–320)	453 (140–600)
E5	404 (130–525)	679 (180–1,025)
E6	496 (150–700)	797 (210–6,025)
E8	830 (260–1,275)	1,045 (360–1,775)
E9	966 (310–1,525)	1,240 (420–2,525)
E10	1,057 (330–1,775)	1,447 (450–6,025)

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

Table 6-11: Example SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Reaction for Mid-Frequency Cetaceans

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	25 (25–25)	118 (80–210)	178 (100–320)
	25	107 (75–170)	476 (150–1,275)	676 (240–1,525)
E3	1	50 (45–65)	233 (110–430)	345 (130–600)
	12	153 (90–250)	642 (220–1,525)	897 (270–2,025)
E5	25	318 (130–625)	1,138 (280–3,025)	1,556 (310–3,775)
E6	1	98 (70–170)	428 (150–800)	615 (210–1,525)
E8	1	160 (150–170)	676 (500–725)	942 (600–1,025)
E9	1	215 (200–220)	861 (575–950)	1,147 (650–1,525)
E10	1	275 (250–480)	1,015 (525–2,275)	1,424 (675–3,275)

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

Note: Clusters size refers to ordnance deployed within a short duration, typically within a few minutes. For modeling purposes, counts are modeled as independent sources spaced out in time while clusters are modeled as a group of sources detonating at the same time (i.e., multiple gun bursts).

Table 6-12: **Example Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Mid-Frequency Cetaceans**

Bin	PTS	TTS
E1	43 (35–45)	81 (45–95)
E2	57 (40–65)	102 (50–110)
E3	96 (50–110)	174 (65–210)
E5	149 (65–160)	272 (95–300)
E6	188 (70–230)	338 (110–400)
E8	337 (300–370)	580 (400–750)
E9	450 (350–525)	757 (450–1,025)
E10	534 (240–700)	902 (410–1,275)

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

Table 6-13: Example SEL-Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Otariids

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	7 (7–7)	34 (30–40)	56 (45–70)
	25	30 (25–35)	136 (80–180)	225 (100–320)
	10	25 (25–30)	115 (70–150)	189 (95–250)
E3	1	16 (15–19)	70 (50–95)	115 (70–150)
	12	45 (35–65)	206 (100–290)	333 (130–450)
	12	55 (50–60)	333 (280–750)	544 (440–1,025)
E5	25	98 (60–120)	418 (160–575)	626 (240–1,000)
E6	1	30 (25–35)	134 (75–180)	220 (100–320)
E8	1	50 (50–50)	235 (220–250)	385 (330–450)
E9	1	68 (65–70)	316 (280–360)	494 (390–625)
E10	1	86 (80–95)	385 (240–460)	582 (390–800)

[1]Average distance in meters (m) is depicted above the minimum and maximum distances which are in parentheses.
Note: Clusters size refers to ordnance deployed within a short duration, typically within a few minutes. For modeling purposes, counts are modeled as independent sources spaced out in time while clusters are modeled as a group of sources detonating at the same time (i.e., multiple gun bursts).

Table 6-14: Example Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Otariids Underwater

Bin	PTS	TTS
E1	35 (30–40)	64 (40–95)
E2	45 (35–50)	82 (45–95)
E3	77 (45–95)	133 (60–150)
E5	117 (55–130)	212 (80–250)
E6	148 (65–170)	263 (95–310)
E8	272 (260–280)	482 (370–525)
E9	368 (320–400)	610 (420–800)
E10	442 (230–525)	715 (330–1,025)

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

Table 6-15: Example SEL-Based Ranges[1] for Explosives to PTS, TTS, and Behavioral Reaction for Phocids Underwater

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	45 (40–65)	210 (100–290)	312 (130–430)
	25	190 (95–260)	798 (280–1,275)	1,050 (360–2,275)
E2	1	58 (45–75)	258 (110–360)	383 (150–550)
	10	157 (85–240)	672 (240–1,275)	934 (310–1,525)
E3	1	96 (60–120)	419 (160–625)	607 (220–900)
	12	277 (120–390)	1,040 (370–2,025)	1,509 (525–6,275)
E5	25	569 (200–850)	2,104 (725–9,275)	2,895 (825–11,025)
E6	1	182 (90–250)	767 (270–1,275)	1,011 (370–1,775)
E8	1	311 (290–330)	1,154 (625–1,275)	1,548 (725–2,275)
E9	1	416 (350–470)	1,443 (675–2,025)	1,911 (800–3,525)
E10	1	507 (340–675)	1,734 (725–3,525)	2,412 (800–5,025)

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

Note: Cluster size refers to ordnance deployed within a short duration, typically within a few minutes. For modeling purposes, counts are modeled as independent sources spaced out in time while clusters are modeled as a group of sources detonating at the same time (i.e., multiple gun bursts).

Table 6-16: Example Peak Pressure Based Ranges[1] to Onset PTS ad Onset TTS for Phocids Underwater

Range to Effects for Explosives: Phocids[1]		
Bin	**PTS**	**TTS**
E1	144 (60–160)	258 (95–300)
E2	180 (70–220)	323 (110–370)
E3	303 (100–350)	533 (150–675)
E5	469 (140–600)	815 (190–6,025)
E6	582 (160–775)	910 (230–6,025)
E8	987 (500–1,275)	1,472 (625–2,025)
E9	1,207 (550–1,525)	1,790 (700–3,025)
E10	1,407 (450–3,275)	2,043 (775–5,275)

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

6.5.2.3 Impacts to Marine Mammals from Explosives under the Proposed Action

The results of the analysis of potential impacts to marine mammals from explosives as enumerated in Chapter 5 (Type of Incidental Taking Authorization Requested) are discussed in detail 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 above in Table 5-2. Additionally, estimated numbers of potential impacts from the quantitative analysis for each species are detailed in the following subsections.

6.5.2.4 Mysticetes

Potential impacts on mysticetes from exposure to certain levels of explosive energy and sound may include PTS, TTS, and behavioral reactions; masking; and physiological stress (see 83 FR 66849, U.S. Department of the Navy (2017e), and Section 6.4, Acoustic Stressors). TTS would recover fully, and PTS would leave some residual hearing impairment. Recovery from 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 recover. 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 reduction in hearing sensitivity from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. Mysticetes that do experience threshold shift (i.e., TTS or PTS) from exposure to explosives may have reduced ability to detect biologically important sounds (e.g., social vocalizations). For example, during the short period that a mysticete experiences TTS, 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 success in feeding.

Research and observations (Section 6.4.1.5.1, Behavioral Reactions to Impulsive Sound Sources) show that if mysticetes are exposed to impulsive sounds such as those from explosives, 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 and in consideration of the context for an exposure, mysticetes have been observed to be more reactive to acoustic disturbance when a noise source is located directly in their path or the source is nearby (somewhat independent of the sound level) (Dunlop et al., 2016; Dunlop et al., 2018; Ellison et al., 2011; Friedlaender et al., 2016; Henderson et al., 2019; Malme et al., 1985; Richardson et al., 1995; Southall et al., 2007a). Mysticetes disturbed while migrating could pause their migration or change direction and 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, if they occur at all, are likely to be short term and of little to no consequence (see Pirotta et al. (2018) and Ellison et al. (2011)). Additionally, and as detailed in Section 1.4.1.1 (Context for Explosives as Acoustic Stressors in the PMSR Study Area), mysticetes that seasonally return to the PMSR Study Area are likely to have been exposed on multiple occasions to explosions from seal bombs used by fishermen. As a result, exposure to sound from underwater explosions should not be a novel experience and therefore should be less likely to result in a significant behavioral reaction.

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 these short duration detonations would not be significant. Activities that have multiple, repeated detonations, such as some naval gunfire activities, could result in masking for mysticetes near the target impact area over the duration of the event. Potential impacts on 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, and the effect is over the moment the sound is no longer detectable. In addition, the ubiquitous and near-continuous presence of broadband commercial vessel noise, with energy concentrated below a few hundred Hertz (Section 1.4.1.1, Context for Explosives as Acoustic Stressors in the PMSR Study Area), and the prevalent use of seal bombs by fishermen (Bland, 2017), is likely to overwhelm noise from the Navy's comparatively infrequent use of explosives, except possibly in close proximity to the detonation site. For these same reasons, and due to the short durations and intermittent use of explosives, physiological stress, if it results at all, 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.

