NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
SECTION 7 BIOLOGICAL OPINION

Title:	Biological Opinion on (1) U.S. Navy Point Mugu Sea Range (PMSR) Testing and Training Activities; and (2) the National Marine Fisheries Service's Promulgation of Regulations and Issuance of a Letter of Authorization Pursuant to the Marine Mammal Protection Act for the U.S. Navy to "Take" Marine Mammals Incidental to PMSR Activities from February 2022 through February 2029
Consultation Conducted By:	Endangered Species Act (ESA) Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Action Agencies:	United States Navy (Navy) and NOAA's National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division
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1 INTRODUCTION

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed) or designated critical habitat that may be affected by the proposed action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitat, in accordance with the ESA Subsection 7(b)(3)(A), NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is reasonably certain to occur, section 7(b)(4), as implemented by 50 CFR 402.14(g)(7), requires NMFS to provide an incidental take statement (ITS), which exempts take incidental to an otherwise lawful action, and specifies the impact of any incidental taking, including reasonable and prudent measures, considered necessary or appropriate, to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. When the incidental take of ESA-listed marine mammals is reasonable certain to occur, the ITS specifies those measures that are necessary to comply with section 101(a)(5) of the Marine Mammal Protection Act of 1972 and applicable regulations with regard to such taking. 50 C.F.R. §402.14(i)(iii).

The Federal action agencies for this consultation are the United States Navy (Navy) and NMFS's Permits and Conservation Division (Permits Division). The Navy proposes to conduct testing and training activities in the Point Mugu Sea Range (PMSR) Study Area and the Permits Division proposes to promulgate regulations pursuant to the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to PMSR activities. The regulations propose the issuance of a Letter of Authorization (LOA) that will authorize the Navy to "take" marine mammals incidental to its proposed action, pursuant to the requirements of the MMPA.

This consultation was completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. This biological opinion (opinion) and ITS were prepared by the NMFS Office of Protected Resources ESA Interagency Cooperation Division (hereafter referred to as "we" or "us"). This opinion reflects the best available scientific information on the status and life history of ESA-listed species, the stressors resulting from the proposed action, the likely effects of those stressors on ESA-listed species and their habitats, the consequences of those effects to the fitness and survival of individuals, and the risk that those consequences pose to the survival and recovery of the threatened or endangered populations they represent.

This document represents NMFS' opinion on the effects of the proposed PMSR activities and the Permits Division's promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to PMSR activities on the following endangered and threatened species and (where noted) critical habitat that has been designated for those species: blue whale (*Balaenoptera musculus)*, fin whale (*Balaenoptera physalus)*, humpback whale (*Megaptera novaeangliae*) Central America DPS and Mexico DPS and critical habitat, sperm whale (*Physeter macrocephalus*), North Pacific right whale (*Eubalaena japonica*), gray whale Western North Pacific DPS (*Eschrichtius robustus*), sei whale (*Balaenoptera borealis*), Guadalupe fur seal (*Arctocephalus townsendi*), leatherback sea turtle (*Dermochelys coriacea*) and critical habitat, loggerhead sea turtle (*Caretta caretta*) North Pacific DPS, green sea turtle (*Chelonia mydas*) East Pacific and Central North Pacific DPSs, black abalone (*Haliotis cracherodii*), white abalone (*Haliotis sorenseni*), steelhead (*Oncorhynchus mykiss*) Southern California DPS, giant manta ray (*Manta birostris*), and scalloped hammerhead shark (*Sphyrna lewini*) East Pacific DPS.

A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The Navy proposes to conduct military testing activities and operational training activities within the PMSR Study Area starting in February 2022 and continuing into the reasonably foreseeable future. Proposed testing and training activities are similar to those that have occurred in the action area for decades. The Navy has been conducting testing and training activities in the PMSR since the range was established in 1946 (U.S. Navy 2021). 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). The proposed action includes current activities as analyzed in the 2002 PMSR Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) plus changes in operational activity frequency. The Navy consulted informally with NMFS on the activities covered in the 2002 PMSR EIS/OEIS pursuant to ESA section 7 (U.S. Department of the Navy 2002).

1.2 Consultation History

This opinion is based on information provided by the Navy during pre-consultation technical assistance, the Navy's Biological Assessment (final BA dated January, 2021), draft PMSR EIS/OEIS, and supplemental information provided throughout the consultation process. This opinion also considers information provided by NMFS' Permits Division, including its request for ESA section 7 consultation, which included the proposed Federal regulations under the MMPA proposing to authorize the incidental take of marine mammals, including ESA-listed marine mammals, specific to the proposed Navy activities (86 FR 37790) and related draft letters of authorization.

Our communication with the Navy and NMFS' Permits Division regarding this consultation is summarized below:

- On August 20, 2019, the Navy provided us with the PMSR Draft EIS/OEIS V2 for review. NMFS provided comments to the Navy on this version on October 16, 2019.
- On September 27, 2019, the Navy provided us with an ESA section 7 consultation timeline (referred to by the Navy as a "stick chart") for the proposed action.
- On December 10, 2019, the Navy provided us with the PMSR Draft EIS/OEIS V3 for review. NMFS provided comments to the Navy on this version on January 17, 2020.
- On March 5, 2020, the Navy submitted to the NMFS Permits Division a request for Regulations and an application for a Letter of Authorization for military readiness activities occurring on the PMSR beginning in 2021.
- On September 2, 2020, the Navy provided us with a draft PMSR BA for section 7 consultation.
- On October 1, 2020, we provided the Navy with comments on their draft BA.
- On November 25, 2020, the Navy provided us with a revised PMSR BA along with a request for initiation of formal consultation on testing and training activities.
- On December 11, 2020, we provided the Navy with comments on their revised BA and indicated that additional information was needed before we could initiate formal consultation.
- On December 17, 2020, the Navy provided us with a revised consultation timeline with proposed milestones for ESA consultation documents. We responded that we accepted the revised ESA milestones.

- On December 18, 2020, we held a BA comment resolution meeting with the Navy. The Navy provided written responses to our remaining questions/comments in advance of this meeting.

- From December 21-23, 2020, we exchanged emails with the Navy on the topic of loggerhead sea turtle distribution and density in the action area. This information is directly relevant for conducting an effects analysis on the impacts of Navy explosives on this species. Under typical oceanic thermal conditions loggerhead sea turtles are very rare within the action area. However, given the species' thermal preferences, and based on recent studies, their abundance is likely to increase significantly during periods of marine heatwaves.

- On December 30, 2020, the Navy provided us with a revised PMSR BA with changes based on our comment resolution meeting on December 18, 2020.

- On January 5, 2021, we emailed the Navy requesting additional information and clarification on the Navy's approach for analyzing the effects of in air explosions on ESA-listed species. The Navy responded with the additional information and clarification requested on January 7, 2021.

- On January 8, 2021, we notified the Navy that we had accepted the Navy's PMSR Testing and Training BA as complete. We indicated that since the Navy's proposed action is interrelated with the NMFS Permits Division's proposed issuance of regulations in accordance with the MMPA, initiation of formal consultation would commence only after we also receive and accept the NMFS Permits Division's initiation package as complete.

- On January 26, 2021, we emailed the NMFS Permits Division asking when we could expect the proposed MMPA regulations associated with the Navy's proposed action. The Permits Division responded that the proposed rule would likely be published in March, 2021.

- On April 5, 2021, we emailed the Navy requesting additional information on the number of decelerators and parachutes proposed for use annually within PMSR by size category. The Navy responded to our request in emails dated April 5 and April 6, 2021.

- On July 26, 2021, we received a request for formal consultation from the NMFS Permits Division, along with a proposed rule, for its promulgation of regulations and issuance of a letter of authorization pursuant to the MMPA for the U.S. Navy to "take" marine mammals incidental to Point Mugu Sea Range Training and Testing activities from October 2021 through October 2028.

- On July 29, 2021, we emailed the Navy our draft biological opinion on their Point Mugu Sea Range proposed action.

- On August 4, 2021, we emailed the Navy a letter initiating formal consultation on their Point Mugu Sea Range proposed action. We also emailed the Permits Division a memo initiating formal consultation on its proposed MMPA action.

- On August 9, 2021, we received comments from the Navy on our draft biological opinion.

- On August 24, 2021, we met with the Navy to resolve comments on our draft biological opinion.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of an ESA-listed species as a whole (50 C.F.R. §402.02).

This ESA section 7 consultation involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and those aspects (or stressors) of the proposed action that may have effects on the physical, chemical, and biotic environment. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

Action Area (Section 4): We describe the action area with the spatial extent of the stressors from the action.

Potential Stressors (Section 5): We deconstruct the action into the component elements such that we can identify those aspects of the proposed action that are likely to result in stressors from the action that may result in effects on the physical, chemical, and biotic environment within the action area.

Species and Designated Critical Habitat that May be Affected (Section 6): We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time and evaluate the status of those species and critical habitats. During consultation, we determined that some ESA-listed species and critical habitat that occur in the action area were not likely to be adversely affected by the proposed action and detail our effects analysis for these species (Section 6.1). We then describe the status of those species that are likely to be adversely affected by the proposed action (Section 6.2).

Environmental Baseline (Section 7): We describe the environmental baseline in the action area and the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02).

Effects of the Action (Section 8): We evaluate the effects of the action on ESA-listed species and designated critical habitat. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. During our evaluation, we determined that some stressors were not likely to adversely affect ESA-listed species (or categories of ESA-listed species; e.g., marine mammals; Section 8.1) and did not carry them forward for further evaluation. The stressors that we determined were likely to adversely affect ESA-listed species or critical habitats were carried forward for additional analyses (Section 8.2). For those stressors likely to adversely affect ESA-listed species (Section 8.2), we identify the number, age (or life stage), and gender if possible, of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong to the extent possible based on available data. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analysis. Our effects analysis for critical habitat (Section 6.1) considers the impacts of the proposed action on the essential habitat features and conservation value of designated (or proposed) critical habitat within the action area.

Cumulative Effects (Section 9): We describe the cumulative effects in the action area. Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02)

Integration and Synthesis (Section 10): We integrate and synthesize by adding the effects of the action and cumulative effects to the environmental baseline in full consideration of the status of the species and critical habitat likely to be adversely affected, to formulate our opinion as to whether the action would reasonably be expected to: 1) Reduce appreciably the likelihood of both the survival and recovery of the ESA-listed species in the wild by reducing its reproduction, numbers, or distribution; or 2) Appreciably diminish the value of designated critical habitat as a whole for the conservation of an ESA-listed species.

Conclusion (Section 11): We state our conclusions regarding whether the action is likely to jeopardize the continued existence of ESA-listed species or result in the destruction or adverse modification of designated critical habitat. If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative(s) to the action , if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (see 50 C.F.R. §402.14(h)(3)).

Incidental Take Statement (Section 12): An Incidental Take Statement is included for those actions for which take of ESA-listed species is reasonably certain to occur in keeping with the revisions to the regulations specific to ITSs (80 FR 26832, May 11, 2015; ITS rule). The ITS specifies the impact of the take, reasonable and prudent measures considered necessary or appropriate to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i)). The ITS must also include reasonable and prudent measures with implementing terms and conditions to ensure the action is carried out in compliance with any incidental take authorization provided under the MMPA, Section 101(a)(5). Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation (50 C.F.R. §222.102) to include acts that actually kill or injure wildlife and acts that may cause significant habitat modification or degradation that actually kill or injure fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. NMFS has not defined "harass" under the ESA in regulation. However, on December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering" (NMFS 2016a). For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed species.

Conservation Recommendations (Section 13): Consistent with the ESA section 7(a)(1), we also provide discretionary conservation recommendations that may be implemented by the action agency (50 C.F.R. §402.14(j)).

Reinitiation Notice (Section 14): Finally, we identify the circumstances in which reinitiation of consultation is required (50 C.F.R. §402.16).

2.1 Evidence Available for this Consultation

To conduct the analyses necessary for this opinion and to comply with our obligation to use the best scientific and commercial data available, we considered all lines of evidence available through published and unpublished sources. We conducted electronic literature searches throughout this consultation, including within the NMFS Office of Protected Resources' electronic library. We examined the Navy's BA (U.S. Navy 2021), the Navy's Final EIS (U.S. Navy 2022), the literature that was cited in the Navy's BA, FEIS, and DEIS, and the information provied in the Permits Division's proposed MMPA rule (86 FR 37790). These searches were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated (or proposed) critical habitat for the conservation of ESA-listed species. In addition, we engaged regularly with the Navy to discuss new science and technical issues as part of the ongoing adaptive management program for Navy training and testing and incorporated new information obtained as a result of these engagements in this consultation.

As is evident later in this opinion, many of the stressors considered in this opinion involve sounds produced during Navy training and testing activities. Considering the information that was available, this consultation and our opinion includes uncertainty about the basic hearing capabilities of some marine mammals, sea turtles, and fishes; how these taxa use sounds as environmental cues; how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of the different species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals; and the circumstances that are likely to produce outcomes that have adverse consequences for individuals and populations of exposed species. We relied on conservative assumptions when addressing such uncertainties in our analyses of the potential effects of PMSR training and testing activities on ESA-listed species and their designated critical habitat in the action area.

The sections below discuss our approach to analyzing the effects of sound produced by Navy training and testing activities in the PMSR action area on ESA-listed marine mammals and sea turtles. The estimates of the number of ESA-listed marine mammals and sea turtles exposed to sound from Navy training and testing, as well as the magnitude of effects from these exposures (e.g., injury, hearing loss, behavioral response), are from the Navy's acoustic effects analysis described in detail 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 2020). NMFS has independently reviewed and evaluated the Navy's modeling approach for this consultatuion and considers the modeling conclusions from the Navy's analysis to represent the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action. Our analysis of the effects of and potential consequences of such exposures is included in Section 8 of this opinion.

2.2 Acoustic Effects Analysis for Marine Mammals and Sea Turtles

Acoustic stressors include incidental sources of broadband sound produced as a byproduct of vessel movement, aircraft transits, and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique energetic characteristics. To estimate impacts from acoustic stressors (i.e., explosives) associated with proposed training and testing activities, the Navy performed a quantitative analysis to estimate the number of instances that could affect ESA-listed marine mammals and sea turtles and the magnitude of that effect (e.g., injury, hearing loss, behavioral response). The quantitative analysis utilizes the Navy's Acoustic Effects Model (NAEMO) and takes into account criteria and thresholds used to predict impacts in conjunction with spatial densities of species within the action area.

A summary of the quantitative analysis is provided below. A more detailed explanation of this analysis can be found in the Navy's 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 2020). NMFS verified the methodology and data used by the Navy in this analysis and, unless otherwise specified in Section 8 of this opinion, accepted the modeling conclusions on exposure of marine mammals and sea turtles to sound generated by the proposed action. NMFS, as noted, considers the modeling conclusions from the Navy's analysis to represent the best available data on exposure of marine mammals and sea turtles to acoustic stressors from the proposed action and the estimates of take resulting from this analysis are reasonably certain to occur.

2.2.1 Navy Acoustic Effects Model

NAEMO is used to assess potential impacts from sound sources utilized during Navy testing and training activities to estimate the level of behavioral disruptions and physiological impacts (e.g., temporary threshold shift [TTS] and permanent threshold shift [PTS], respectively) to marine mammals and sea turtles. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. There are no underwater detonations for the proposed action within the PMSR. In-air explosives detonating within 10 meters (m) of the ocean's surface or upon impact with the surface were conservatively modeled as detonating as a point source located 0.1 m below the surface, with all the energy from the detonation contained underwater. Detonation of munitions at a height of more than 10 m from the ocean's surface were not modeled for potential underwater impacts.