6.5.2.4.1 Blue whales

Blue whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis, using the number of explosives per year under the Proposed Action estimates seven behavioral reactions and four TTS may occur annually (see Table 5-2). Considering the factors presented above for mysticetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

As described in Section 4.1.1.2 (Geographic Range and Distribution), three of nine feeding areas for blue whales identified by Calambokidis et al. (2015) along the U.S. West Coast overlap (one wholly and two partially) with the PMSR Study Area (note that these three areas are designated on a seasonal timeframe from June through October). Navy testing and training activities that use explosives could occur year round within the Study Area. However, activities using explosives generally would not take place in the Point Conception/Arguello to Point Sal Feeding Area or the Santa Barbara Channel and San Miguel Feeding Area, because both areas are close to the northern Channel Islands, the National Park/National Marine Sanctuary, oil production platforms, and major vessel routes leading to and from the ports of Los Angeles and Long Beach.

In contrast to the two feeding areas to the north, the area encompassed by the SNI feeding area overlaps a part of the PMSR that has been in high use for Navy testing and training activities for decades; the Proposed Action is for continued use of the area into the future consistent with the past levels of activity. Over the years, there has been very little change in Navy testing and training off SNI, and no significant changes in use are anticipated in the Proposed Action. The waters within Warning Area 289, which overlap with the SNI Feeding Area, are essential for testing and training given their proximity to SNI. The area is used during activities requiring an aerial target impact area, missile launches from SNI, aerial and ship-based gunnery events, and sea surface missile launches. Moving these activities farther from SNI and outside of the SNI Feeding Area would not be possible, because the added distance would substantially limit the capabilities of ground-based telemetry systems, antennas, surveillance, and metric radar systems, as well as command transmitter systems located at Point Mugu, Laguna Peak, Santa Cruz Island, and SNI. These systems are required to measure, monitor, and control various test platforms in real time; collect transmitted data for post-event analysis; and enable surveillance of the area to ensure the safety of the public. Optimal functional distance for some of the ground-based radar systems is 10–200 NM and may be limited by line-of-sight for some systems. Ground-based telemetry systems rely on using in-place fiber optic cables directly linked to remote locations or microwave to transmit signals. The ground-based command transmitter system provides safe, controlled testing of unmanned targets, platforms, and missiles, including unmanned aircraft, boat or ship targets, ballistic missiles, and other long-range vehicles, all within a 40 mile radius of the transmitter. The command transmitter system also provides flight termination capability for weapons and targets that are considered too hazardous for test flights. Relocating ground-based instrumentation to other locations would result in an extensive cost to the Navy, or potentially reduce military readiness.

As discussed above for mysticetes in general, and in light of the underwater acoustic environment at PMSR (as detailed in Section 1.4.1.1, Context for Explosives as Acoustic Stressors in the PMSR Study Area), blue whale behavioral reactions to explosions would most likely be short term and mild to moderate, and may even be ignored, especially when the animals are engaged in important biological behaviors, such as feeding, that may override a startle response due to an explosion. Routine civilian use of seal bombs have been documented over many years, with thousands of those explosions occurring each year at multiple monitoring sites in and around SNI and the PMSR (Baumann-Pickering et al., 2013b; Bland, 2017; Debich et al., 2015a; Debich et al., 2015b; Rice et al., 2017; Rice et al., 2018; Rice et al., 2019; Širović et al., 2016; Wiggins et al., 2019; Wiggins et al., 2018). As a result of the documented widespread use of civilian marine mammal deterrents in the area, the occasional detonations of explosives at or near the ocean surface during Navy testing and training activities should not be a novel experience to blue whales returning to the PMSR Study Area.

Blue whales are known to return to feeding areas regardless of the location's proximate krill productivity in any one year (Abrahms et al., 2019a). However, in a year or season when the area provides limited prey for the whales, they may spend little actual time in the area and move elsewhere in search of prey (Mate et al., 2015b; Mate et al., 2017; Mate et al., 2018). Given the combinations of relatively short time periods and small impact areas of individual Navy testing and training activities in the PMSR and the seasonal variability of blue whale occurrence, a dynamic management approach (see Abrahms et al. (2019b); Dunn et al. (2016); Hazen et al. (2018); Lewison et al. (2015)) may be the most effective means of mitigating impacts on individuals and the population. The current geographic mitigation approach is implemented within a static boundary and is based on an average multi-year occurrence trend, which may not be as effective in mitigating impacts particularly when prey availability in the area is low. As presented in Chapter 5 of the PMSR Draft EIS/OEIS (Standard Operating Procedures and Mitigation), the Navy has focused on avoiding or reducing potential impacts on marine mammals by implementing mitigation wherever and whenever marine mammals are detected within the vicinity of a Navy activity.

Although they are still listed as endangered under the ESA, the most current information suggests that the blue whale population in the North Pacific may have recovered (Campbell et al., 2015; Carretta et al., 2015; Carretta et al., 2019b; International Whaling Commission, 2016; Monnahan, 2013; Monnahan et al., 2014; National Marine Fisheries Service, 2018a; Širović et al., 2015; Smultea, 2014). Considering that the Navy has used the PMSR and other range complexes along the U.S. West Coast for decades coincident in space and time with the apparent recovery of the blue whale population, it is reasonable to conclude that significant impacts on blue whale feeding behaviors from the proposed testing and training activities are unlikely to occur within the SNI Blue Whale Feeding Area.

Pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of Eastern North Pacific stock blue whales.

6.5.2.4.2 Bryde's whales

Bryde's whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to Bryde's whales. Considering these results, the factors presented above for mysticetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of California, Oregon, and Washington stock Bryde's whales.

6.5.2.4.3 Fin whales

Fin whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates 14 behavioral reactions, 7 TTS, and one PTS (see Table 5-2) but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for mysticetes and the mitigation measures that would be implemented as described in Chapter 11

(Mitigation Measures), long-term consequences for the species or stocks would not be expected. Overall, the population trend for fin whales in the area has been a continual increase (Barlow, 2016; Jefferson et al., 2014; Smultea, 2014; Towers et al., 2018).

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock fin whales.

6.5.2.4.4 Gray whales

Gray whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. Almost all of the approximately 21,000[5] gray whales moving through the PMSR are from the non-endangered Eastern North Pacific stock, and all of the predicted impacts are for this stock. For the Eastern North Pacific stock of gray whales, the quantitative analysis using the number of explosives per year under the Proposed Action estimates 9 behavioral reactions and 5 TTS may occur (see Table 5-2) but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Data from satellite tags have indicated that on rare occasions a few endangered Western North Pacific individual gray whales may be present in the Study Area as they migrate through on their way to Mexican waters (Mate et al., 2015a). For the Western North Pacific stock of gray whales, the quantitative analysis estimates no exposures resulting from Navy's activities. Considering the factors presented above for mysticetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stocks would not be expected.

As presented in Section 4.1.3.2 (Geographic Range and Distribution), four migration areas for gray whales are located north of Point Conception, and a fifth area is located contiguous to and south of Point Conception (Calambokidis et al., 2015). Collectively, all five areas are active migration areas from October through July, although each individual area has its own specific date range depending on what portion of the northbound or southbound migration it is meant to cover. Based on an average speed of approximately 6.2 km per hour for migrating gray whales (Mate et al., 2015a), it would take approximately 65 hours for a gray whale moving continuously along a direct route to cross through the entirety of the PMSR Study Area (a distance of approximately 400 km). The whales would cross the PMSR twice a year during their annual southbound and northbound migrations. Navy testing and training activities that use explosives could occur year round within the PMSR, but generally they would occur farther offshore than the shallow-water, nearshore habitat generally preferred by gray whales during their migration.

As noted in Section 1.4.1.1 (Context for Explosives as Acoustic Stressors in the PMSR Study Area), civilian use of seal bombs has been documented over many years with thousands of explosions occurring each year at multiple monitoring sites in and around the PMSR Study Area. Seal bombs are also used within the gray whale migration path along the U.S. West Coast and off Alaska, suggesting that migrating gray whales have likely been exposed to sound from explosions at multiple locations on the U.S. west coast and over multiple years (Baumann-Pickering et al., 2013b; Bland, 2017; Debich et al., 2015a; Debich et al., 2015b; Kerosky et al., 2013; Oleson & Hildebrand, 2012; Rice et al., 2015; Rice et al., 2017; Rice et al.,

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[5] This abundance is approximate since the population trends for gray whales moving through the area as counted has continued to increase (Cooke, 2019; Durban et al., 2017; Guazzo et al., 2019).

2018; Rice et al., 2019; Širović et al., 2016; Trickey et al., 2015; Wiggins et al., 2019; Wiggins et al., 2017; Wiggins et al., 2018). As a result the occasional detonation of explosives at or near the ocean surface during Navy testing and training activities would not be a novel experience to most gray whales migrating through the PMSR Study Area and is unlikely to significantly delay or change their migration behavior.

In an early study investigating the behavior of migrating gray whales exposed to an impulsive source in their migration path, a startle response was observed in 42 percent of the cases, but the change in behavior, when it occurred, did not persist (Malme et al., 1984; Malme et al., 1988; Richardson, 1995). As discussed above for mysticetes in general, if a gray whale were to react to sound from an explosion, it may pause its migration until the noise ceases or moves, or it may choose an alternate route around the location of the sound source if the source was directly in the whale's migratory path. As with most other mysticetes, gray whale reactions to explosions are most likely to be short term and mild to moderate, if they occur at all. Therefore, significant impacts on gray whale migration behaviors from testing and training activities at PMSR are unlikely to occur.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of Eastern North Pacific stock gray whales.

6.5.2.4.5 Humpback whales

Humpback whales may be exposed to sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis, using the number of explosives per year under the Proposed Action estimates seven behavioral reactions and four TTS may occur annually for Mexico DPS humpback whales in the California, Oregon, and Washington stock (see Table 5-2). For the Central America DPS humpback whales in the California, Oregon, and Washington stock, the quantitative analysis estimates one behavioral reaction may occur annually. These estimates do not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures described in Chapter 11 (Mitigation Measures).

There are two identified biologically important humpback whale feeding areas that overlap with a portion of the PMSR Study Area (Calambokidis et al., 2015). These feeding areas are called the Morro Bay to Point Sal Feeding Area (designated from April to November) and the Santa Barbara Channel–San Miguel Feeding Area (designated from March to September) (Calambokidis et al., 2015). Navy testing and training activities that use explosives could occur year round within the Study Area, although they generally would not occur in these relatively nearshore feeding areas, because both areas are close to the northern Channel Islands, the National Park/National Marine Sanctuary, oil production platforms, and major vessel routes leading to and from the ports of Los Angeles and Long Beach.

That acoustic context, as detailed in Section 1.4.1.1 (Context for Explosives as Acoustic Stressors in the PMSR Study Area), includes thousands of fishing related in-water explosions (i.e., seal bombs) occurring at multiple sites in the area. Given the routine and widespread use of civilian explosive marine mammal deterrents, and that proximity to an impulsive source such as an explosion is an important factor in the response of humpback whales to noise (Dunlop et al., 2015; Dunlop et al., 2016; Dunlop et al., 2018; Ellison et al., 2011), it is unlikely that Navy activities involving the detonation of explosives at or near the surface in offshore areas away from the coast would have any meaningful effect on humpback whale feeding behavior in the designated areas.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock humpback whales.

6.5.2.4.6 Minke whales

Minke whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates two behavioral reactions and one TTS may occur annually for the California, Oregon, and Washington stock of minke whales (see Table 5-2). Considering the factors presented above for mysticetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock minke whales.

6.5.2.4.7 Sei whales

Sei whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to sei whales. Considering these results, the factors presented above for mysticetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of California, Oregon, and Washington stock sei whales.

6.5.2.5 Odontocetes

As noted in Section 1.4.1.1 (Context for Explosives as Acoustic Stressors in the PMSR Study Area), given the prevalence of explosions from seal bombs used by fishermen, any Navy activities using explosives are unlikely to be novel experiences for most odontocetes inhabiting the waters of Southern California. For these same reasons and due to the durations and intermittent use of explosives by Navy, physiological stress, if resulting at all, from Navy's activities is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound from explosives would not be expected for odontocetes.

6.5.2.5.1 Baird's beaked whales

Baird's beaked whales may be exposed to sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to the California, Oregon, and Washington stock of Baird's beaked whales (see Table 5-2). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Baird's beaked whales.

6.5.2.5.2 Bottlenose dolphins

Bottlenose dolphins may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to the California Coastal stock of bottlenose dolphins. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington Offshore stock of bottlenose dolphins estimates five behavioral reactions, five TTS, and one PTS may occur (see Table 5-2). These estimates have been made without considering any avoidance or reduction in the number of effects resulting from the implementation of the measures presented Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented, long-term consequences for the species or stocks would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of California Coastal stock of bottlenose dolphins and may result in the incidental harassment of the California, Oregon, and Washington Offshore stock of bottlenose dolphins.

6.5.2.5.3 Cuvier's beaked whales

Cuvier's beaked whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to the California, Oregon, and Washington stock of Cuvier's beaked whales (see Table 5-2). Considering the factors presented above for odontocetes, the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), the documented high abundances observed on the Navy's training and testing areas in Southern California compared to the remainder of the U.S. West Coast (Debich et al., 2015a; Debich et al., 2015b; DiMarzio et al., 2018; Falcone & Schorr, 2012, 2014; Hildebrand & McDonald, 2009; Moretti, 2016; Smultea, 2014), long-term residency by individual beaked whales (Falcone & Schorr, 2012; Schorr et al., 2018), and increasing abundance trend for beaked whales (Moore & Barlow, 2017), the long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Cuvier's beaked whales.

6.5.2.5.4 Dall's porpoises

Dall's porpoises may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of Dall's porpoises estimates 261 behavioral reactions, 406 TTS, and 49 PTS may occur annually (see Table 5-2). These estimates do not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented, long-term consequences for the species or stocks would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Dall's porpoises.

6.5.2.5.5 Dwarf sperm whales

Dwarf sperm whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates 20 behavioral reactions, 31 TTS, and 6 PTS may occur annually for the California, Oregon, and Washington stock of dwarf sperm whales (see Table 5-2). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Dwarf sperm whales.

6.5.2.5.6 Harbor porpoises

Harbor porpoises should only be present in the nearshore edge of the PMSR north of Point Conception, which is not where Navy activities using explosives would be located. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no acoustic exposures to the species. Considering these results, the factors presented above for odontocetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

As detailed in Section 4.1.15.2 (Geographic Range and Distribution), the designated Morro Bay harbor porpoise small and resident population area partially overlaps the northern nearshore portion of the PMSR Study Area. Navy activities that use explosives could occur year round within the Study Area, although generally they would not occur in the relatively nearshore location of the designated area given the nearshore waters are encumbered by proximity to the coastline, oil production platforms, and commercial vessel traffic transiting along the California coast. As provided above, the Navy's acoustic effects model predicts no exposures to harbor porpoise resulting from the use of explosives; therefore, impacts would not be anticipated within the identified small and resident population area for harbor porpoises.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of Morro Bay stock of harbor porpoises.

6.5.2.5.7 Killer whales

Killer whales may be exposed to sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no acoustic effects to the species. Considering these results, the factors presented above for odontocetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of Eastern North Pacific Offshore stock or Eastern North Pacific Transient/West Coast Transient stock killer whales.

6.5.2.5.8 Long-beaked common dolphins

Long-beaked common dolphins may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of long-beaked common dolphins estimates 66 behavioral reactions, 44 TTS, and 9 PTS effects may occur (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of long-beaked common dolphins.

6.5.2.5.9 Mesoplodont beaked whales

Mesoplodont beaked whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to the Mesoplodont beaked whale management group (the six Mesoplodont beaked whale species in this group are *M. densirostris*, *M. carlhubbsi*, *M. ginkgodens*, *M. perrini*, *M. peruvianus*, and *M. stejnegeri*). Considering these results, the factors presented above for odontocetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), and increasing abundance trend for beaked whales (Moore & Barlow, 2017) long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of California, Oregon, and Washington stock of Mesoplodont beaked whales.

6.5.2.5.10 Northern right whale dolphins

Northern right whale dolphins may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of Northern right whale dolphins estimates three behavioral reactions, two TTS, and one PTS may occur annually (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Northern right whale dolphins.

6.5.2.5.11 Pacific white-sided dolphins

Pacific white-sided dolphins may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of Pacific white-sided dolphins estimates 11 behavioral reactions, 8 TTS, and 2 PTS may occur annually (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 5 (Standard Operating Procedures and Mitigation) of the PMSR Draft EIS/OEIS. Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Pacific white-sided dolphins.