NAEMO calculates sound energy propagation from explosives and the energy or sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals and sea turtles distributed in the area around the modeled naval activity. Each of the animat dosimeters records its individual sound "dose." The model bases the distribution of animats over the action area on the density values (see Section 2.3.1 below) for a given area and month 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. In order to incorporate statistical uncertainty surrounding density estimates into the NAEMO, 30 distributions were produced for each species for each season, each of which varied according to the standard deviations provided with the density estimates (U.S. Navy 2021).

Physical environmental data plays an important role in acoustic propagation of underwater sound sources used in the impact modeling process (U.S. Department of the Navy 2020). Physical environmental parameters that influence propagation modeling include bathymetry, seafloor composition/sediment type, wind speed, and sound speed profiles. NAEMO accounts for environmental variability in sound propagation with both distance and depth, as well as boundary interactions, when computing the received sound level of the animats. The model conducts a statistical analysis based on multiple model runs to compute the potential acoustic effects on animals. The number of animats for which the thresholds of effects is exceeded is tallied to estimate the number of times marine mammals or sea turtles could be affected by the aspects of the proposed activity that generate sound.

Marine mammal and sea turtle data input to the NAEMO include densities, depth distribution, and (for mammals) stock breakouts (U.S. Department of the Navy 2020). Because many marine mammals are known to travel and feed in groups, species-specific group sizes are incorporated into animat distributions. Species specific group sizes are estimated using literature review, survey data, and density data, and uncertainty of group size estimates are statistically represented by the standard deviation. The model accounts for depth distributions by changing each animat's depth during the simulation process according to the typical depth pattern observed for each species**.** Depth distribution information was collected by a literature review and is presented as a percentage of time the animal typically spends within various depth bins in the water column. Many marine mammals species are divided into multiple stocks based on life history and genetic stock structure for management purposes. For some stocks there is enough survey information to support stock-specific density models. In these cases, a density layer for the stock is provided and is modeled independently of other stocks. In other cases, predicted impacts were assigned by stock, as opposed to the species as a whole (U.S. Department of the Navy 2020).

The model estimates the impacts caused by individual training and testing events. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances during which marine mammals or sea turtles may be exposed to sound levels resulting in an effect. Therefore, the model estimates the annual number of exposures that may result in different effects but does not estimate the number of individual marine mammals or sea turtles that may be affected. Some individuals may be exposed more than once per year but the model does not estimate whether a single individual is exposed multiple times.

As described further in Section 3.5.1, the Navy proposes to implement a series of procedural mitigation measures designed to minimize or avoid potentially injurious impacts on marine mammals and sea turtles from acoustic stressors. The Navy implements mitigation measures during training and testing activities when a marine mammal or sea turtle is observed in the mitigation zone. The mitigation zones encompass much of the estimated range to injury for explosives. The Navy designed the mitigation zones for explosive stressors according to its source bins. Explosives are binned by net explosive weight (NEW). Mitigation does not pertain to stressors that would have no effect on an ESA-listed species (e.g., explosive sources that do not have the potential to impact ESA-listed marine mammals or sea turtles).

NAEMO does not take into account mitigation measures or animal avoidance behavior when predicting impacts to marine mammals and sea turtles from acoustic stressors. Therefore, to account for the potential for mitigation measures to minimize potential impacts on marine mammals and sea turtles, the Navy quantifies the potential for mitigation to reduce model-estimated mortality in some specific instances and consider those exposures to detonations occurring at or near the surface as injury rather than mortality. For the proposed activities at PMSR, however, there were no predicted mortalities so there was no subsequent requirement to better estimate impacts by incorporating mitigation effectiveness (U.S. Navy 2021). The Navy's PMSR explosives impact analysis did not analyze the potential for mitigation to further reduce non-auditory injury, PTS, TTS, or behavioral effects, even though mitigation that is intended to avoid or reduce mortalities would, in some specific instances, also reduce the likelihood and/or severity of these effects (e.g., PTS reduced to TTS or TTS reduced to behavioral effects).

2.2.2 Criteria and Thresholds to Predict Impacts to Marine Mammals

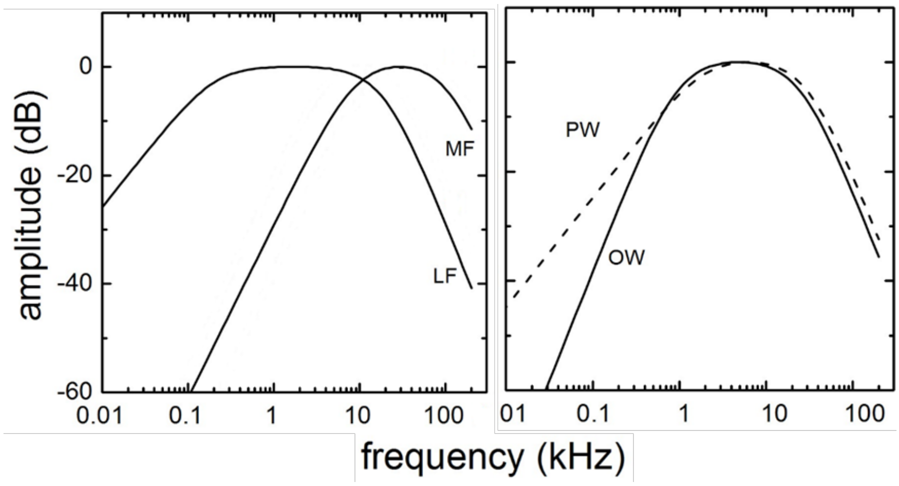
The Navy's quantitative acoustic effects analysis for marine mammals relies on information about the numerical sound and energy values that are likely to elicit certain types of physiological and behavioral reactions. The following section describes the specific criteria developed and applied for each species and sound sources associated with Navy PMSR training and testing activities.

For marine mammals, the Navy, in coordination with NMFS, established acoustic thresholds using the best available science that identifies the received level of underwater sound above which exposed marine mammals would reasonably be expected to experience a potentially significant disruption in behavior, or to incur some degree of TTS or PTS. Thresholds have also been developed to identify the pressure levels above which animals may incur different types of tissue damage from exposure to pressure waves from explosive detonation. A detailed description of the criteria and threshold development is included in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). The thresholds used by the Navy were developed by compiling and synthesizing the best available science on the susceptibility of marine mammals to effects from acoustic exposure. NMFS has independently evaluated and adopted the Navy's marine mammal criteria and thresholds for use in this consultation as the best available science on the exposure and response of marine mammals to underwater sound produced by PMSR activities.

2.2.2.1 Marine Mammal Criteria

The Navy's quantitative acoustic effects analysis used criteria to assess auditory injury in different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from impulsive sources (i.e., explosives). The criteria used in the analysis are described in *NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2018b).

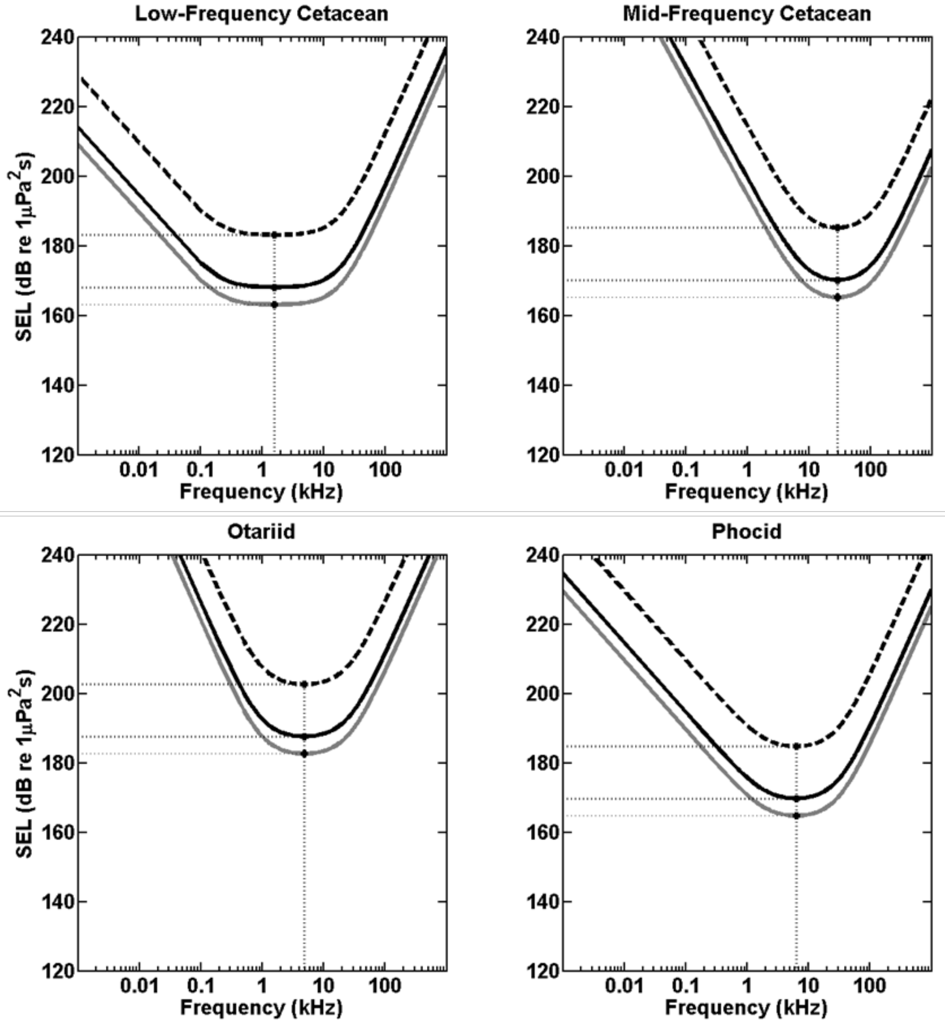
The Navy used auditory weighting and exposure functions to assess the varying susceptibility of marine mammals to effects from noise exposure. Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions were used (Figure 1). Auditory weighting functions are mathematical functions that adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges with less or no auditory sensitivity. They incorporate species-specific hearing abilities from composite audiograms to calculate a weighted received sound level in decibel (dB) units of sound pressure level (SPL) or sound exposure level (SEL). For example, the Navy used a mid-frequency cetacean composite audiogram that was consistent with recently published behavioral audiograms of killer whales (Branstetter et al. 2017) to develop the mid-frequency auditory weighting function. The auditory weighting functions 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, while the frequencies below and above this range (where amplitude declines) are de-emphasized.



Note. LF = Low-Frequency Cetacean, MF = Mid-Frequency Cetacean, PW = Phocid (In-water), and OW = Otariid (In-water). ESA-listed phocids (PW) are not present in the action area. For parameters used to generate the functions and more information on weighting function derivation see Navy (2017a).

Figure 1. Navy auditory weighting functions for all marine mammal species groups.

The thresholds for onset of behavioral effects, TTS, PTS and non-auditory injury from PMSR explosives for marine mammals are shown in Table 1 by functional hearing group. The Navy developed explosive criteria for behavioral thresholds for marine mammals based on the hearing group’s TTS threshold minus five dB for events that contain multiple impulses from explosives underwater.



Note: 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 sound exposure level (SEL) threshold for behavioral response, TTS, and PTS onset at each group's most sensitive frequency (i.e., the weighted SEL threshold). ESA-listed phocids are not present in the action area.

Figure 2. Behavioral, TTS, and PTS exposure functions for explosives (Navy 2018a).

Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is informed to varying degrees by other factors related to the source (e.g., frequency, predictability, duty cycle), the environment (e.g., bathymetry), and the receiving animal (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Ellison et al. 2011; Southall et al. 2007a). Within the Navy's quantitative analysis, many behavioral reactions are predicted from exposure to sound that may exceed an animal's behavioral threshold momentarily, but would not constitute a significant disruption of normal behavior patterns or rise to the level of ESA "take." The Navy and NMFS have used the best available science to address the challenging differentiation between significant and non-

Table 1. Effects, criteria and threshold for impulsive sources (U.S. Department of the Navy 2020).

Group	*Species*	*Behavioral Criteria*	*Physiological Criteria*		
			Onset TTS	*Onset PTS*	*Onset GI (Gastrointestinal) Tract Injury (SPL) 50%*
Low-Frequency Cetaceans	All mysticetes	163 dB SEL	168 dB SEL 213 dB SPL	183 dB SEL 219 dB SPL	243 dB re 1 µPa peak
Mid-Frequency Cetaceans	All odontocetes	165 dB SEL	170 dB SEL 224 dB SPL	185 dB SEL 230 dB SPL	243 dB re 1 µPa peak
Otariidae	Guadalupe Fur seal	183 dB SEL	188 dB SEL 226 dB SPL	203 dB SEL 232 dB SPL	243 dB re 1 µPa peak

significant behavioral reactions, but have erred on the side of caution where uncertainty exists (i.e., counting shorter duration behavioral reactions as "take"). This may result in some overestimation of the number of significant behavioral disruptions or behavioral harassment takes.

In addition to TTS and PTS, Navy explosives also have the potential to result in non-auditory injury or mortality. Two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the "crack" or "stinging" sensation of a blast wave, compared to the "thump" associated with a received impulse. Two sets of thresholds were used in the non-auditory injury assessment. The exposure thresholds were used to estimate the number of animals that may be affected during Navy training and testing activities. The thresholds for the farthest range to effects are based on the received level at which one percent risk is predicted and are useful for informing mitigation zones. Mortality and slight lung injury thresholds are calculated using the mass and depth of the mammal. An adult mass and a calf mass are defined for each species based on the literature. Increasing animal mass (size) and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). The masses used for impact assessment assume marine mammal populations are 70 percent adult and 30 percent calf/pup.

Table 2. Criteria to quantitatively assess marine mammal mortality and non-auditory injury due to underwater explosions.

Impact Category	*Impact Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s	$103M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s
Injury[1]	$65.8M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s	$47.5M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s
	243 dB re 1 μPa SPL peak	237 dB re 1 μPa SPL peak

[1] Impulse delivered over 20 percent of the estimated lung resonance period. See U.S. Department of the Navy (2017).

[2] Threshold for one percent risk used to assess mitigation effectiveness.