6.5.2.5.12 Pygmy killer whales

Pygmy killer whales are only likely to be present in the PMSR Study Area in the warm season and when water temperatures are above normal, as occurred in 2014. The quantitative analysis conservatively assumes their annual presence, but using number of explosives per year under the Proposed Action estimates no acoustic effects to the species. Considering these results, the factors presented above for odontocetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of California, Oregon, and Washington stock of pygmy killer whales.

6.5.2.5.13 Pygmy sperm whales

Pygmy sperm whales may be exposed to sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of pygmy sperm whales estimates 20 behavioral reactions, 31 TTS, and 6 PTS may occur annually (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of pygmy sperm whales.

6.5.2.5.14 Risso's dolphins

Risso's dolphins may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of Risso's dolphins estimates 6 behavioral reactions, 3 TTS, and 1 PTS may occur annually (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation) of the PMSR Draft EIS/OEIS, long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of Risso's dolphins.

6.5.2.5.15 Short-beaked common dolphins

Short-beaked common dolphins may be exposed to sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California, Oregon, and Washington stock of short-beaked common dolphins estimates 90 behavioral reactions, 65 TTS, and 15 PTS may occur annually (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of short-beaked common dolphins.

6.5.2.5.16 Short-finned pilot whales

Short-finned pilot whales may be exposed to sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates no effects to the species may occur (see Table 5-2), and does not consider any avoidance or reduction in the number of effects resulting from the implementation of measures presented in Chapter 11 (Mitigation Measures). Considering these results, the factors presented above for odontocetes, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of California, Oregon, and Washington stock of short-finned pilot whales.

6.5.2.5.17 Sperm whales

Sperm whales may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates one behavioral reaction and one TTS may occur annually (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Navy activities have been occurring in the PMSR for decades and there is evidence for an increasing number of sperm whales in the stock inhabiting the area (Moore & Barlow, 2017). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of California, Oregon, and Washington stock of sperm whales.

6.5.2.5.18 Striped dolphins

Striped dolphins may be exposed to sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action estimates 1 behavioral effect and 1 TTS may occur (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for odontocetes and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of the California, Oregon, and Washington stock of striped dolphins.

6.5.2.6 Pinnipeds

As noted in Section 1.4.1.1 (Context for Explosives as Acoustic Stressors in the PMSR Study Area) and Section 6.4.1.5 (Behavioral Reactions), given the prevalence of explosions from seal bombs used by fishermen, the sound from explosives should not be a novel experience for pinnipeds in the PMSR Study Area. As a result, the sound from explosives occurring at or near the water surface in association with Navy testing and training activities should not generally result in significant behavioral reactions by pinnipeds.

6.5.2.6.1 Phocids (true seals)

Harbor seals

Harbor seals may be exposed to underwater sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California stock of harbor seals estimates 202 behavioral reactions, 120 TTS, and 14 PTS effects may occur (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for pinnipeds and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of the California stock of harbor seals.

Northern elephant seals

Northern elephant seals may be exposed to underwater sound or energy from explosions associated with Navy activities. The quantitative analysis using the number of explosives per year under the

Proposed Action for the California stock of northern elephant seals estimates 37 behavioral reactions, 63 TTS, and 22 PTS effects may occur (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for pinnipeds and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of the California stock of northern elephant seals.

6.5.2.6.2 Otariids (eared seals)

California sea lions

California sea lions may be exposed to underwater sound or energy from explosions associated with Navy activities throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the U.S stock of California sea lions estimates 8 behavioral reactions, 12 TTS, and 2 PTS may occur (see Table 5-2), but does not consider any avoidance or reduction in the number of effects resulting from the implementation of the measures presented in Chapter 11 (Mitigation Measures). Considering the factors presented above for pinnipeds and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives may result in the incidental harassment of the U.S. stock of California sea lions.

Guadalupe fur seals

Guadalupe fur seals may be exposed to underwater sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the Mexico stock of Guadalupe fur seals estimates 1 behavioral reaction and one TTS for the species. Considering these results, the factors presented above for pinnipeds, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of the Mexico stock of Guadalupe fur seals.

Northern fur seals

Northern fur seals may be exposed to underwater sound or energy from explosions associated with Navy activities occurring throughout the year. The quantitative analysis using the number of explosives per year under the Proposed Action for the California stock of northern fur seals estimates no acoustic effects for the species. Considering these results, the factors presented above for pinnipeds, and the mitigation measures that would be implemented as described in Chapter 11 (Mitigation Measures), long-term consequences for the species or stock would not be expected.

Under the Proposed Action, pursuant to the MMPA and based on results predicted by the Navy's Acoustic Effects Model, Navy use of explosives would not result in the incidental harassment of the California stock of northern fur seals.

6.6 ESTIMATED TAKE OF MARINE MAMMALS BY TARGET AND MISSILE LAUNCHES FROM SAN NICOLAS ISLAND

The total estimated take of marine mammals (pinnipeds) per year and over the seven-year period being requested is shown in Table 5-3. The total number launches, the number of takes per launch, and the total annual potential Level B harassments under the Proposed Action are shown in Table 6-17. Under the Proposed Action, there are 40 launch events per year from SNI involving various missiles and aerial targets as described in Section 1.5.1 (Current and Projected Activities), U.S. Department of the Navy (2014), and National Marine Fisheries Service (2019a). As shown in Table 6-17 and consistent with the current NMFS authorization for the activity (84 FR 18809), the total number of pinnipeds assumed to be taken by Level B harassment at SNI per launch is one elephant seal, 12 harbor seals, and 275 California sea lions per launch event.

Table 6-17: Total Annual Launch Related Level B Takes Under the Proposed Action

Total Annual Launches	Species	Takes per Launch	Total Annual Launch Related Level B Harassments
40	Elephant seal	1	40
	Harbor seal	12	480
	California sea lion	275	11,000

Based on observations made during monitoring launch events at SNI for almost two decades (Burke, 2017; Holst & Greene Jr., 2005; Holst et al., 2011), the current incidental harassment authorization (National Marine Fisheries Service, 2019a), and the mitigation measures for this event, the predicted MMPA Level B behavioral harassments are not expected to result in long-term consequences for elephant seals, harbor seals, or California sea lions. Pursuant to the MMPA, land-based launch of targets and missiles from SNI as described for the Proposed Action may result in the unintentional taking of elephant seals, the California stock of harbor seals, and the U.S. stock of California sea lions.

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7 Anticipated Impact of the Activity

Consideration of negligible impact to the species or stock is required for NMFS to authorize incidental take of marine mammals. An activity has a "negligible impact" on a species or stock when the activity cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

The Navy concludes that testing and training activities proposed in the Study Area would result in Level B and Level A takes, as summarized in Chapter 5 (Type of Incidental Taking Authorization Requested). Based on best available science including well over a decade of data from monitoring of Navy activities, the Navy concludes that exposures of marine mammal species and stocks associated with proposed testing and training activities would result in only short-term effects on most individual animals exposed and would not affect annual rates of recruitment or survival for the following reasons:

- Most exposures are Level B harassments resulting from behavioral reactions and non-injurious TTSs.
- There are no non-auditory injuries or mortalities resulting from the analysis.
- Although the numbers presented in Chapter 5 (Type of Incidental Taking Authorization Requested) represent estimated harassment under the MMPA, they are conservative estimates (i.e., overpredictions) of harassment, primarily by behavioral disturbance.
- The mitigation measures described in Chapter 11 (Mitigation Measures) are designed to avoid or reduce the potential for injury from explosive and physical disturbance stressors to the maximum extent practicable.
- Range complexes where intensive testing and training have been occurring for decades have populations of multiple species with strong site fidelity (including resident beaked whales at some locations, and pinnipeds at SNI) and increases in the number of some species.

This request for LOAs assumes that short-term non-injurious SELs 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 explosives detonating at or above the surface 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

A sound-producing activity can cause a variety of behavioral reactions in animals ranging from very minor and brief, to more severe reactions such as aggression or prolonged absence from the area (Southall et al., 2007b). The acoustic stimuli can cause a stress reaction (e.g., startle or annoyance); they may act as a cue to an animal that has experienced a stress reaction in the past to similar sounds or activities, or that acquired a learned behavioral response to the sounds from conspecifics. An animal may choose to deal with these stimuli or ignore them based on the severity of the stress response, the animal's past experience with the sound, and the other stimuli that are present in the environment. If an animal chooses to react to the acoustic stimuli, then the behavioral responses fall into two categories: alteration of natural behavior patterns and avoidance. The specific type and severity of these reactions helps determine the costs and ultimate consequences to the individual and population.