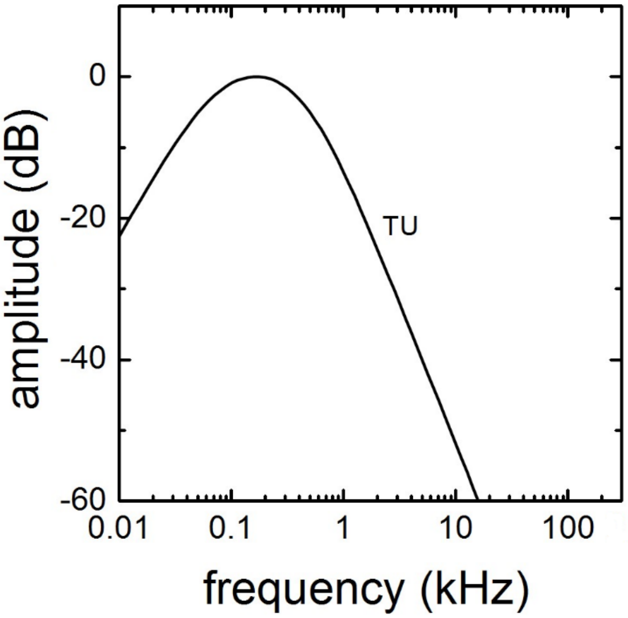
Notes: D = animal depth (m), dB re 1 μPa = decibels referenced to 1 micropascal, M = animal mass (kg), Pa-s = Pascal-second, SPL = sound pressure level

2.2.3 Criteria and Thresholds to Predict Impacts to Sea Turtles

The Navy's quantitative acoustic effects analysis for sea turtles relies on information about the numerical sound and energy values that are likely to elicit certain types of physiological and behavioral reactions. The following section describes the specific criteria developed and applied for sea turtles and sound sources associated with Navy training and testing activities. The thresholds used by the Navy were developed by compiling and synthesizing the best available science on the susceptibility of sea turtles to effects from acoustic exposure. The Navy provided NMFS with estimated sea turtle impacts using a behavior threshold set by NMFS based on the best available science on the exposure and response of sea turtles to underwater sound produced by PMSR activities. A more detailed description of the criteria and threshold development is included in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a).

2.2.3.1 Auditory Weighting Function – Sea Turtles

In order to develop the hearing thresholds of received sound sources for sea turtles expected to produce behavioral effects, TTS, and PTS, the Navy compiled all sea turtle audiograms available in the literature to create a composite audiogram for sea turtles as a hearing group (U.S. Navy 2021). Measured or predicted auditory threshold data were used to influence the weighting function shape for sea turtles. For sea turtles, the weighting function parameters were adjusted to provide the best fit to the experimental data. However, because these data were insufficient to successfully model a composite audiogram via a fitted curve (as was done for marine mammals) median audiogram values were used in forming the sea turtle hearing group's composite audiogram (U.S. Navy 2021). Based on this composite audiogram, an auditory weighting function was created to estimate the susceptibility of sea turtles to hearing loss or damage. This auditory weighting function for sea turtles is shown in Figure 3, and is described in detail in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle (Navy 2017a).



Notes: dB = decibels, kHz = kilohertz, TU = sea turtle species group

Figure 3. Auditory weighting function for sea turtles (Navy 2017).

2.2.3.2 Explosives Criteria – Sea Turtles

NMFS and the Navy apply a peak pressure metric criterion to assess the potential onset of sea turtle physical injury and hearing impairment from explosives. Similar to other marine species, the sound pressure or blast wave produced from a detonation does not only affect hearing, but may also induce other physical injuries such as external damage to the carapace, and internal damage to organs and blood vessels. For sea turtles, the Navy developed criteria to determine the potential onset of hearing loss, physical injury (i.e., GI and lung injury) and non-injurious behavioral response to detonation exposure using the weighting function described above. The derivation of these injury criteria (and the species mass estimates) are described in the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (Navy 2017a).

The peak pressure metric criterion thresholds for non-auditory injury for sea turtles and range to farthest effects are shown in Table 3. These thresholds include the farthest range to effect, based on the received level at which a one percent risk is predicted and are useful for assessing the effectiveness of mitigation measures (described in greater detail later). In order to evaluate the degree to which a sea turtle may be susceptible to injury from the blast energy of an explosive detonation, both the size of the sea turtle as well as depth of the animal in the water column at exposure must be considered. This is because a larger sea turtle located deeper in the water column is assumed to be less susceptible to impacts than a smaller sea turtle, located closer to the surface in the water column. In addition, the Navy divided the percentage of the sea turtle populations according to age classes that are most likely to comprise the populations present in the action area for their impact assessment. The Navy assumed five percent of the population would be adult, and the remaining 95 percent of individuals to be sub-adult. This ratio is estimated from what is currently known about the population age structure for sea turtles based upon egg clutch size, early juvenile survival rates, and survival rates for sub-adult and adult turtles. In general, sea turtles typically lay multiple clutches of 100 or more eggs and have low juvenile survival rates, but those that make it past early life stages have increased survival at later life stages.

No studies of hearing loss from explosives have been conducted on sea turtles. Therefore, sea turtle susceptibility to hearing loss due to an acoustic exposure is evaluated using knowledge about sea turtle hearing abilities in combination with impulsive auditory effect data from other species (marine mammals and fish). This yields sea turtle exposure functions, shown in Table 3, which are mathematical functions that relate the SELs for onset of TTS or PTS to the frequency of the sound exposure. The derivation of the sea turtle exposure functions are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a).

Table 3. Criteria to quantitatively assess sea turtle non-auditory injury due to underwater explosions.

Impact Category	*Impact Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s	$103M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s
Injury[1]	$65.8M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s	$47.5M^{1/3}[1 + (D/10.1)]^{1/6}$ Pa-s
	243 dB re 1 μPa SPL peak	237 dB re 1 μPa SPL peak

[1] Impulse delivered over 20 percent of the estimated lung resonance period. See U.S. Department of the Navy (2017).

[2] Threshold for one percent risk used for mitigation.

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

For impulsive sounds, hearing loss in other species has been observed to be related to the unweighted peak pressure of a received sound. Because these data do not exist for sea turtles, unweighted peak pressure thresholds for TTS and PTS were developed by applying relationships observed between impulsive peak pressure TTS thresholds and auditory sensitivity in marine mammals to sea turtles. This results in dual-metric hearing loss criteria for sea turtles for impulsive sound exposure: the SEL-based exposure functions in Figure 4 and the peak pressure thresholds in Table 4. The derivation of the sea turtle impulsive peak pressure TTS and PTS thresholds are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy 2017).

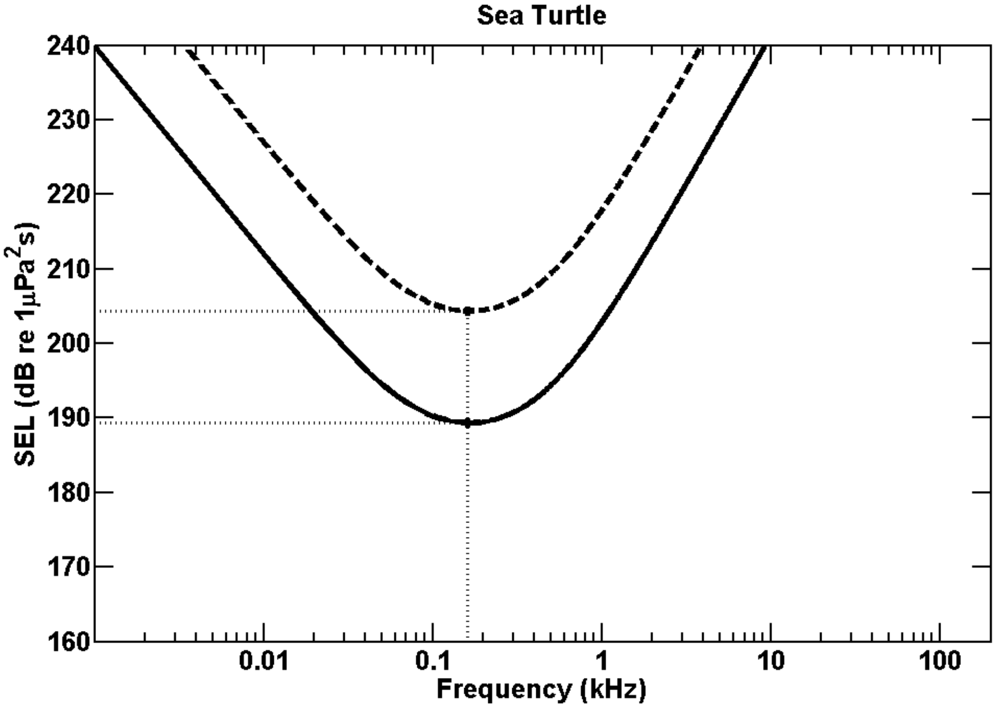


Figure 4. TTS and PTS exposure functions for impulsive sounds - sea turtles.

Notes: kHz = kilohertz, SEL = Sound Exposure Level, dB re 1 μPa^{2}s = decibels referenced to 1 micropascal squared second. The solid black curve is the exposure function for TTS onset and the dashed black curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL thresholds and most sensitive frequency for TTS and PTS.

Table 4. TTS and PTS peak pressure thresholds derived for sea turtles exposed to impulsive sounds

Auditory Effect	*Unweighted Peak Pressure Threshold*
TTS	226 dB re 1 μPa SPL peak
PTS	232 dB re 1 μPa SPL peak

Notes: dB re 1 μPa = decibels referenced to 1 micropascal, PTS = permanent threshold shift, SPL = sound pressure level, TTS = temporary threshold shift

For behavioral response assessment, the Navy estimated the number of sea turtles that could be exposed to explosions at received levels of 175 dB rms (re 1 μPa) or greater. This is the level at which Mccauley et al. (2000a) determined sea turtles would begin to exhibit avoidance behavior after multiple firings of nearby or approaching air guns.

2.3 Species Density Estimates

A quantitative acoustic effects analysis requires information on the abundance and density of ESA-listed species in the potentially impacted area. In this section, we provide the species density estimates that were used for the quantitative effects analyses in Section 8.2. For marine mammals and leatherback sea turtles, density estimates were taken directly from the Navy's 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 2020). For other species considered in this opinion, including North Pacific DPS loggerhead sea turtles and three fish species (i.e., Southern California DPS steelhead, giant manta ray, and East Pacific DPS scalloped hammerhead shark) the available information did not allow for a reliable estimate of density within the action area.

2.3.1 Marine Mammal and Sea Turtle Density Estimates

To characterize marine mammal and sea turtle densities in the PMSR, the Navy compiled data from multiple sources and developed a protocol to select the best available density estimates based on species, area, and season. When multiple data sources were available, the Navy ranked density estimates based on a hierarchal approach to ensure that the most accurate estimates were selected (U.S. Department of the Navy 2020). The highest tier included peer-reviewed published studies of density estimates from spatial models because these provide spatially explicit density estimates with relatively low uncertainty. Other preferred sources included peer-reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for NMFS marine mammal stock assessment reports (SARs). In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches including Relative Environmental Suitability models (U.S. Department of the Navy 2020). Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists. The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the action area, and density data are provided as a geographic grid of typically ten kilometers by ten kilometers.

For several species, estimated densities were based on a spatial model resulting in numerous density values throughout different portions of the action area. These spatially explicit densities are shown in the figures below for blue whale (Figure 5 and Figure 6), fin whale (Figure 7 and Figure 8), humpback whale (Figure 9 and Figure 10), sperm whale (Figure 11), and Guadalupe fur seal (Figure 12 and Figure 13). For Western North Pacific DPS gray whale, estimated density was uniformly low (i.e., less than 0.005 whales per km^2) across most months and areas within PMSR. Higher (and variable) densities were estimated for fin whales in a few relatively small nearshore portions of the action area from January through May (for details see U.S. Department of the Navy 2020).

For other species, only a uniform density estimate could be derived across all months and areas based on the best available information. These include sei whale (0.000046 whales per km^2) and leatherback sea turtle (0.001 turtles per km^2). The Navy's leatherback density estimate was based on aerial surveys conducted by Benson et al. (2007) along the coast of California from Pt. Conception to the California/Oregon border between 1990-2003 (U.S. Department of the Navy 2021a). The density estimate calculated for the "South Central California" region of the survey area, which partially overlaps PMSR to the south, was applied by the Navy in their NAEMO quantitative analysis for leatherbacks. Subsequent to running NAEMO for leatherback sea turtles using this density estimate (i.e., 0.001 turtles per km^2), the Navy revised its density estimate for leatherbacks within the PMSR to 0.00009 turtles per km^2 (see U.S. Department of the Navy 2021a for details). However, the Navy did not re-run NAEMO using this lower density estimate. Therefore, NAEMO estimated impacts to leatherback sea turtles from explosive detonations are likely biased high (see Section 8.2.2.2).

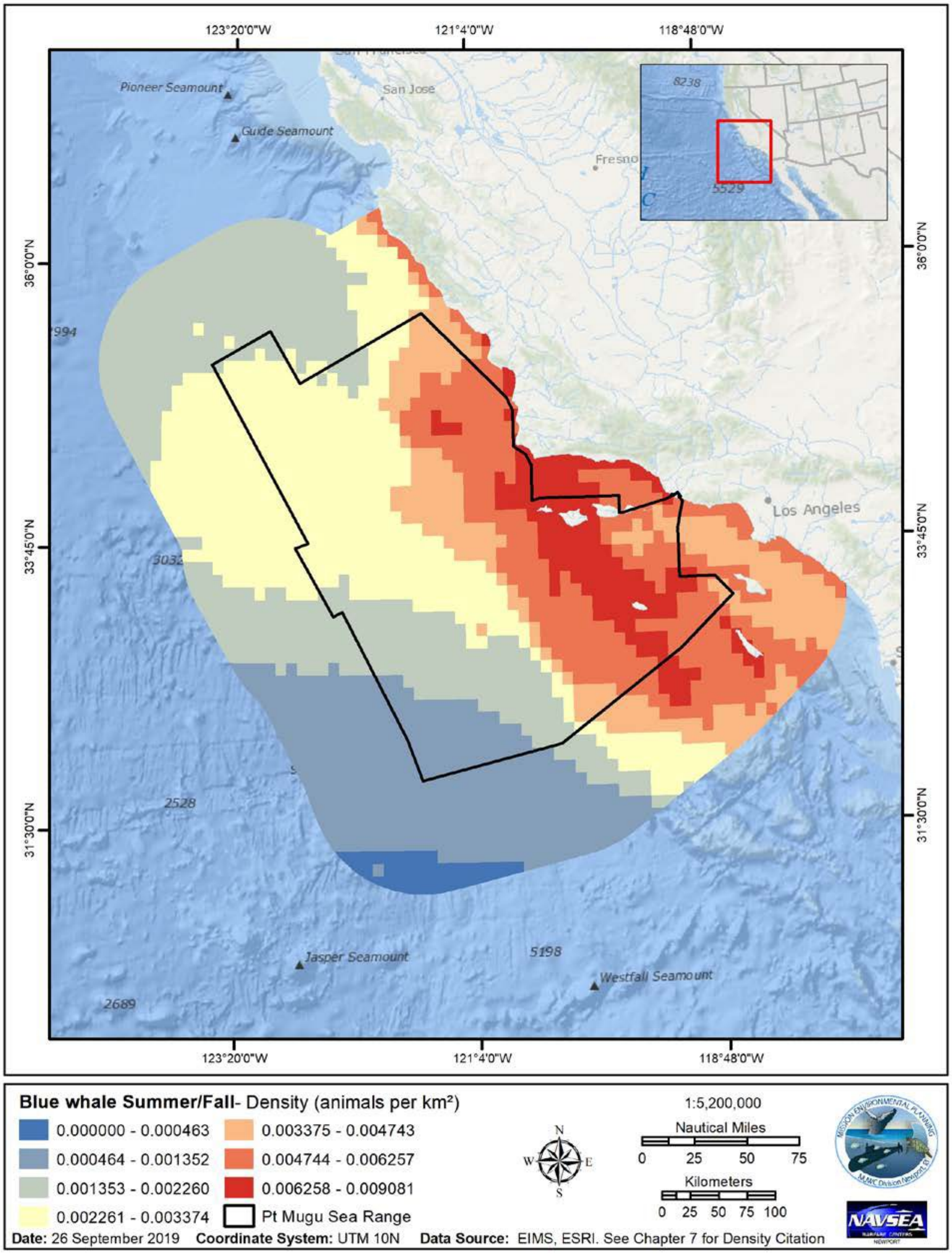


Figure 5. Blue whale summer/fall density in the PMSR (U.S. Department of the Navy 2020).

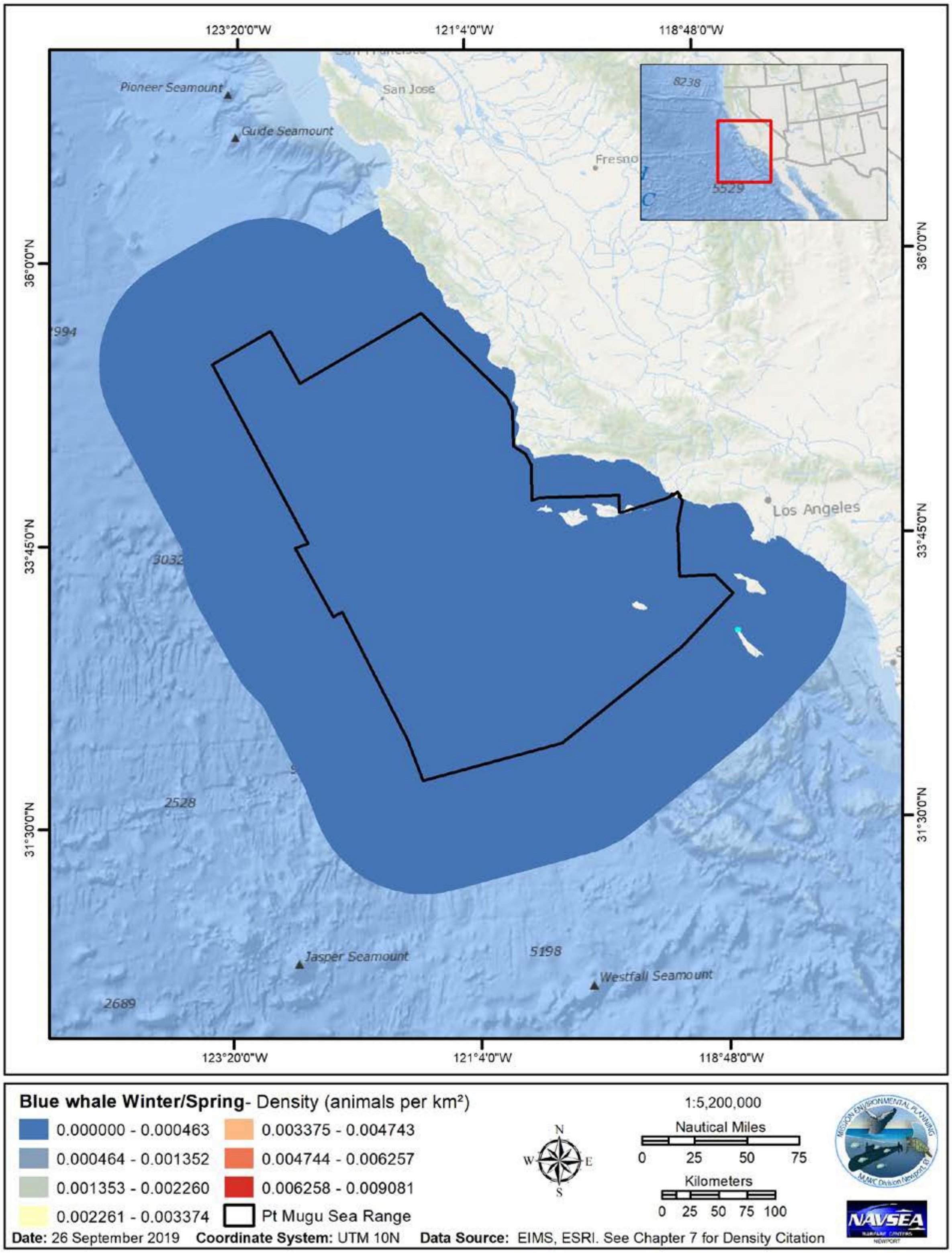


Figure 6. Blue whale spring/winter density in the PMSR (U.S. Department of the Navy 2020).

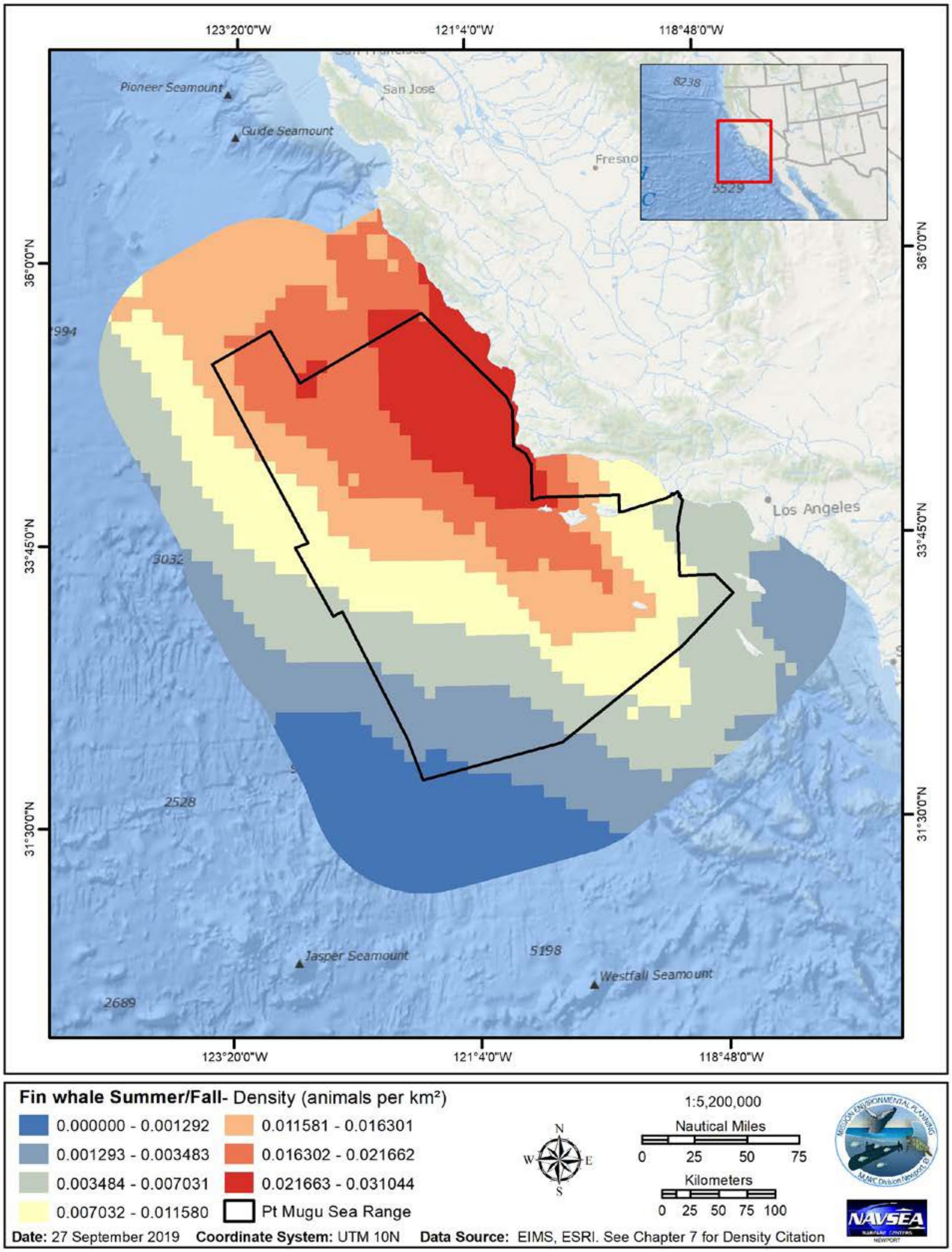


Figure 7. Fin whale summer/fall density in the PMSR (U.S. Department of the Navy 2020).

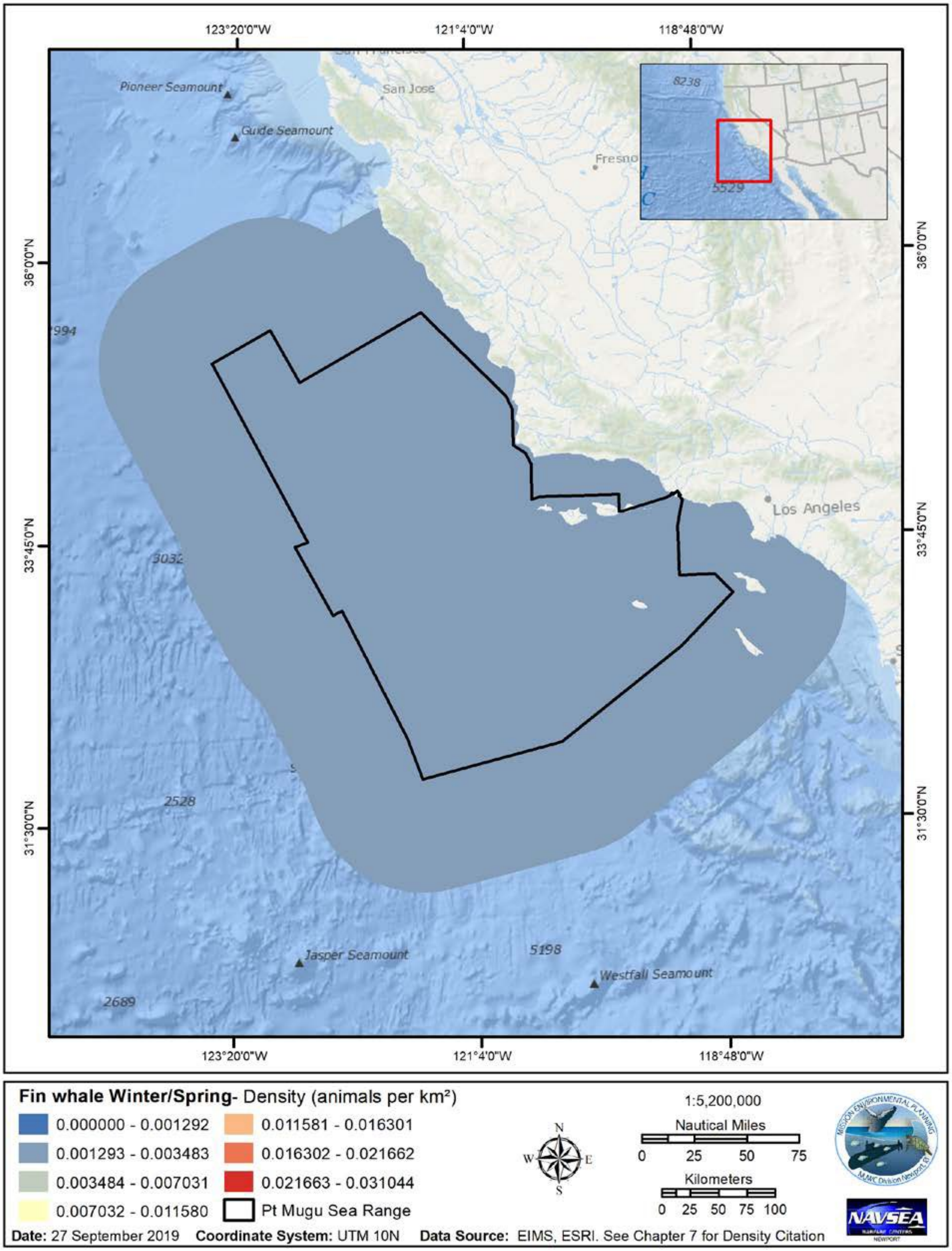


Figure 8. Fin whale winter/spring density in the PMSR (U.S. Department of the Navy 2020).

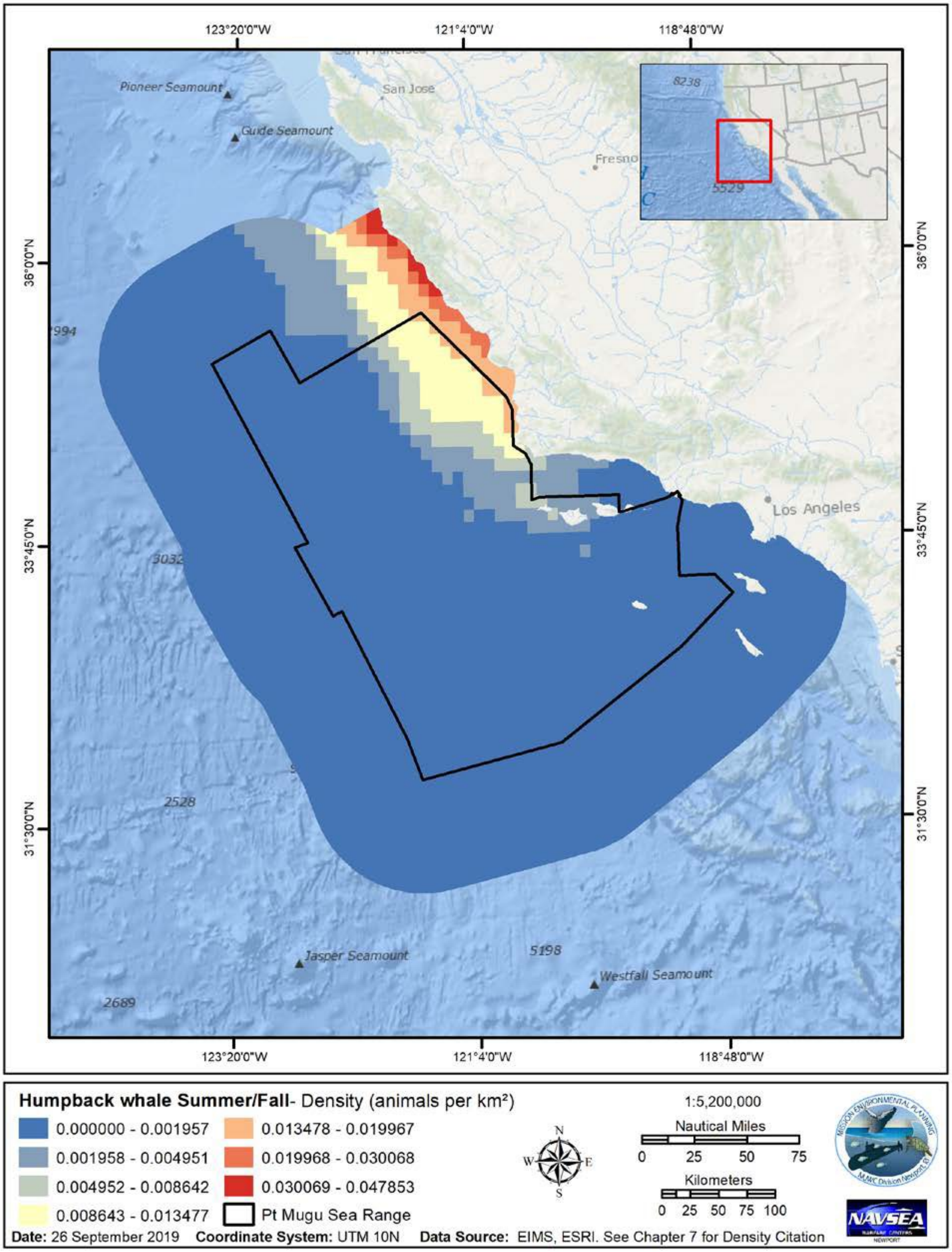


Figure 9. Humpback whale summer/fall density in the PMSR (U.S. Department of the Navy 2020).