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

The potential long-term consequences from behavioral responses are difficult to discern. Animals displaced from their normal habitat due to an avoidance reaction may return over time and resume their typical normal behaviors. This is likely to depend upon the severity of the reaction and how often the activity is repeated in the area. In areas of repeated and frequent acoustic disturbance, some animals may habituate to the new baseline; conversely, species that are more sensitive may not return, or return but not resume use of the habitat in the same manner. For example, an animal may return to an area to feed but no longer rest in that area. Long-term abandonment or a change in the utilization of an area by enough individuals can change the distribution of the population. Frequent disruptions to natural behavior patterns may not allow an animal to recover between exposures, which increase the probability of causing long-term consequences to individuals.

Animals that recover quickly and completely are unlikely to suffer reductions in their health or reproductive success, or experience changes in habitat utilization. No population-level effects would be expected if individual animals do not suffer reductions in their lifetime reproductive success or change their habitat utilization. Any long-term consequences to the individual can potentially lead to consequences for the population, although population dynamics and abundance play a role in determining how many individuals would need to experience long-term consequences before there was an effect on the population. Abundant or stable populations that suffer consequences on a few individuals may not be affected overall.

7.2 The Context of Behavioral Disruption and TTS–Biological Significance to Populations

The exposure estimates calculated by currently available predictive models reliably predict propagation of sound and received levels and measure a short-term, immediate response of an individual using applicable criteria. Consequences to populations are much more difficult to predict, and empirical measurement of population effects from anthropogenic stressors is limited (King et al., 2015; National Research Council, 2005). However, recent research concludes that it is feasible 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, to changes in vital rates (Fleishman et al., 2016). To predict indirect, long-term, and cumulative effects, the processes must be well understood and the underlying data available for models. In response to the National Research Council review (2005), the Office of Naval Research (ONR) founded a working group to formalize the Population Consequences of Acoustic Disturbance 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, size, 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, 2001b)). 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 robust mitigation procedures proposed in Chapter 11 (Mitigation Measures), PMSR testing and training activities are anticipated to have a negligible impact on marine mammal populations within the Study Area.

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8 Anticipated Impacts on Subsistence Uses

Potential marine mammal impacts resulting from the Proposed Action in the PMSR Study Area will be limited to individuals located in the Study Area and where no subsistence requirements exist. Additionally, no serious injury or mortality is predicted or expected, so Navy actions would have no impact on the availability of marine mammals for subsistence uses. Therefore, impacts on the availability of species or stocks for subsistence use are not considered further.

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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 PMSR EIS/OEIS and was determined to have no impact on marine mammal habitat. A summary of the conclusions are included below.

Water Quality. The PMSR EIS/OEIS analyzed the potential effects on water quality from MEMs. Testing and training activities may introduce water quality constituents into the water column. Based on the analysis of the PMSR EIS/OEIS, MEMs (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. For example, in the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents and the remainder is rapidly diluted below threshold effect level. Explosion by-products associated with high order detonations present no secondary stressors to marine mammals through sediment or water. However, low order detonations and unexploded ordnance present elevated likelihood of impacts on marine mammals.

Indirect effects of explosives and unexploded ordnance to marine mammals via sediment is possible in the immediate vicinity of the ordnance. Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Carniel et al., 2019; Rosen & Lotufo, 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6–12 in. away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3–6 ft. from the degrading ordnance. Taken together, it is possible that marine mammals could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1–6 ft.).

Equipment used by the Navy within the Study Area, including ships and other marine vessels, aircraft, and other equipment, are also potential sources of by-products. 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 (Rice et al., 2018; Wiggins et al., 2018), offshore oil and gas production facilities (Bureau of Ocean Energy Management, 2012, 2017), and in-water explosives from commercial fishing use of explosive seal deterrents (Baumann-Pickering et al., 2013a; Bland, 2017; Rice et al., 2017; Wiggins et al., 2019). Low frequency (15–30 Hz) ambient noise peaks during fall and winter are related to seasonal increases in fin whale calls (Rice et al., 2017).

Anthropogenic noise attributable to Navy testing and training activities in the Study Area emanates from multiple sources including explosives, vessels, and launched targets and missiles occurring in the vicinity of pinniped haul out sites. The sounds produced by Navy activities can be widely dispersed or concentrated in small areas for varying periods. However, any anthropogenic noise attributed to Navy testing and training activities in the Study Area would be temporary, and the affected area would be expected to immediately return to the original state when these activities cease.

Prey Distribution and Abundance. Fish and invertebrate (e.g., squid; krill) marine mammal prey species are present in the Study Area. Fishes, like other vertebrates, have 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., 2004b; 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, 2017). 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,), (2) fishes with a swim bladder not involved in hearing (e.g., salmon, cod, pollock), (3) fishes with a swim bladder involved in hearing (e.g., sardines, anchovy, herring), and (4) fishes with a swim bladder involved in high-frequency hearing (e.g., shad and menhaden).

In terms of behavioral responses, 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. Occasional behavioral reactions to intermittent explosions occurring at or near the surface are unlikely to cause long-term consequences for individual fish or populations; there are no detonations of explosives occurring underwater in the Proposed Action. Fish that experience hearing loss as a result of exposure to explosions 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. Physical effects from pressure waves generated by detonations at or near the surface could potentially affect fish within proximity of training or testing activities. The shock wave from an explosion occurring at or near the surface may be 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. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

In conclusion, testing and training events involving explosions at or near the surface are dispersed in space and time; therefore, repeated exposure of individual fishes are unlikely. Mortality and injury effects to fishes from explosives would be localized around the area of a given explosion at or near the surface, 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 Navy events involving detonations at or near the surface 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 surface targets 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). Explosions could kill or injure nearby marine invertebrates that are close to the surface. 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 and marine mammal habitat.

10 Anticipated Effects of Habitat Impacts on Marine Mammals

The proposed testing and training events for the PMSR 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.

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11 Mitigation Measures

The Navy will implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors to marine mammals. A complete discussion of the evaluation process used to develop, assess, and select mitigation measures can be found in Chapter 5 (Standard Operating Procedures and Mitigation) of the PMSR Draft EIS/OEIS.

The mitigation measures are designed to achieve one or more benefit, 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 are expected to be implemented in association with the testing and training 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 practicable to implement by the definitions provided in Section 5.3.2 (Practicality of Implementing Procedural Mitigation) of the PMSR EIS/OEIS. Specific, case-by-case, mission requirements, safety, and environmental conditions will also be considered when determining a mitigation measure is practicable to implement (e.g. mission essential components, risk to personnel, equipment limitations and fuel constraints, adverse weather).

11.1 Procedural Mitigation

Procedural mitigation is mitigation that the Navy will implement whenever and wherever an applicable training or testing activity takes place within the Study Area. The Navy customizes procedural mitigation for each applicable activity category or stressor. Procedural mitigation generally involves (1) the use of one or more trained Lookouts to diligently observe for specific biological resources within a mitigation zone, (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate watch station for information dissemination, and (3) requirements for the watch station to implement mitigation (e.g., halt an activity) until certain recommencement conditions have been met.

The first procedural mitigation (Table 11-1) is designed to aid Lookouts and other applicable personnel with their observation, environmental compliance, and reporting responsibilities. The remainder of the procedural mitigations are organized by stressor type and activity category.

Table 11-1: Procedural Mitigation for Environmental Awareness and Education

Procedural Mitigation Description
Stressor or Activity • All testing and training activities, as applicable
Mitigation Zone Size and Mitigation Requirements • Appropriate 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: o **Introduction to the U.S. Navy Afloat Environmental Compliance Training Series.** The introductory module provides information on environmental laws (e.g., ESA, MMPA) and the corresponding responsibilities relevant to Navy testing and training. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship. o **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. o **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.

11.1.1 ACOUSTIC STRESSORS

Mitigation measures for weapons firing noise as acoustic stressors are provided in Table 11-2.

Table 11-2: Procedural Mitigation for Weapons Firing Noise

Procedural Mitigation Description
Stressor or Activity • Weapons firing noise associated with large-caliber gunnery activities
Number of Lookouts and Observation Platform • 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 11-7 (Procedural Mitigation for Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions)
Mitigation Requirements • Mitigation zone: – 30° on either side of the firing line out to 70 yd. from the muzzle of the weapon being fired • Prior to the initial start of the activity: – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of weapons firing. • During the activity: – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease weapons firing. • Conditions for commencing/recommencing the activity after a marine mammal or sea turtle sighting before or during the activity: – The Navy will allow a sighted marine mammal or sea turtle 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

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals from the explosive stressors occurring at or near the surface resulting in underwater noise and energy. Mitigation measures for explosive stressors are provided in Table 11-3 through Table 11-5.