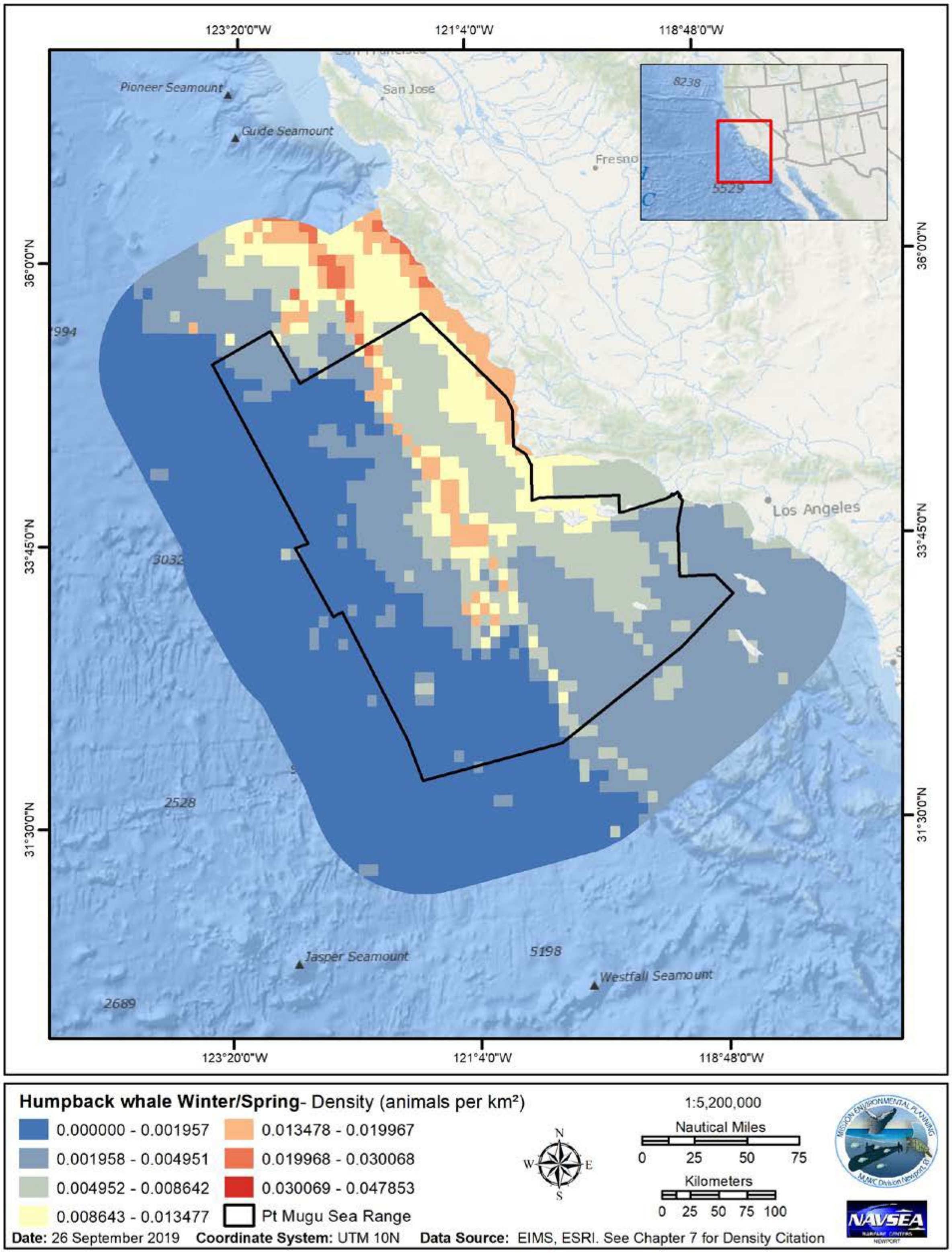


Figure 10. Humpback whale winter/spring density in the PMSR (U.S. Department of the Navy 2020).

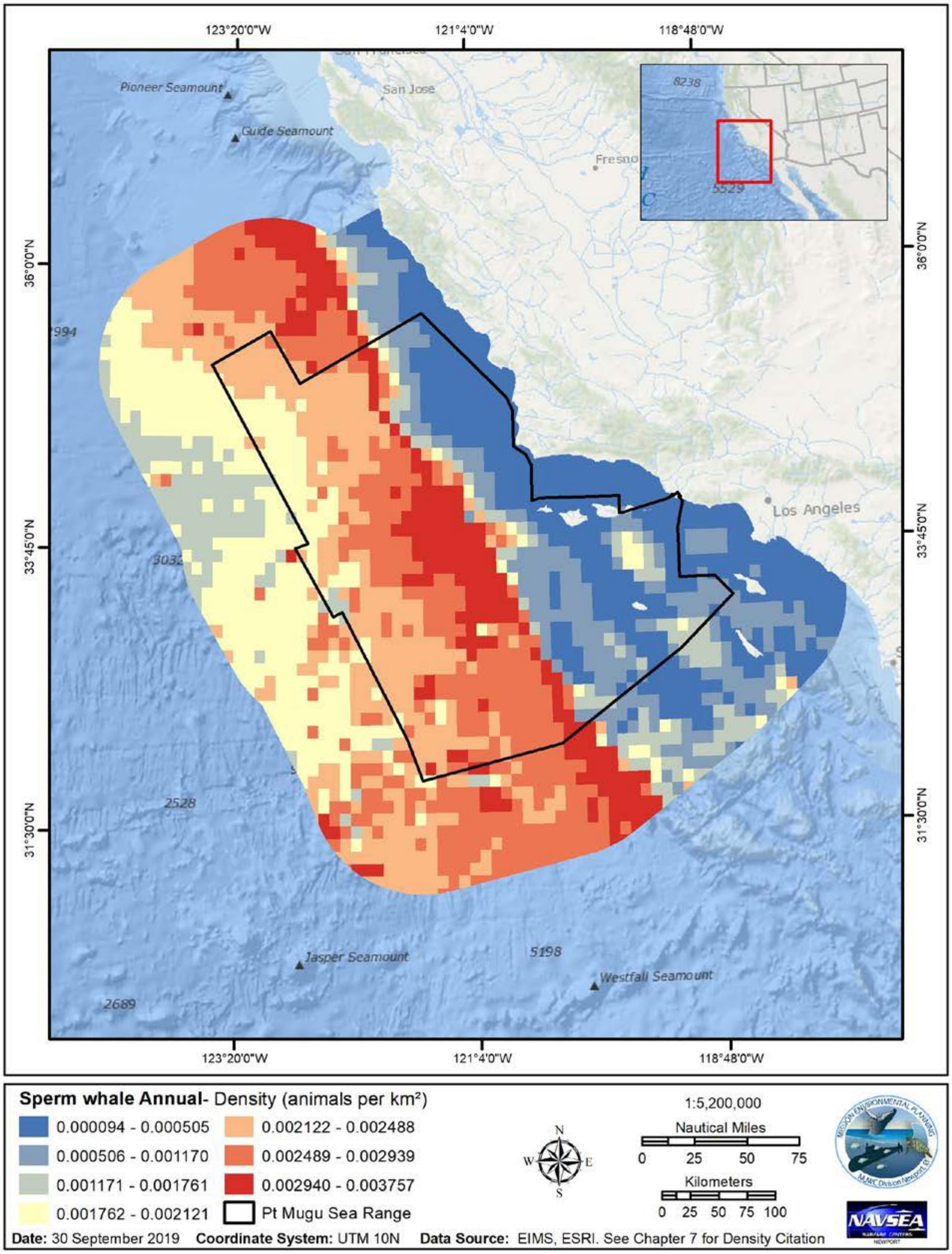


Figure 11. Sperm whale annual density in PMSR (U.S. Department of the Navy 2020).

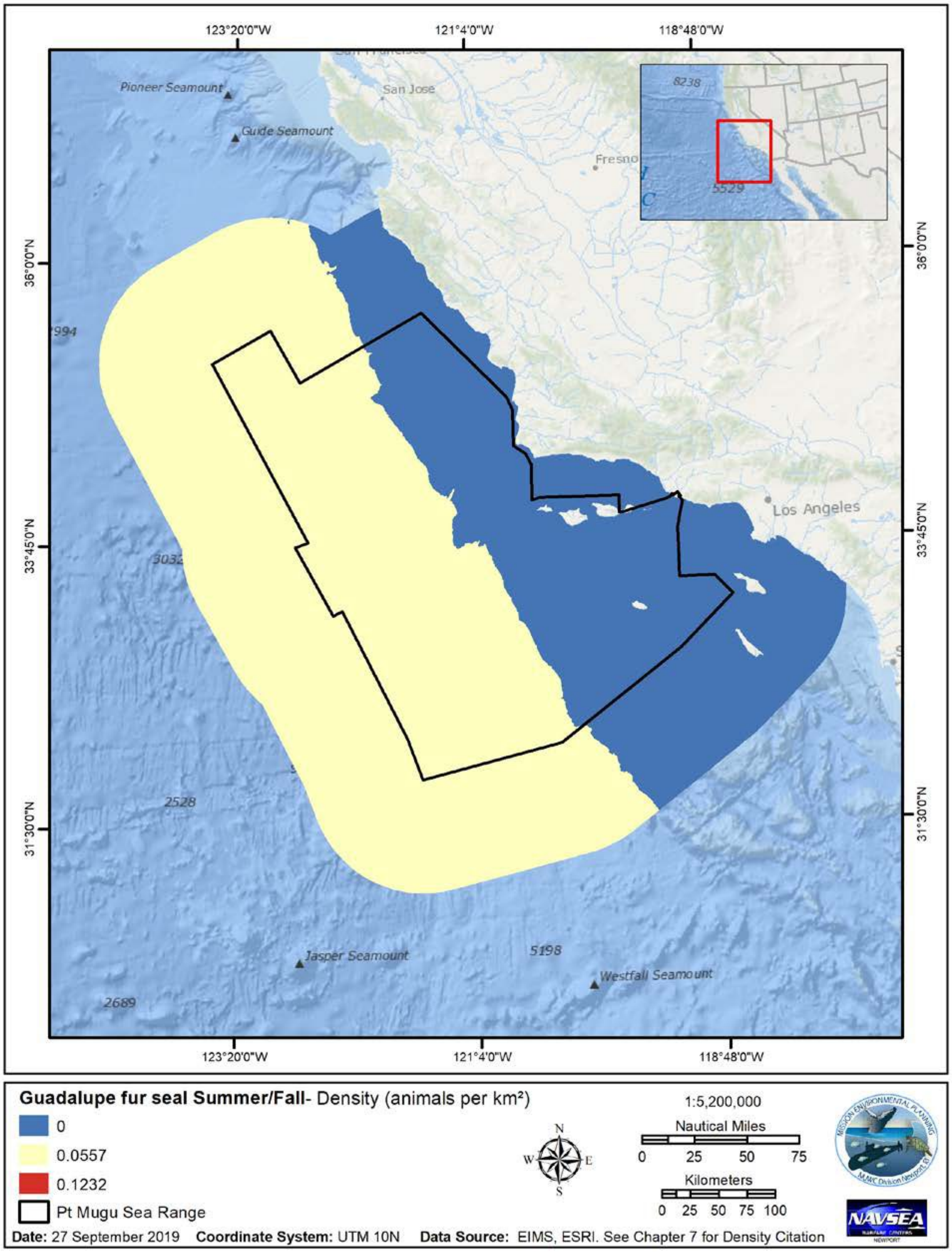


Figure 12. Guadalupe fur seal summer/fall density in PMSR (U.S. Department of the Navy 2020).

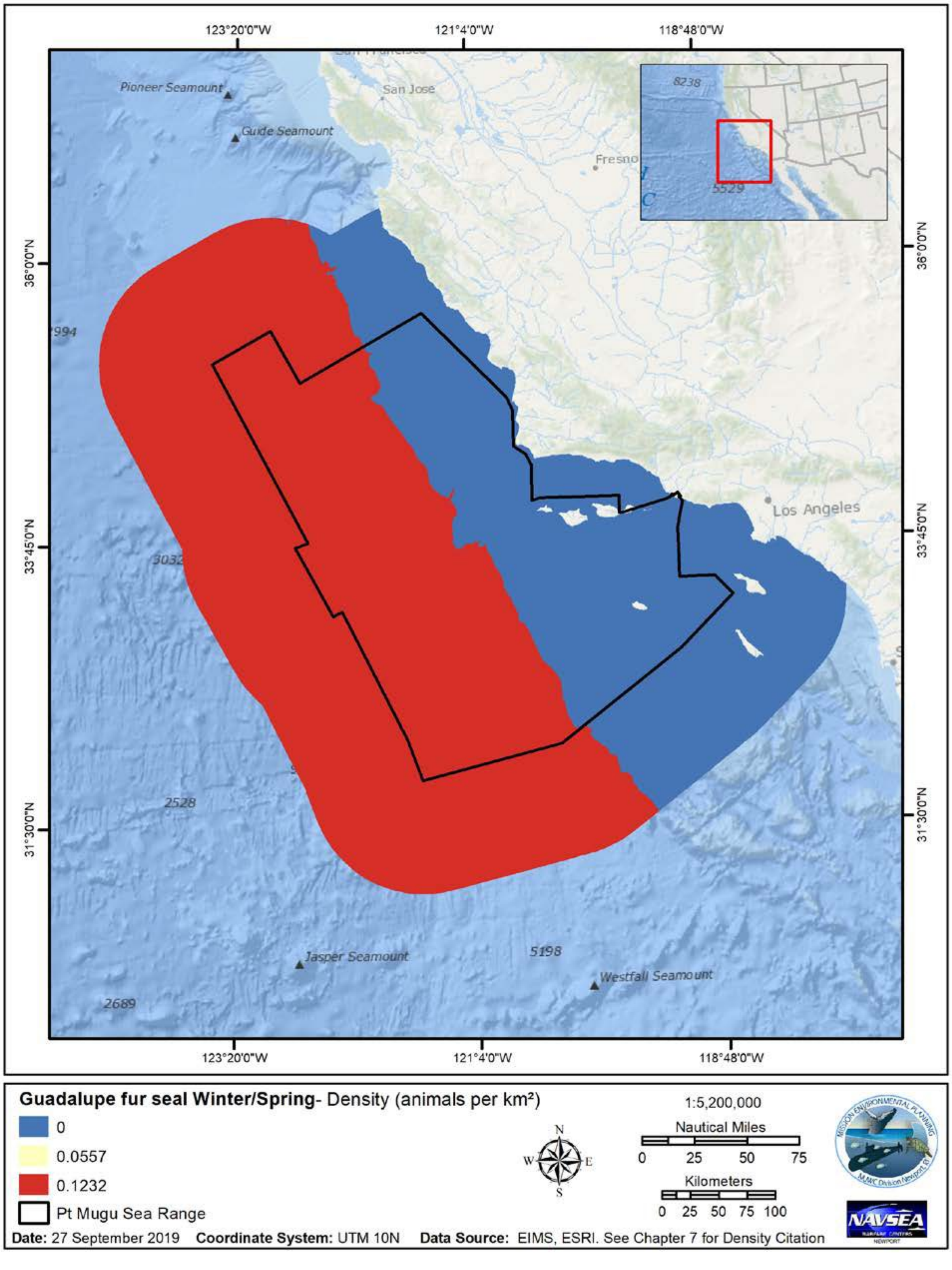


Figure 13. Guadalupe fur seal winter/spring density in PMSR (U.S. Department of the Navy, 2020c).

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. 50 C.F.R. §402.02.

Two federal actions were evaluated during this consultation. The first proposed action for this consultation is the Navy's military training and testing activities (i.e., military readiness activities) conducted within the PMSR. The second proposed action for this consultation is the Permits Division's implementation of the MMPA through 1) promulgation of regulations pursuant to the MMPA governing the Navy's "take" of marine mammals incidental to the Navy's military readiness activities within the PMSR from February 2022 through February 2029; and 2) issuance of an LOA pursuant to the regulations that authorize the U.S. Navy to "take" marine mammals under the MMPA incidental to military readiness activities within the PMSR through February 2029.

The Navy proposes to conduct military readiness training and testing ("testing" includes research, development, testing, and evaluation) activities within the PMSR. The Permits Division proposes to promulgate regulations pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to PMSR activities from February 2022 to February 2029. The regulations propose to authorize the issuance of a LOA that will allow the Navy to "take" marine mammals under the MMPA incidental to their training and testing activities. This consultation considers the MMPA regulations for the Navy to "take" marine mammals incidental to PMSR activities.

NMFS recognizes that while Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types and tempo of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assumed that the training and testing activities proposed by the Navy during the seven-year period of NMFS' proposed incidental take authorization pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed in this opinion.

For the training activities considered during consultation, Naval personnel (Sailors and Marines) first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and expeditionary warfare) and the community's unique requirements (U.S. Navy 2021). Personnel then train within their warfare community at sea in preparation for deployment. For the testing activities, the Navy researches, develops, tests, and evaluates new platforms, systems, and technologies, collectively known as testing. Many tests require realistic conditions at sea and can range from testing new software to complex operations of multiple systems and platforms. Testing activities may occur independent of or in conjunction with training activities (U.S. Navy 2021).

The sections below (Sections 3.1 through 3.3) provide greater detail on the Navy's proposed training and testing activities in the PMSR. We present information on the locations where activities are proposed to occur, describe the specific types of activities proposed, and present information on the levels of activities proposed in the different locations. We then present information on the standard operating procedures (Section 3.4) and mitigation measures (i.e. conservation measures to avoid and minimize effects to listed species; Section 3.5) that will be implemented by the Navy as part of the training and testing activities. We conclude this section by describing the NMFS Permits Division's action under the authority of the MMPA. The primary sources of information for this section were the Navy's PMSR BA (U.S. Navy 2021), the PMSR FEIS/OEIS (U.S. Navy 2022), and NMFS' proposed rule for its promulgation of regulations and issuance of an LOA pursuant to the MMPA for the U.S. Navy (86 FR 37790).

3.1 Primary Mission Areas

The Navy categorizes its activities into eight functional warfare areas called primary mission areas. Activities occurring within the PMSR fall under three of these primary mission areas:

- Electronic warfare (EW; electronic jamming, electronic counter measures and directed energy - lasers and high-powered microwave [HPM] systems)
- Air warfare (air-to-air, surface-to-air)
- Surface warfare (surface-to-surface, air-to-surface, and subsurface-to-surface)

The PMSR is the Navy's primary ocean testing area for guided missiles and related ordnance. Two of the U.S. Navy's Systems Commands, Naval Sea Systems Command (NAVSEA) and Naval Air Systems Command (NAVAIR), sponsor the majority of the testing at PMSR. A frequent test conducted at the PMSR is the NAVSEA 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. CSSQTs are conducted within the primary warfare mission areas listed above. Weapons testing may contain both flight and surface elements (target, weapon, launch aircraft or vessel, or range support aircraft). Fixed-wing and rotary-wing aircraft, including both manned and unmanned systems, also conduct weapons tests. Tests may be captive carry (i.e., the weapon is not released from the aircraft) or involve the release of ordnance or other expendables, including non-explosive and TM-only warheads and live fire munition rounds. Chaff or flares may be used during weapons tests, with the restriction that they be expended offshore in compliance with environmental regulations. Training conducted in parallel with testing activities provides Fleet operators opportunities to train with ship and aircraft combat weapon systems and personnel in scripted warfare environments, including live-fire exercises.

3.1.1 Electronic Warfare

Typical electronic warfare training activities include threat avoidance, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking 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, to defeat tracking and communications systems.

The proposed action would expand electronic warfare capabilities on the PMSR to provide representative nearshore, littoral, and open water environments to test military systems against electronic warfare threats, as well as train crews against representative electronic warfare threats. The use of electronic warfare range threat emitters would include up to 20 specialized mobile radars (radar signal emulator systems) positioned around the PMSR, including positions at Point Mugu, San Nicolas Island (SNI), Santa Cruz Island, Vandenberg Air Force Base, and possibly Laguna Peak. The radar signal emulator systems are mobile and self-contained and emulate multiple threat signals using frequencies similar to those used for satellite communications, cordless phones, Bluetooth devices, and weather radar systems. Other electronic warfare technologies include a wide range of pulsed, continuous wave, Doppler, and multispectral emitters. These systems operate over multiple frequency spectrums including infrared, radio frequency, electro-optical, and millimeter wave. The types of electronic warfare events would include electronic countermeasure, radar warning receiver, unmanned aircraft system (UAS) operation, chaff and flare effectiveness evaluation, towed and air-launch decoy testing, anti-radiation missile flight testing to evaluate seekers and avionics, and tactics development.

The electronic warfare mission area also includes all directed energy weapons testing activities. For high energy laser and high power microwave testing and the testing and evaluation of other inbound non-warhead missiles, bombs and rockets may be fired at stationary targets located in the Land Impact Site on SNI. While these weapons are considered inert, some do use small pyrotechnic devices (e.g., spotting charges, live fuses).

All laser testing and training activities fall within the electronic warfare mission area. Laser testing and training includes the test and evaluation of laser systems under various weather conditions on the PMSR and includes multiple types of lasers, among them weapons, designators, tracking lasers, and communications and range finders (U.S. Department of the Navy 2010a). Testing and scheduled training activities involve directing laser energy at various types of fixed or dynamic targets from fixed or dynamic laser sources. Lasers could be operated from surface craft at sea, aircraft, or on land at SNI or Point Mugu and be directed at targets at sea, in the air, or on land at SNI or Point Mugu. Laser-based systems are used as sensors for atmospheric characterization to measure atmospheric turbulence and transmission capabilities to predict the effects of the high-power lethal laser on its intended target.

Under the proposed action, increases in radar and microwave testing on the PMSR are anticipated as the Navy studies the wavelengths, frequencies, and powers of radar and high power microwave systems in step with their development. High power microwave weapons will be employed on surface and subsurface vessels, as well as aircraft.

3.1.2 Air Warfare

The mission of air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats). 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 cannons for close-in point defense. Air-to-air scenarios involve the employment of an airborne weapon system against airborne targets. 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.

Long-range weapons delivery systems testing fall within the existing Air Warfare and Surface Warfare (Section 3.1.3 below) mission areas within the PMSR. Examples of long-range weapons include precision standoff missiles and hypersonic vehicle testing on the PMSR. The objective of the Hypersonic Vehicle Test Program is to develop and demonstrate key technologies to enable an air-launched tactical range hypersonic test vehicle for rapid response capabilities. Flight tests are typically conducted at altitudes of up to 80,000 feet (ft) and can range 450 to 2,000 mi., traveling at hypersonic speeds (over Mach 5). The flight vehicle is released and air-launched where its solid rocket motor booster will ignite. The spent booster or boosters and protective shroud then separate from the test vehicle which will continue to travel in a westerly direction through the PMSR towards a pre-determined impact site in the open ocean. Multiple aircraft are used for each test, such as for range clearance, surveillance, and the launch platforms.

The Long Range Anti-Ship Standoff Missile is a stealthy long-range, precision-guided anti-ship missile. It leverages the same features as the Joint Air-to-Surface Standoff Missile – Extended Range, employing precision routing and guidance for use in day or night operations in any weather condition. Long Range Anti-Ship Standoff Missiles will fly at medium altitude, then drop to low altitude for a sea-skimming approach to a target.

3.1.3 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. Surface warfare within PMSR includes aircraft use of cannons, air-launched cruise missiles, or other precision-guided munitions; ships employing naval guns, and surface-to-surface missiles; and submarine-launched, anti-ship cruise missiles.

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.

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.

Subsurface launches evaluate the performance 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.

3.2 Point Mugu Sea Range Platforms and Systems

Activities on the PMSR may include the use of a variety of platforms and systems (aircraft, support vessels and range craft, ships, submarines, targets, and munitions).

Range aircraft that support the mission of the PMSR fall into three categories: range surveillance and instrumentation, logistics, and testing and training platforms (including target launch). Typical aircraft may include F-35, F/A-18, MH-60, E2, and P-3. Aircraft activities are referred to as sorties, which consist of a takeoff, the assigned mission, and a subsequent landing by a single aircraft. Aircraft sorties typically last a few hours depending on the type of aircraft and the mission.

Vessel types supporting the PMSR include tugs, target boats, range support boats (e.g., aviation rescue boats, Navy's Self Defense Test Ship) based out of Port Hueneme, and ships (e.g., destroyers, cruisers, aircraft carriers, submarines) that are based elsewhere. A vessel activity is referred to as an event. An event may include a vessel entering the sea range, accomplishing its assigned mission, and then exiting the range. Events can last from a few hours to several days.

Typical Navy vessels may include Guided Missile Cruiser, Guided Missile Destroyer, and Littoral Combat Ship.

Testing and training on the PMSR requires a large array of representative targets, both airborne and surface targets. Typical airborne target systems include small jet powered drones, supersonic missiles, and full-scale unmanned fighter aircraft, which can be flown via remote control from the ground. Most target systems are not destroyed during testing or training and are recovered for reuse. Airborne targets can be launched from aircraft or from surface launch sites at NBVC Point Mugu, SNI, or from a support vessel. Representative types of aerial targets may include BQM-34s, BQM-177s, and GQM-163s. Representative surface targets may include Mobile Ship Target, Fast Attack Craft Target, High-Speed Maneuvering Surface Target, Low-Cost Modular Target, and QST-35.

Foreign military sales (FMS)[1] are approximately five percent of the PMSR activities, with the majority of those activities having no vessel involvement other than range support vessels used to recover air or surface targets and parachutes. PMSR averages one FMS activity annually that involves vessels. These events can last up to 10 days and typically involve only one naval vessel (depending on the activity, this is typically a foreign vessel) as the firing platform for aerial or surface targets. FMS activities are required to follow the same mitigations, at a minimum, as are all customers on the PMSR. When a customer does not have the capability to implement a required protective measure, PMSR staff with marine mammal observer training will implement the required measures (e.g., marine mammal surveys aboard vessels and aircraft). PMSR supports test and evaluation of a wide variety of weapons, ships, aircraft, and specialized systems. PMSR serves a broad spectrum of Department of Defense, Homeland Defense, NASA, foreign ally (FMS), and private sector programs, from small-scale static tests to complex multi-participant, multi-target operations. PMSR's activities support test and evaluation of transferred defense articles in accordance with the FMS program (U.S. Department of the Navy 2021c).

Military munitions are used throughout the PMSR. It is an integral component of most PMSR events, as new systems must receive a validated end-to-end evaluation prior to being introduced to the fleet for combat use. Munition use is organized by type and includes bombs, projectile ammunition from various naval weapon systems, missiles, and rockets. Munitions may contain high explosives or be inert, depending on the mission objective.

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[1] Includes training activities for international partners. FMS is the U.S. Government's program for transferring defense articles, services, and training to the United States' international partners and international organizations. Under FMS, the U.S. Government uses the Department of Defense's acquisition system to procure defense articles and services on behalf of its partners. Eligible countries may purchase defense articles and services with their own funds or with funds provided through U.S. Government-sponsored assistance programs.

3.3 Proposed Training and Testing Activity Levels

The proposed training and testing activity levels are shown below. A comparison of PMSR baseline and proposed levels of surface targets and ordnance used is shown in Table 5. A comparison of PMSR baseline and proposed levels of explosives (i.e., projectiles, bombs, missiles, and rockets) used by activity and bin is shown in Table 6.

Table 5. Proposed number of surface targets and ordnance compared to current baseline levels (U.S. Navy 2021).

Item	Sub Category	Baseline	Proposed Action	Change
Surface Targets	-	430	522	+92
Ordnance	Bombs	22	30	+8
	Gun Ammunition	2,862	50,316	+47,454
	Missiles	161	322	+161
	Rockets	30	40	+10

Note: The increase in tempo under the proposed action is mostly a result of an increase in Combat Systems Ship Qualification Trials as discussed above.

Table 6. Proposed number of explosives (i.e., projectiles, bombs, missiles, and rockets) used by activity and bin compared to current baseline levels (U.S. Navy 2021).

Activity	Baseline Ordnance	Proposed Ordnance	Explosive Bin
Gunnery Exercise/Test (Surface-to-Surface, Air-to-Surface; Ship) (Medium- or Large-Caliber)	1,147 medium-caliber projectiles (1,121 HE)	40,200 medium-caliber projectiles (22,110 HE)	E1
	1,715 large-caliber projectiles (943 HE)	10,116 large-caliber projectiles (6,575 HE)	E3, E5
Bombing Exercise/Test (Air-to-Surface)	22 bombs (18 HE)	30 bombs (20 HE)	E7, E9
Missile Exercise/Test (Surface-to-Air)	54 missiles (35 HE)	152 missiles (100 HE)	E6, E8
Missile Exercise/Test (Air-to-Surface)	99 missiles (64 HE)	150 missiles (98 HE)	E6, E7, E8, E9

Activity	Baseline Ordnance	Proposed Ordnance	Explosive Bin
Missile Exercise/Test (Surface-to-Surface, Subsurface-to-Surface)	8 missiles (5 HE)	20 missiles (13 HE)	E9, E10
Missile Exercise/Test (Air-to-Surface, Rocket)	30 rockets (24 HE)	40 rockets (26 HE)	E5, E7

HE=High explosives

3.4 Standard Operating Procedures

When conducting training and testing activities, the Navy implements standard operating procedures to provide for safety and mission success. Navy standard operating procedures are broadcast via numerous naval instructions and manuals to ensure compliance. Standard operating procedures applicable to training and testing have been developed through years of experience, and their primary purpose is to provide for safety (including public health and safety) and mission success. In many cases, there are benefits to environmental resources resulting from standard operating procedures. For example, the Naval Air Training and Operating Procedures Standardization General Flight and Operating Instructions Manual (CNAF M-3710.7) contains naval air training procedures pertaining to safe operations of aircraft, which includes requirements to minimize the disturbance of wildlife.