Table 11-3: Procedural Mitigation for Explosive Medium-Caliber and Large-Caliber Projectiles

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive medium-caliber and large-caliber projectiles • Mitigation applies to activities using a surface target
Number of Lookouts and Observation Platform 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 11-2 (Procedural Mitigation for 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.

Procedural Mitigation Description

Mitigation Requirements

- Mitigation zones:
  - 200 yd. around the intended impact location for air-to-surface activities using explosive medium-caliber projectiles, or
  - 600 yd. around the intended impact location for surface-to-surface activities using explosive medium-caliber projectiles, or
  - 1,000 yd. around the intended impact location for surface-to-surface activities using explosive large-caliber projectiles.
- Prior to the start of the activity (e.g., when maneuvering on station):
  - Observe for floating vegetation and marine mammals; if observed, relocate or delay the start until the mitigation zone is clear.
  - During the activity, observe for marine mammals; if resource is observed, cease firing.
- Conditions for commencing/recommencing the activity after a marine mammal or sea turtle sighting before or during the activity:
  - The Navy will allow a sighted marine mammal or sea turtle 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 until one of the recommencement 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 or ESA-listed species 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 11-4: 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 at ranges up to 75 NM
<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.
Mitigation Requirements • 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 floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing. • Conditions for commencing/recommencing the activity after a marine mammal or sea turtle sighting before or during the activity: – The Navy will allow a sighted marine mammal or sea turtle 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 or ESA-listed species 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 11-5: Procedural Mitigation for Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Number of Lookouts and Observation Platform • 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.
Mitigation Requirements • Mitigation zone: – 2,500 yd. around the intended target • Prior to the start of the activity (e.g., when arriving on station): – Observe 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. • Conditions for commencing/recommencing of the activity 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 recommencement 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 or ESA-listed species 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 11-6 through Table 11-9.

Table 11-6: Procedural Mitigation for Vessel Movement

Procedural Mitigation Description
Stressor or Activity • 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 impracticable based on mission requirements.
Number of Lookouts and Observation Platform • 1 Lookout on the vessel that is underway
Mitigation Requirements • Mitgation zone: – 500 yd. around whales – 200 yd. around all other marine mammals (except bow-riding dolphins and pinnipeds hauled out on man-made navigational structures, port structures, and vessels) • 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 11-7: 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 11-2 (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 floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing. • Conditions for commencing/recommencing the activity after a marine mammal or sea turtle sighting before or during the activity: – The Navy will allow a sighted marine mammal or sea turtle 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 intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

Table 11-8: Procedural Mitigation for Non-Explosive Missiles and Rockets

Stressor or Activity • Aircraft-deployed non-explosive missiles and rockets • Mitigation applies to activities using a surface target at ranges of up to 75 NM
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 floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing. • Conditions for commencing/recommencing the activity after a marine mammal or sea turtle sighting prior to or during the activity: – The Navy will allow a sighted marine mammal or sea turtle 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 11-9: Procedural Mitigation for Non-Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs
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 start of the activity (e.g., when arriving on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start of bomb deployment until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during approach of the target): – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Conditions for commencing/recommencing the activity after a marine mammal or sea turtle sighting prior to or during the activity: The Navy will allow a sighted marine mammal or sea turtle 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.

11.1.4 Target and Missile Launches from San Nicolas Island

Based on almost 20 years of monitoring, the Navy proposes to make some refinements to existing mitigation measures based on an assessment of the practicality and compatibility of implementing the measures based on planning, scheduling, and conducting vehicle launch activities on SNI. Table 11-10 provides the Navy's proposed future procedural mitigation, taking into consideration factors necessary to meet mission objectives.

Table 11-10: Proposed Procedural Mitigation for Vehicle Launch Activities on SNI

Procedural Mitigation Description
Stressor or Activity • Vehicle launches from SNI
Mitigation Requirements • Navy personnel shall not enter pinniped haulouts. Personnel may be adjacent to pinniped haulouts prior to and following a launch for monitoring purposes. • Missiles shall not cross over pinniped haulouts at elevations less than 305 meters (m) (1,000 ft.) unless necessary to meet test mission objectives. • The Navy may not conduct more than 10 launch events at night unless necessary to meet test mission objectives. • Launches shall be limited during pinniped pupping seasons, to the maximum extent practicable. • All manned aircraft and helicopter flight paths must maintain a minimum distance of 305 m (1,000 ft.) from recognized seal haulouts and rookeries, unless necessary to meet test mission objectives. • If a species for which authorization has not been granted is taken, or a species for which authorization has been granted but the authorized takes are met, the Navy must consult with NMFS to determine how to proceed. • The Navy must review the launch procedure and monitoring methods, in cooperation with NMFS, if any incidents of injury or mortality of a pinniped are discovered during post-launch surveys, or if surveys indicate possible effects to the distribution, size, or productivity of the affected pinniped populations as a result of the specified activities. If necessary, appropriate changes must be made through modification to this Authorization prior to conducting the next launch of the same vehicle.

11.1.5 Awareness Notification Messages

While not specifically mitigation, the Navy will issue awareness notification messages seasonally to alert ships and aircraft to the possible presence of concentrations of large whales in portions of the Study Area. In order to maintain safety of navigation and to avoid interactions with large whales during transit, vessels will be instructed to remain vigilant to the presence of certain large whale species, that when concentrated seasonally, may become vulnerable to vessel strikes. Lookouts will use the information from the awareness notification messages to assist their visual observations of mitigation zones and to aid in implementing procedural mitigation. The Navy anticipates that providing Lookouts additional information about the possible presence of concentrations of large whales in certain locations seasonally will likely help the Navy further avoid interactions with these animals during vessel transits and when training and testing activities are conducted in the area. The Navy reports all whale strikes within the Study Area, should one occur. Navy will issue awareness notification messages for the following species and seasons:

Blue Whale Awareness Notification Message (June 1–October 31):

- The Navy will issue a seasonal awareness notification message to alert ships and aircraft operating in the area to the possible presence of concentrations of large whales, including blue whales.

- To maintain safety of navigation and to avoid interactions with large whales during transits, the Navy will instruct vessels to remain vigilant to the presence of large whale species (including blue whales), that when concentrated seasonally, may become vulnerable to vessel strikes.
- Lookouts will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during testing and training activities and to aid in the implementation of procedural mitigation observation of applicable mitigation zones during testing and training activities and to aid in the implementation of procedural mitigation

Gray Whale Awareness Notification Message (November 1–March 31):

- The Navy will issue a seasonal awareness notification message to alert ships and aircraft operating in the area to the possible presence of concentrations of large whales, including gray whales.
- To maintain safety of navigation and to avoid interactions with large whales during transits, the Navy will instruct vessels to remain vigilant to the presence of large whale species (including gray whales), that when concentrated seasonally, may become vulnerable to vessel strikes.
- Lookouts will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during testing and training activities and to aid in the implementation of procedural mitigation.

Fin Whale Awareness Notification Message (November 1–May 31):

- The Navy will issue a seasonal awareness notification message to alert ships and aircraft operating in the area to the possible presence of concentrations of large whales, including fin whales.
- To maintain safety of navigation and to avoid interactions with large whales during transits, the Navy will instruct vessels to remain vigilant to the presence of large whale species (including fin whales), that when concentrated seasonally, may become vulnerable to vessel strikes.
- Lookouts will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during testing and training activities and to aid in implementation of procedural mitigation.

11.2 Mitigation Summary

The Navy's mitigation measures are summarized in Table 11-11 and Table 11-12.

Table 11-11: Summary of At-Sea Procedural Mitigation

Stressor or Activity	*Summary of Mitigation Zone Requirements*
Weapons Firing Noise	30° on either side of the firing line out to 70 yd.
Explosive Medium-Caliber and Large-Caliber Projectiles	1,000 yd. around the intended impact location (large-caliber projectiles) 600 yd. around the intended impact location (medium-caliber projectiles during surface-to-surface activities) 200 yd. around the intended impact location (medium-caliber projectiles during air-to-surface activities)
Explosive Missiles and Rockets	2,000 yd. around the intended impact location (21–500 lb. net explosive weight) during air to surface activities 900 yd. around the intended impact location (0.6–20 lb. net explosive weight) during air to surface activities
Explosive Bombs	2,500 yd. around the intended impact location during air to surface activities
Vessel Movement	500 yd. distance from the vessel (whales) 200 yd. distance from the vessel (other marine mammals)
Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions	200 yd. around the intended impact location
Non-Explosive Missiles and Rockets	900 yd. around the intended impact location during air to surface activities
Non-Explosive Bombs	1,000 yd. around the intended impact location during air to surface activities
All Activities	The Navy will issue awareness notification messages seasonally to alert ships and aircraft to the possible presence of concentrations of large whales in portions of the Study Area: Blue Whales: June 1–October 31 Gray Whales: November 1–March 31 Fin Whales: November 1–May 31

Table 11-12: Summary of Land-based Procedural Mitigation

Stressor or Activity	***Summary of Mitigation Requirements***
Vehicle Launches from SNI (proposed modifications to be determined during consultation with NMFS)	Navy personnel shall not enter pinniped haulouts. Personnel may be adjacent to pinniped haulouts prior to and following a launch for monitoring purposes. Missiles and targets shall not cross over pinniped haulouts at elevations less than 305 meters (m) (1,000 ft.) unless necessary to meet test mission objectives. The Navy may not conduct more than 10 launch events at night unless necessary to meet test mission objectives. Launches shall be limited during pinniped pupping seasons, to the maximum extent practicable. All manned aircraft and helicopter flight paths must maintain a minimum distance of 305 m (1,000 ft.) from recognized seal haulouts and rookeries, unless necessary to meet test mission objectives. If a species for which authorization has not been granted is taken, or a species for which authorization has been granted but the authorized takes are met, the Navy must initiate informal consultation with NMFS to determine how to proceed. The Navy must review the launch procedure and monitoring methods, in cooperation with NMFS, if any incidents of injury or mortality of a pinniped are discovered during post-launch surveys, or if surveys indicate possible effects to the distribution, size, or productivity of the affected pinniped populations as a result of the specified activities. If necessary, appropriate changes must be made through modification to this Authorization prior to conducting the next launch of the same vehicle.

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 available for subsistence use.

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13 Monitoring and Reporting

In the PMSR, the Navy has been monitoring missile launches at SNI in accordance with the MMPA under IHAs or LOAs since 2001 (National Marine Fisheries Service, 2014a, 2019a). Associated with those authorizations, monitoring reports submitted to NMFS in various periodic reports have included the measuring of sound levels from the launches and documentation the behavior of hauled out pinnipeds before, during, and after those launches by direct observation and in video recordings (Burke, 2017; Holst & Lawson, 2002; Holst & Greene Jr., 2005, 2006; Holst & Greene Jr., 2008; Holst & Greene Jr., 2010; Holst et al., 2011; Holst et al., 2003; Ugoretz & Greene Jr., 2012; Ugoretz, 2014, 2015, 2016). In other locations where Navy testing and training occurs, the Navy has also been conducting marine mammal research and monitoring in the Pacific Ocean for decades. A formal coordinated marine species monitoring program in support of the MMPA and ESA authorizations for the Navy Range Complexes worldwide was first implemented 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 (www.navymarinespeciesmonitoring.us) and the data on the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (www.seamap.env.duke.edu).

The Navy commits to continue monitoring the occurrence, exposure, response and consequences of marine species to Navy testing and training 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 mitigations 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 testing and training actions. No changes to the current monitoring program or reporting that has been made to date. However, discussions with resource agencies during the consultation and permitting processes under the Proposed Action may result in changes to the monitoring 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 included the further development of the Strategic Planning Process (U.S. Department of the Navy, 2013), which is a planning tool for selection of monitoring investments, and its incorporation into the Integrated Comprehensive Monitoring Program, which was used for subsequent 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 (see for example U.S. Department of the Navy (2017c, 2018d)). 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, 2010) 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 testing and training activities on protected marine species is designed to accomplish one or more top-level goals as described in the Integrated Comprehensive Monitoring Program charter (U.S. Department of the Navy, 2010):

- 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 continue to serve as guiding principles for the continued evolution of the Integrated Comprehensive Monitoring Program. Key recommendations include

- 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.
- 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, 2013) 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, 2013);
- 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 testing and training 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 with 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 responses of marine mammals to Navy testing and training 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 testing and training 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 testing and training ranges; and
- Leveraging 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 Navy Monitoring Program 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, 2008)) 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, 2011), ranging from occurrence of animals, to their exposure, response, and population consequences. Lessons-learned with monitoring in the Hawaii Range Complex and the SOCAL Range Complex suggested that “layering” multiple simultaneous components of monitoring could provide a way to leverage an increase in return of the progress toward answering scientific monitoring questions. This approach of layering different monitoring assets continues to the present day, and each component has grown more technically sophisticated in the pursuit of a monitoring study type known as opportunistic behavioral response study.

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 ONR) and demonstration-validation (e.g., Living Marine Resources [LMR]) 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, in the Pacific and Atlantic Oceans at the various testing ranges. Publications from the LMR and ONR programs have also resulted in significant contributions to hearing, acoustic criteria used in effects modeling, exposure, and response, as well as developing tools to assess biological significance (e.g., consequences).

NMFS and Navy also consider data collected during procedural mitigations as monitoring. Data are collected by shipboard personnel on hours spent training, hours of observation, marine mammals observed within the mitigation zone during Major Training Events, mitigations implemented, etc. This data is provided to NMFS in both classified and unclassified annual event reports.

13.5 PROPOSED PMSR NAVY-FUNDED MONITORING

In coordination with NMFS and based on almost 20 years of monitoring on SNI during vehicle launch events on SNI, the Navy has proposed to modify the current monitoring protocols for pinnipeds. The proposed monitoring requirements include the following:

- For missiles or targets not previously monitored for at least three launches, Navy staff shall place video cameras and autonomous audio recorders at up to three selected haulout sites to record pinniped reactions to the launches and received level sound.
- The Navy must use one autonomous audio recorder to make acoustical measurements near the launch site of missiles or targets not previously monitored for at least three launches.
- In consultation with NMFS, the Navy shall develop and implement a monitoring plan for beaches exposed to vehicle launch noise with the goal of assessing baseline pinniped distribution/abundance and potential changes in pinniped use of these beaches after launch events.

13.6 REPORTING

The Navy adheres to the following reporting and coordination requirements for activities within the PMSR:

- Monitoring and annual reporting on observations of pinniped reactions to target and missile launches from SNI Reports
- Ship strike notification
- Stranding notification – marine mammal and sea turtles

The Navy will discuss the need to continue all of these requirements with NMFS during the MMPA and ESA consultations.

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 ONR, 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 ONR, Code 322 Marine Mammals and Biological Oceanography Program. Primary focus of these programs since the 1990s is on understanding the effects of sound on marine mammals, including physiological, behavioral and ecological effects. 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 ONR's current Marine Mammals and Biology Program thrusts include, but are not limited to (1) monitoring and detection research, (2) integrated ecosystem research including sensor and tag development (3) effects of sound on marine life (such as hearing, behavioral response studies, physiology [diving and stress], Population Consequences of Acoustic Disturbance), and (4) models and databases for environmental compliance.

To manage some of the Navy's marine mammal research programmatic elements, OPNAV N45 developed in 2011 a new LMR Research and Development (R&D) Program. The goal of the LMR R&D Program is to identify and fill knowledge gaps and to demonstrate, validate, and integrate new processes and technologies to minimize potential effects to marine mammals and other marine resources. The LMR 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 LMR program include:

- Develop an open and transparent process with a dedicated web site for both project management and public review;
- Provide program management and execution including inputs from various Navy commands involved in monitoring and research;
- Ensure funding of research and development projects that include internationally respected and authoritative researchers and institutions;
- Establish and validate critical needs and requirements with input from a Navy Regional Advisory Committee;
- 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 ONR basic and early stage applied research program;
- Develop effective information for Navy environmental planners and operators;
- Provide effective management of project funding.