3.4.1 Vessel Safety

Ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when vessels are moving through the water (underway). Watch personnel undergo training on tasks such as avoiding hazards and ship handling. Training includes on-the-job instruction and a formal qualification program to certify that they have demonstrated all necessary skills. Skills include detection and reporting of floating or partially submerged objects. Watch personnel include officers, enlisted men and women, and civilians operating in similar capacities. Their duties as watchstanders may be performed in conjunction with other job responsibilities, such as navigating the ship or supervising other personnel. While on watch, personnel use visual search and scanning techniques aided by binoculars. After sunset and prior to sunrise, watch personnel use night visual search techniques and night vision devices when available.

The primary duty of watch personnel is to ensure safety of the ship, and this includes the requirement to detect and report all objects and disturbances sighted in the water that may be indicative of a threat to the ship and its crew, such as debris, a periscope, a surfaced submarine, or a surface disturbance. Per safety requirements, watch personnel also report any marine mammals sighted that have the potential to be in the direct path of the ship as a standard collision avoidance procedure. The standard operating procedures for vessel safety could reduce adverse effects to marine mammals and sea turtles through a reduction in the potential for vessel strike due to the presence of watch personnel at all times.

3.4.2 High-Energy Laser Safety

The Navy operates laser systems approved for fielding by the Laser Safety Review Board or service equivalent. Only properly trained and authorized personnel operate high-energy lasers within designated operating areas (OPAREAs) and ranges. OPAREAs and ranges where lasers are used are required to have a Laser Range Safety Certification Report updated every three years. Prior to commencing activities involving high-energy lasers, the operator performs a search of the intended impact location to ensure that the area is clear of unauthorized persons and wildlife.

3.4.3 Weapons Firing Safety

Most weapons firing activities that involve the use of explosive munitions are conducted during daylight hours. In addition, pilots of Navy aircraft are not authorized to expend ordnance, fire missiles, or drop other airborne devices through extensive cloud cover where visual clearance for non-participating aircraft and vessels in the air and on the sea surface is not possible. The two exceptions to this requirement are: (1) when operating in the open ocean, clearance for non-participating aircraft and vessels in the air and on the sea surface through radar surveillance is acceptable; and (2) when the Officer Conducting the Exercise or civilian equivalent accepts responsibility for the safeguarding of airborne and surface traffic. This standard operating procedure benefits marine mammals and sea turtles by increasing the effectiveness of visual observations for mitigation during applicable explosive weapons firing activities.

3.4.4 Target Deployment and Retrieval Safety

The deployment and retrieval of targets is dependent upon environmental conditions. Firing exercises involving the deployment and retrieval of targets from small boats are typically conducted in daylight hours in Beaufort Sea State[2] number 4 conditions (i.e., winds 11 to 16 knots, small waves 1 to 4 feet becoming longer, numerous whitecaps) or less to ensure safe operating conditions during target deployment and recovery. These standard operating procedures benefit marine mammals and sea turtles by increasing the effectiveness of visual observations for mitigation, thereby reducing the potential for interactions with the weapons firing activities associated with the use of applicable deployed targets. For more details on Navy use of deployed targets and potential stressors associated with military expended materials see Section 5.3.2.

During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. Recovery of these items helps minimize the amount of materials that remain on the surface or on the seafloor, which could alert enemy forces to the presence of Navy assets during military missions and combat operations. This standard operating procedure benefits marine mammals, sea turtles, and fish by reducing the potential for

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[2] http://w1.weather.gov/glossary/index.php?word=beaufort+scale

entanglement or ingestion of target materials and any associated decelerators/parachutes. For more details on proposed use of decelerators/parachutes and potential stressors associated with entanglement see Section 5.4.

3.4.5 Towed Target Safety

As a standard collision avoidance procedure, prior to deploying a towed in-water device (e.g., surface target) from a manned platform, the Navy searches the intended path of the device for any floating debris, objects, or animals (e.g., driftwood, concentrations of floating vegetation, marine mammals) that have the potential to obstruct or damage the device. Concentrations of floating vegetation can be indicators of potential marine mammal or sea turtle presence because marine mammals and sea turtles are known to seek shelter in, feed on, or feed among it. For example, young sea turtles are known to hide from predators and eat the algae associated with floating concentrations of kelp paddies or other marine vegetation. This standard operating procedure benefits marine mammals, sea turtles, and vegetation serving as habitat for these animals through a reduction in the potential for physical disturbance and strike by a towed target. For more details on proposed use of in-water devices and potential stressors associated with physical disturbance and strike see Section 5.3.3.

3.5 Mitigation Measures[3]

The Navy proposed to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors from training and testing activities on ESA-listed species in the action area (described in Section 4). NMFS considers these measures identified and described by the Navy as components of the Navy's proposed action. The following sections summarize the mitigation measures that the Navy proposes to implement in association with the training and testing activities analyzed in this document. For each of the mitigation measures described below, the Navy operational community provided input on the practicability of each measure and whether additional mitigation could be implemented to further reduce potential impacts to ESA-listed species.

3.5.1 Procedural Mitigation

Procedural mitigation is mitigation that the Navy will implement whenever and wherever training or testing activities involving applicable acoustic, explosive, and physical disturbance and strike stressors take place within the PMSR. Specific, case-by-case mission requirements, safety, and environmental conditions will also be considered when determining whether a mitigation measure is practicable to implement (e.g., mission-essential components, risk to personnel, equipment limitations and fuel constraints, adverse weather). The Navy customized procedural mitigation for the activity categories and stressors applicable to the proposed action.

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[3] We consider these mitigation measures "conservation measures": actions that will be taken by the Navy and serve to avoid or minimize project effects on the species under review. As such, we evaluate the effects of these measures as integral parts of the proposed action to be implemented by the Navy.

Procedural mitigation generally involves: (1) the use of one or more trained Lookouts (trained observers) to observe for specific biological resources within a mitigation zone, (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate Test Conductor or watch station for information dissemination, and (3) requirements for the Test Conductor or watch station to implement appropriate mitigation or until an activity condition has been met.

Lookouts are personnel who perform similar duties as the standard watch personnel described previously, such as observing for objects that could present a potential danger to the observation platform (e.g., debris in the water, incoming vessels, and incoming aircraft). Lookouts have an additional duty of helping meet the Navy's mitigation requirements by visually observing for marine mammals and sea turtles. However, for some activities, Lookouts may also be required to observe for additional biological resources, such as birds, fish, jellyfish aggregations, or floating vegetation. Some biological resources can be indicators of potential marine mammal or sea turtle presence because animals have been known to seek shelter in, feed on, or feed in them. For example, young sea turtles have been known to hide from predators and eat the algae associated with floating vegetation, and leatherback sea turtle occurrence is often associated with the presence of jellyfish aggregations, their primary prey. The Navy proposes to observe for these additional biological resources during certain activities to protect ESA-listed species or to offer an additional protection for marine mammals and sea turtles.

Mitigation zones are areas at the surface of the water within which applicable training or testing activities will be ceased or modified to protect specific ESA-listed species from an auditory injury (PTS), non-auditory injury (from impulsive sources), or direct strike (e.g., vessel strike) to the maximum extent practicable. Mitigation zones are measured as the radius from a stressor. Implementation of procedural mitigation is most effective when mitigation zones are appropriately sized to be realistically observed during typical training and testing activity conditions. The Navy customized its mitigation zone sizes and mitigation requirements for each applicable training and testing activity category or stressor. The Navy developed each mitigation zone to be the largest area that (1) Lookouts can reasonably be expected to observe during typical activity conditions, and (2) the Navy can commit to implementing mitigation without impacting safety, sustainability, or the ability to meet mission requirements.

Depending on the activity, a Lookout may be positioned on a ship (i.e., surface ships and surfaced submarines), on a small boat (e.g., a rigid-hull inflatable boat), in an aircraft, on a pier, or on the shore. Certain platforms, such as aircraft and small boats, have manning or space restrictions; therefore, the Lookout on these platforms is typically an existing member of the aircraft or boat crew (e.g., pilot) who is responsible for other essential tasks (e.g., navigation). On platforms that do not have manning and space restrictions (such as large ships), the Officer of the Deck, a member of the bridge watch team, or other personnel may be designated as the Lookout. The Navy is unable to position Lookouts on unmanned vehicles and unmanned aerial systems, or have Lookouts observe during activities that use systems deployed from or towed by unmanned platforms. Although the Navy is unable to position Lookouts on unmanned vessels, as a standard operating procedure, some vessels that operate autonomously have embedded sensors that aid in avoidance of large objects.

The Navy takes several courses of action in response to a sighting of an applicable biological resource (e.g., ESA-listed species, floating vegetation) in a mitigation zone. First, a Lookout will communicate the sighting to the appropriate watch station. Next, the watch station will implement the prescribed mitigation (e.g., halting an explosion, maneuvering a vessel). If floating vegetation is observed prior to the initial start of an activity, the activity will be relocated to an area where floating vegetation is not observed (the Navy does not propose to halt activities if vegetation floats into the mitigation zone after activities commence as the Navy determined such an action not to be practical for operational and safety reasons). For sightings of marine mammals and sea turtles during an activity, the activity will be suspended or otherwise altered based on the applicable mitigation measures until one of the four recommencement conditions listed below has been met. The recommencement conditions are designed to allow a sighted animal to leave the mitigation zone before an activity resumes.

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 stressor source;
3) The mitigation zone has been clear of any additional sightings for a specific wait period; or
4) For mobile activities, the stressor source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

In some instances, such as if an animal dives underwater after a sighting, it may not be possible for a Lookout to visually verify if that animal has left the mitigation zone. To account for this, one of the recommencement conditions is an established post-sighting wait period. Wait periods are designed to allow animals time to resurface and be available to be sighted again before an activity or the use of a stressor resumes. The Navy proposes a 30-minute wait period to activities conducted from vessels and activities that involve aircraft that are not typically fuel constrained (e.g., maritime patrol aircraft). Thirty minutes is the maximum amount of time that those activities can be halted without preventing the activity from meeting its intended objective (Navy 2018a). A 30-minute period covers the average dive times of most marine mammals, and a portion of the dive times of sea turtles and deep-diving marine mammals (i.e., sperm whales, dwarf and pygmy sperm whales [*Kogia* species], and beaked whales). The Navy proposes a shorter wait period of 10 minutes for activities that involve aircraft with fuel constraints (e.g., rotary-wing aircraft [i.e., helicopters], fighter aircraft), since 10 minutes is the maximum amount of time that those activities can be halted without compromising safety due to aircraft fuel restrictions (Navy 2018a). A 10-minute period covers a portion of the marine mammal and sea turtle dive times, but not the average dive times of all species.

The first procedural mitigation (Environmental Awareness and Education) is designed to aid Lookouts and other personnel with their observation and environmental compliance responsibilities, as well as training and testing activity reporting requirements. The remainder of the procedural mitigation measures are organized by stressor type and activity category. For explosive sources, proposed mitigation is dependent on the NEW of the detonation.

3.5.1.1 Environmental Awareness and Education

The Navy provides environmental awareness and education training to aid in visual observation, environmental compliance, and reporting responsibilities. This training helps Navy personnel gain a better understanding of their personal environmental compliance roles and responsibilities and helps to ensure Navy-wide compliance with environmental requirements. The Navy will provide environmental awareness and education training modules to the appropriate personnel as outlined in Table 7.

Table 7. Environmental awareness and education procedural mitigation

Procedural Mitigation Description
Stressor or Activity • All training and testing activities, as applicable
Resource Protection Focus • Marine mammals • Sea turtles
Mitigation Requirements • Appropriate personnel (including civilian personnel) involved in mitigation and training or testing activity reporting under the proposed action will complete one or more modules of the U.S. Navy Afloat Environmental Compliance Training Series, as identified in their career path training plan. Modules include: ○ **Introduction to the U.S. Navy Afloat Environmental Compliance Training Series**. The introductory module provides information on environmental laws (e.g., ESA, MMPA) and the corresponding responsibilities that are relevant to Navy training and testing activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship. ○ **Marine Species Awareness Training**. All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, rotary-wing aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including floating vegetation, jellyfish aggregations, and flocks of seabirds. ○ **U.S. Navy Protective Measures Assessment Protocol**. This module provides the necessary instruction for accessing mitigation requirements during the event planning phase using the Protective Measures Assessment Protocol software tool.

3.5.1.2 Weapons Firing Noise

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from weapons firing noise, as outlined in Table 8. The mitigation zone extends beyond the distance to which marine mammals and sea turtles would likely experience PTS or TTS from weapons firing noise; therefore, mitigation will help avoid or reduce the potential for exposure to these impacts.

Table 8. Procedural mitigation for weapons firing noise.

Procedural Mitigation Description
Stressor or Activity • Weapons firing noise associated with large-caliber gunnery activities
Resource Protection Focus • Marine mammals • Sea turtles
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 one described in Section 2.5.3.1 (Explosive Medium- and Large-Caliber Projectiles) or Section 2.5.4.2 (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.

3.5.1.3 Explosive Medium-Caliber and Large-Caliber Projectiles

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive gunnery activities, as outlined in Table 9.

Large-caliber gunnery activities involve vessels firing projectiles at targets located up to six nautical miles (NM) down range. Medium-caliber gunnery activities involve vessels firing projectiles at targets located up to 4,000 yards (3,658 meters) down range, although typically much closer. Due to their relatively lower vantage point, Lookouts (during medium-caliber or large-caliber gunnery exercises) will be more likely to detect large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles when observing around targets located at the furthest firing distances. The Navy will implement larger mitigation zones for large-caliber gunnery activities than for medium-caliber gunnery activities due to the nature of how the activities are conducted. For example, large-caliber gunnery activities are conducted from surface combatants, so Lookouts can observe a larger mitigation zone because they typically have access to high-powered binoculars mounted on the ship deck. This will enable observation of the distant mitigation zone in combination with hand-held binoculars and naked-eye scanning. Lookouts in aircraft (during medium-caliber gunnery exercises), have a relatively higher vantage point for observing the mitigation zones but will still be more likely to detect individual marine mammals and sea turtles when observing mitigation zones located close to the firing platform than at the furthest firing distances. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce potential impacts on these resources within the mitigation zones.

Explosive bin 5 (E5; e.g., large-caliber projectiles with NEW >5–10 pounds [lb]) have the longest predicted underwater acoustic impact ranges for explosive projectiles applying to the 1,000 yd mitigation zone. Bin E2 (e.g., large-caliber projectiles with NEW >0.5–2.5 lb) has the longest predicted underwater acoustic impact ranges for explosive projectiles that apply to the 600 yd and 200 yd mitigation zones. The 1,000 yd, 600 yd, and 200 yd mitigation zones extend beyond the respective ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The 1,000 yd mitigation zone extends beyond the average ranges to PTS for sea turtles, mid-frequency cetaceans, and otariids, and into a portion of the average ranges to PTS for high-frequency cetaceans and low-frequency cetaceans. The 600 yd and 200 yd mitigation zones extend beyond the respective average ranges to PTS for sea turtles, mid-frequency cetaceans, low-frequency cetaceans, and otariids and into a portion of the average range to PTS for high-frequency cetaceans. The mitigation zones also extend into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E5 and bin E2. Explosives in smaller source bins (e.g., E1; medium-caliber projectiles with NEW 0.1–0.25 lb) have shorter predicted impact ranges; therefore, the mitigation zones extend beyond or cover a greater portion of the impact ranges for these explosives.