The Navy also collaborates regularly with the Bureau of Ocean Energy Management, NMFS, U.S. Fish and Wildlife Service, and other federal agencies on projects with mutual goals. Examples are the 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

Both the ONR and LMR R&D programs have projects ongoing in Southern California waters. The periodicity and length of these research projects varies from one to three years typically, and are on separate approval and funding cycles from the Integrated Comprehensive Monitoring Program. Depending on a given R&D project's goals, and following evaluation of the science provided, cost effectiveness, regional applicability, and other criteria, some R&D technology or analytical techniques may transition to PMSR projects directly via a new technology, or increase the efficiency of current projects. Examples of the former are R&D funding for development and validation of: a) new or improved satellite tracking tags that are now used in many Navy cetacean tracking studies, b) the Marine Mammal Monitoring on Navy Ranges systems that is was developed at the instrumented underwater range located between San Nicolas and San Clemente Islands for acoustic monitoring on instrumented Navy ranges, c) autonomous sea gliders used for acoustic surveys in remote waters of the Pacific. Examples of the latter are improvements to species-specific automated passive acoustic detectors for marine mammal vocalizations. Development and testing of some detectors, which help improve the analysis of large passive acoustic datasets, was funded by Navy R&D investments, and improved detectors are now used by researchers conducting passive acoustic monitoring of marine mammals. Beyond the monitoring program, close integration with the ONR and LMR program also supports improvements in the analyses in the PMSR Draft EIS/OEIS and the associated MMPA and ESA consultations (e.g., new audiograms, risk functions, models).

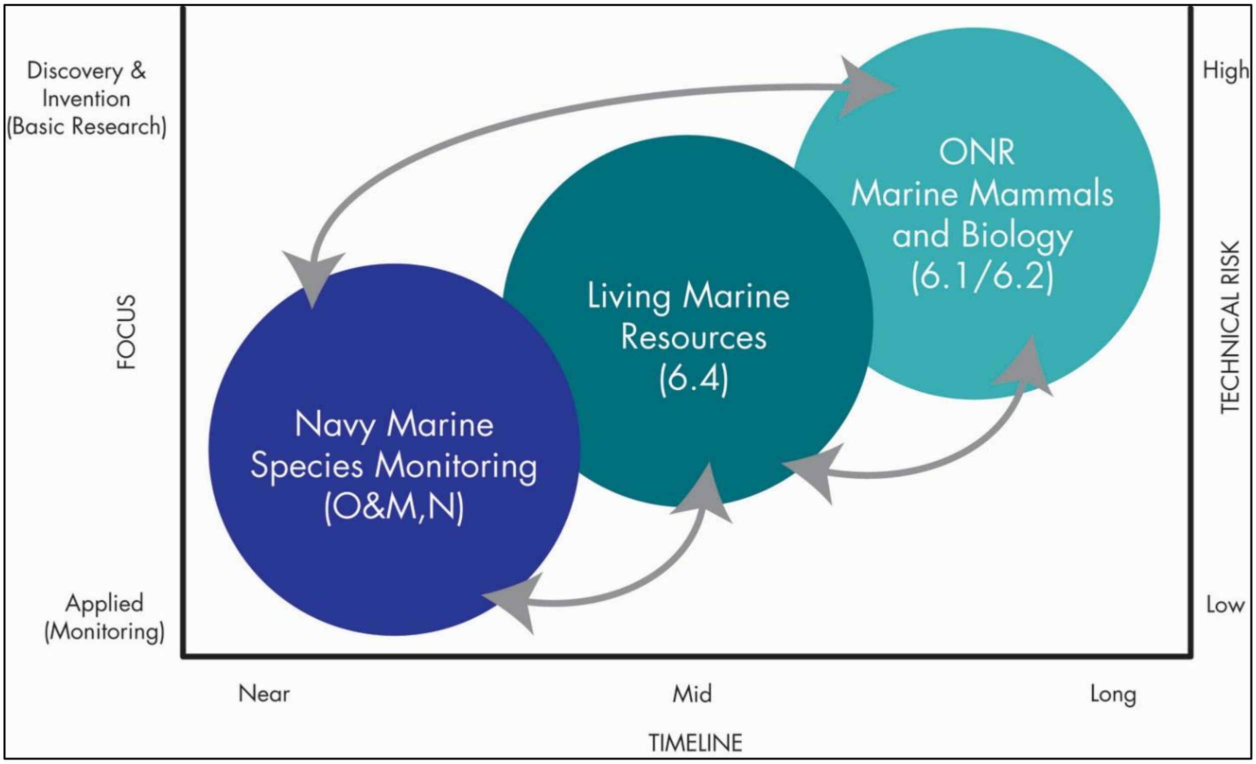
Below are representative Navy R&D funded projects that had started or were ongoing in Southern California as of 2014–2019.

Southern California:

- A Framework For Cetacean Density Estimation Using Slow-moving Underwater Vehicles, Southwest Fisheries Science Center
- Behavioral audiometry in multiple killer whales (*Orcinus orca*), 2015-2017, National Marine Mammal Foundation
- Biomechanical And Energetic Analyses Of Whale-borne Tag Sensor Data To Assess The Population Consequence Of Acoustic Disturbance, Stanford University
- Blood Oxygen Conservation In Diving Sea Lions: How Low Does Oxygen Really Go?, Scripps Institution of Oceanography, University of California San Diego
- Blue and Fin Whale Density Estimation in the U.S. Pacific Fleet Southern California Offshore Range using PAM Data, 2015-2018, Scripps Institution of Oceanography, University of San Diego
- Cetacean Social Behavioral Response To Sonar

- Cuvier's Beaked Whale and Fin Whale Behavior During Military Sonar Operations: Using Medium-term Tag Technology to Develop Empirical Risk Functions, 2016 – 2020, Marine Ecology and Telemetry
- Database and Metrics for Testing Automated Signal Processing for Passive Acoustic Monitoring in Naval Training Ranges, 2014-2017, Scripps Institution of Oceanography, University of California San Diego
- DECAFTEA: Density Estimation for Cetaceans from Acoustic Fixed sensors in Testing and Evaluation Areas, 2015-2019, University of Saint Andrews
- Demonstration of Commercially Available High-Performance PAM Glider and Profiler Float, 2014-2017, Oregon State University
- Frequency-Dependent Growth and Recovery of TTS in Bottlenose Dolphins, 2016-2019, Space and Naval Warfare Systems Center—Pacific
- Improving the Navy's Automated Methods for Passive Underwater Acoustic Monitoring of Marine Mammals, 2014-2016, Space and Naval Warfare Systems Center—Pacific
- Integrated Real-Time Autonomous Passive Acoustic Monitoring (IRAP) System, 2014-2017, OASIS
- Integrating Remote Sensing Methods To Measure Baseline Behavior And Responses Of Social Delphinids To Navy Sonar, Southwest Fisheries Science Center and Southall Environmental Associates, Inc.
- Interactions Among Behavioral Responses Of Baleen Whales To Acoustic Stimuli, Oceanographic Features, And Prey Availability, University of California Santa Cruz and Southall Environmental Associates, Inc.
- Marine Mammal Monitoring on Navy Ranges (M3R), 2009 -2016, Naval Undersea Warfare Center, Newport, RI
- Measuring Stress Hormone Levels And Reproductive Rates In Two Species Of Common Dolphins Relative To Mid-frequency Sonar, Southwest Fisheries Science Center
- Passive Acoustic Density Estimation of Baleen Whales: Using Sonobuoys to Estimate Call Rate Correction Factors, 2015-2017, Southwest Fisheries Science Center
- Southern California Behavioral Response Study, 2010-2017, Southall Environmental Associates
- Technology Demonstration for Fleet Passive Acoustic Monitoring, 2014-2016, Scripps Institution of Oceanography, University of California San Diego
- Using Passive And Active Acoustics To Examine Relationships Of Cetacean And Prey Densities, Scripps Institution of Oceanography, University of California San Diego

The integration between the Navy's ONR and LMR R&D programs, and related Integrated Comprehensive Monitoring Program will continue and improve during this LOA request period as analytical procedures, technology, and new information transitions from R&D to Integrated Comprehensive Monitoring Program (Figure 14-1).



Notes: Parenthesis represent Navy funding sources; 6.1/6.2 = Basic Research, 6.4 = Applied Research, and OM&N (Operation & Maintenance, Navy) = operational funding

Figure 14-1: U.S. Navy Marine Resource Investments From Research To Application

14.2.2 Other Government Funded Research

The Navy also periodically coordinates with, shares information, and on occasion contributes funding to NMFS' Southwest Fisheries Science Center, which conducts marine mammal studies along the U.S. West Coast. The objective of this coordination is to ensure both agencies are aware of each other's efforts, as well as data and resource gaps when specific projects overlap with the Navy's interests in PMSR.

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