The mitigation applies only to activities using maritime surface targets. Most airborne targets are recoverable aerial drones that are not intended to be hit by ordnance. Given the speed of the projectiles and mobile target, and the long ranges that projectiles typically travel, it is not possible to definitively predict or to effectively observe where the projectile fragments will fall. For gunnery activities using explosive medium- and large-caliber projectiles, the potential military expended material fall zone (hazard pattern) can only be predicted within thousands of yards, which can be up to six nautical miles from the firing location. These areas are too large to be effectively observed for marine mammals and sea turtles with the number of personnel and platforms available for this activity. The potential risk to marine mammals and sea turtles during events using airborne targets is limited to the animal being directly struck by falling military expended materials.

Table 9. 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 maritime surface target
Resource Protection Focus • Marine mammals • Sea turtles
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 8 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.
Mitigation Requirements • Mitigation zones: ○ 200 (183 meters) yards around the intended impact location for air-to-surface activities using explosive medium-caliber projectiles ○ 600 yards (549 meters) around the intended impact location for surface-to-surface activities using explosive medium-caliber projectiles ○ 1,000 yards (914 meters) around the intended impact location for surface-to-surface activities using explosive large-caliber projectiles • Prior to the initial start of the activity (e.g., when maneuvering on station): ○ Observe the mitigation zone for 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. • Commencement/recommencement conditions 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

Procedural Mitigation Description
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): o 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 ESA-listed species are observed, follow established incident reporting procedures. o 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.

3.5.1.4 Explosive Missiles and Rockets

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive missiles and rockets, as outlined in Table 10. Missile and rocket exercises involve firing munitions at a maritime surface target typically located up to 15 NM down range, and infrequently up to 75 NM down range. Procedural mitigation for explosive missiles and rockets will involve one Lookout located in an aircraft used to fire at the target. Lookouts are equipped with traditional and Big Eye high-powered binoculars. Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting marine mammals and sea turtles during close-range observations and are less likely to detect these resources once positioned at the firing location, particularly individual marine mammals, cryptic marine mammal species, and sea turtles. There is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its firing position). Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce potential impacts on these resources within the mitigation zones. The mitigation only applies to activities using maritime surface targets. Most airborne targets are recoverable aerial drones that are not intended to be hit by ordnance.

The Navy will implement larger mitigation zones (2,000 yd) for missiles using 21–500 lb NEW than for missiles and rockets using 0.6–20 lb NEW (900 yd mitigation zone) due to the nature of how these activities are conducted. During activities using missiles in the larger NEW category, the firing aircraft (e.g., maritime patrol aircraft) have the capability of mitigating a larger area due to their larger fuel capacity. During activities using missiles or rockets in the smaller NEW category, the firing aircraft (e.g., rotary-wing aircraft) are typically constrained by their fuel capacity. The mitigation only applies to aircraft-deployed missiles and rockets because aircraft can fly over the intended impact area prior to commencing firing. Mitigation would be ineffective for vessel-deployed missiles and rockets because of the inability for a Lookout to detect marine mammals or sea turtles from a vessel from the distant firing position.

Bin E10 (e.g., Harpoon missiles), the largest explosive bin for the proposed action, has the longest predicted impact ranges for explosive missiles that apply to the 2,000 yd mitigation zone. Bin E6 (e.g., Hellfire missiles) has the longest predicted impact ranges for explosive missiles and rockets that apply to the 900 yd mitigation zone. The 2,000 yd and 900 yd mitigation zones extend beyond the respective ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zones extend beyond the respective average ranges to PTS for sea turtles and all marine mammal hearing groups except high-frequency cetaceans (the mitigation zones extend into a portion of the respective average ranges to PTS for this hearing group). The mitigation zones also extend into a portion of the

Table 10. Procedural mitigation for explosive missiles and rockets.

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed explosive missiles ○ Mitigation applies to activities using a maritime surface target at ranges up to 75 NM
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: ○ 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. • Commencement/recommencement conditions 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 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.

average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E10 and bin E6. Explosives in smaller source bins (e.g., missiles in bin E9, rockets in bin E3) have shorter predicted impact ranges; therefore, the mitigation zones will cover a greater portion of the impact ranges for these explosives.

3.5.1.5 Explosive Bombs

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive bombs, as outlined in Table 11. The explosive bombing mitigation zone is based on NEW and the associated average ranges to PTS. The Navy determined that the proposed mitigation zone for explosive bombs is the largest area within which it is practical to implement mitigation for this activity.

Bombing exercises involve an aircraft deploying munitions at a surface target located beneath the firing platform. During target approach, aircraft maintain a relatively steady altitude of approximately 1,500 ft. Lookouts, by necessity for safety and mission success, primarily focus their attention on the water surface surrounding the intended detonation location (i.e., the mitigation zone). Being positioned in an aircraft gives the Lookout a good vantage point for observing marine mammals and sea turtles throughout the mitigation zone.

Bin E10 (e.g., 500-lb NEW bombs) has the longest predicted impact ranges for explosive bombs used in the PMSR Study Area. The 2,500-yd (2,286-meter) mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles, mid-frequency cetaceans, low-frequency cetaceans, and otariids. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest bombs in bin E10. Smaller bombs (e.g., 250-lb bombs) have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

Table 11. Procedural mitigation for explosive bombs.

Procedural Mitigation Description
Stressor or Activity • Explosive bombs • Mitigation applies to activities using a maritime surface target at ranges up to 75 NM
Resource Protection Focus • Marine mammals • Sea turtles
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 yards (2,286-meters) around the intended target • Prior to the initial start of the activity (e.g., when arriving 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 bomb deployment. • During the activity (e.g., during target approach): ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Commencement/recommencement conditions 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 bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 min.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): ○ When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead 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.

3.5.1.6 Vessel Movement

The Navy will implement procedural mitigation to avoid or reduce the potential for vessel strikes of marine mammals and sea turtles, as outlined in Table 12. Although the Navy is unable to position Lookouts on unmanned vessels, as a standard operating procedure, some vessels that operate autonomously have embedded sensors that aid in avoidance of large objects. The embedded sensors may help those unmanned vessels reduce the risk of vessel strikes of marine mammals, sea turtles, and large fish.

Table 12. Procedural mitigation for vessel movement.

Procedural Mitigation Description
Stressor or Activity • Vessel movement o 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., e.g., during launching and recovery of target, during towing activities), (3) the vessel is operated autonomously, or (4) when impractical based on mission requirements.
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout on the vessel that is underway
Mitigation Requirements • Mitigation zones: o 500 yards (457 meters) around whales o 200 yards (183 meters) around other marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) o 100 yards (91 meters) (for small boats, such as range craft) around other marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) o Within the vicinity of sea turtles • During the activity: o When underway, observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance. • Additional requirements: o If a marine mammal or sea turtle vessel strike occurs, the Navy will follow the established incident reporting procedures.

3.5.1.7 Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from small-, medium-, and large-caliber non-explosive practice munitions, as outlined in Table 13. The mitigation zone is designed to be several times larger than the impact footprint for large-caliber non-explosive practice munitions, which are the largest projectiles used for these activities. Small-caliber and medium-caliber non-explosive practice munitions have smaller impact footprints than large-caliber non-explosive practice munitions; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller projectiles.

Large-caliber gunnery activities involve vessels firing projectiles at a target located up to six nautical miles down range. Small- and medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets located up to 4,000 yds (3,658 meters) down range, although typically much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets located close to the firing platform. When observing activities that use a target located far from the firing platform, Lookouts will be more likely to detect large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles.

Table 13. 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 maritime surface target
Resource Protection Focus • Marine mammals • Sea turtles
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 8 for Weapons Firing Noise.
Mitigation Requirements • Mitigation zone: ○ 200 yards (183 meters) 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. • Commencement/recommencement conditions 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.

3.5.1.8 Non-Explosive Missiles and Rockets

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from non-explosive missiles and rockets, as outlined in Table 14. The mitigation zone for non-explosive missiles and rockets is designed to be several times larger than the impact footprint for the largest non-explosive missile used for these activities. Smaller non-explosive missiles and non-explosive rockets have smaller impact footprints than the largest non- explosive missile used for these activities; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller projectiles.

Mitigation applies to activities using non-explosive missiles fired from aircraft at targets that are typically located up to 15 nautical miles down range, and infrequently up to 75 nautical miles down range. There is a chance that animals could enter the mitigation zone after the aircraft conducts its close-range mitigation zone observations and before firing begins (once the aircraft has transited to its firing position). Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting marine mammals and sea turtles during the close-range observations and are less likely to detect these resources once positioned at the firing location, particularly individual marine mammals, cryptic marine mammal species, and sea turtles.

Table 14. Procedural mitigation for non-explosive missiles.

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed non-explosive missiles and non-explosive rockets ○ Mitigation applies to activities using a maritime surface target at ranges up to 75 NM
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: ○ 900 yards (823 meters) 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. • Commencement/recommencement conditions 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.

3.5.1.9 Non-Explosive Bombs

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from non-explosive bombs, as outlined in Table 15. The mitigation zone for non-explosive bombs is designed to be several times larger than the impact footprint for the largest non-explosive bomb used for these activities. Smaller non-explosive bombs have smaller impact footprints than the largest non-explosive bomb used for these activities; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller military expended materials.

Activities involving non-explosive bombing involve aircraft deploying munitions from a relatively steady altitude of approximately 1,500 ft at a surface target or in an intended minefield located beneath the aircraft. Due to the mitigation zone size, proximity to the observation platform, and the good vantage point from an aircraft, Lookouts will be able to observe the entire mitigation zone during approach of the target or intended minefield location.

Table 15. Procedural mitigation for non-explosive bombs.

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs • Mitigation applies to activities using a maritime surface target at ranges up to 75 NM
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: o 1,000 yards (914 meters) around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o 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): o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting prior to or during the activity: o 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) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 min.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

3.6 Awareness and Notification Messages

In addition to the procedural mitigation measures described above (Section 3.5.1), the Navy will continue to issue awareness notification messages seasonally to alert ships and aircraft to the possible presence of concentrations of large whales in portions of the action 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 will issue awareness notification messages for the following species and seasons:

- Blue whale awareness notification message (June 1–October 31);
- Gray whale awareness notification message (November 1–March 31); and
- Fin whale awareness notification message (November 1–May 31).

In addition to the ongoing large whale awareness notification messages, the Navy will issue the following new awareness notification message for loggerhead sea turtles within the PMSR:

> *The Navy will use information from NOAA to monitor oceanographic and environmental conditions (e.g., Temperature Observations To Avoid Loggerhead (TOTAL) tool) to assess the potential for loggerhead sea turtles to be present within the boundaries of the Point Mugu Sea Range. When NOAA resources indicate the potential for loggerhead sea turtle presence, such as an "Alert Status" from the TOTAL tool for the given month, the Navy will notify test managers and test conductors to increase the awareness and vigilance of personnel to the potential presence of loggerhead sea turtles. Should loggerhead sea turtles be sighted in pre-event monitoring efforts, mitigation and protective measures identified in the Navy's Protective Measures Assessment Protocol (PMAP) will be implemented to significantly reduce the potential for unauthorized taking.*

The TOTAL tool was developed by the NOAA CoastWatch program (West Coast Regional node), which provides timely access to near real-time satellite data for management purposes. The tool was designed for management of loggerhead bycatch in the California drift gillnet fishery, and covers the Pacific Loggerhead Conservation area, which partially overlaps with the PMSR. In this context, an alert is indicated when the sea surface temperature anomaly indicator values (the timeseries) exceed a particular threshold (for details see: https://coastwatch.pfeg.noaa.gov/loggerheads/loggerhead_closure.html). The Navy has indicated that they will monitor and provide feedback on the usefulness of the TOTAl tool, as well as their internal notification process, through an adaptive management process (Cory Scott, Navy - Point Mugu Sea Range Sustainability Office, personal communication [Email] to Ron Salz, NMFS – OPR/PR5, January 6, 2022).

3.7 MMPA Regulations and Issuance of a Letter of Authorization

On March 5, 2020, NMFS' Permits Division received an application from the Navy requesting regulations and a LOA for the take of marine mammals incidental to Navy training and testing activities to be conducted in the PMSR over seven years. The six marine mammal species in the LOA that are also ESA-listed species (or DPSs) are: blue whale, fin whale, humpback whale Central America DPS and Mexico DPS, sperm whale, and Guadalupe fur seal. The Navy requested regulations that would establish a process for authorizing take, via a seven-year LOA, of these marine mammals for training and testing activities proposed to be conducted from February 2022 through February 2029.

The Permits Division proposes to promulgate regulations pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to PMSR activities from February 2022 through February 2029. The regulations propose to authorize the issuance of a LOA that will allow the Navy to "take" marine mammals incidental to their training and testing activities.

The Permits Division's proposed regulations are available at the following website: https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities. This consultation considers the proposed MMPA regulations for the Navy to "take" marine mammals incidental to PMSR activities (86 FR 37790). The final MMPA regulations, upon publication, will also be available at the website shown above. Note that this biological opinion was completed prior to the publication of the final MMPA regulations in the Federal Register. We anticipate that, upon publication, the MMPA regulations will reflect the mitigation and monitoring measures proposed by the Navy and/or agreed to during ESA consultation (a description of the mitigation measures is in Section 3.5 of this opinion). We will also review mitigation measures imposed by the final regulations to ensure they are consistent with measures to avoid and minimize take prescribed in the ITS. We also anticipate that the levels of take of ESA-listed marine mammals authorized under the final MMPA regulations and LOA will be consistent with those analyzed in this opinion. Upon publication, we will review the MMPA regulations to ensure these conditions are met. If administrative changes are needed following publication of the MMPA regulations, we will update the biological opinion to reflect these changes. If more substantive changes (e.g., those related to the effects analyses, take authorization, and/or avoidance and minimization measures) are needed, the reinitiation triggers described in Section 14 may apply.

4 ACTION AREA

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02).

The PMSR consists of 36,000 mi^2 of controlled sea and associated airspace (Figure 14). The airspace can be temporarily expanded to execute the Naval Air Warfare Center Weapons Division (NAWCWD) mission to provide full-spectrum weapons and warfare systems testing (e.g., using long-range missiles and other long-range weapons delivery systems). Temporary airspace expansion, when needed to support mission requirements, would include a horizontal expansion of the airspace typically no further than 200 NM. No explosives are used within the expanded area outside of the PMSR boundaries. The expansion of temporary airspace would occur infrequently, would last just a few hours, and would not occur over multiple days. The PMSR includes a highly instrumented coastline and offshore islands, two full-service military airfields, target and missile launch facilities, data collection and surveillance aircraft, and a skilled staff of technical personnel. Additional details on the PMSR-controlled sea space, airspace, and range facilities as they relates to the action area are provided below.

4.1 Point Mugu Sea Range Controlled Sea Space

The PMSR-controlled sea space parallels the California coast for approximately 225 NM and extends approximately 180 NM seaward (Figure 14), aligning with the PMSR Warning Area airspace. 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 mi^2 of the PMSR daily. When required for test 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 (USCG) to provide timely maritime safety within the PMSR-controlled sea space and Notices to Airmen for the temporary expansion of the airspace.

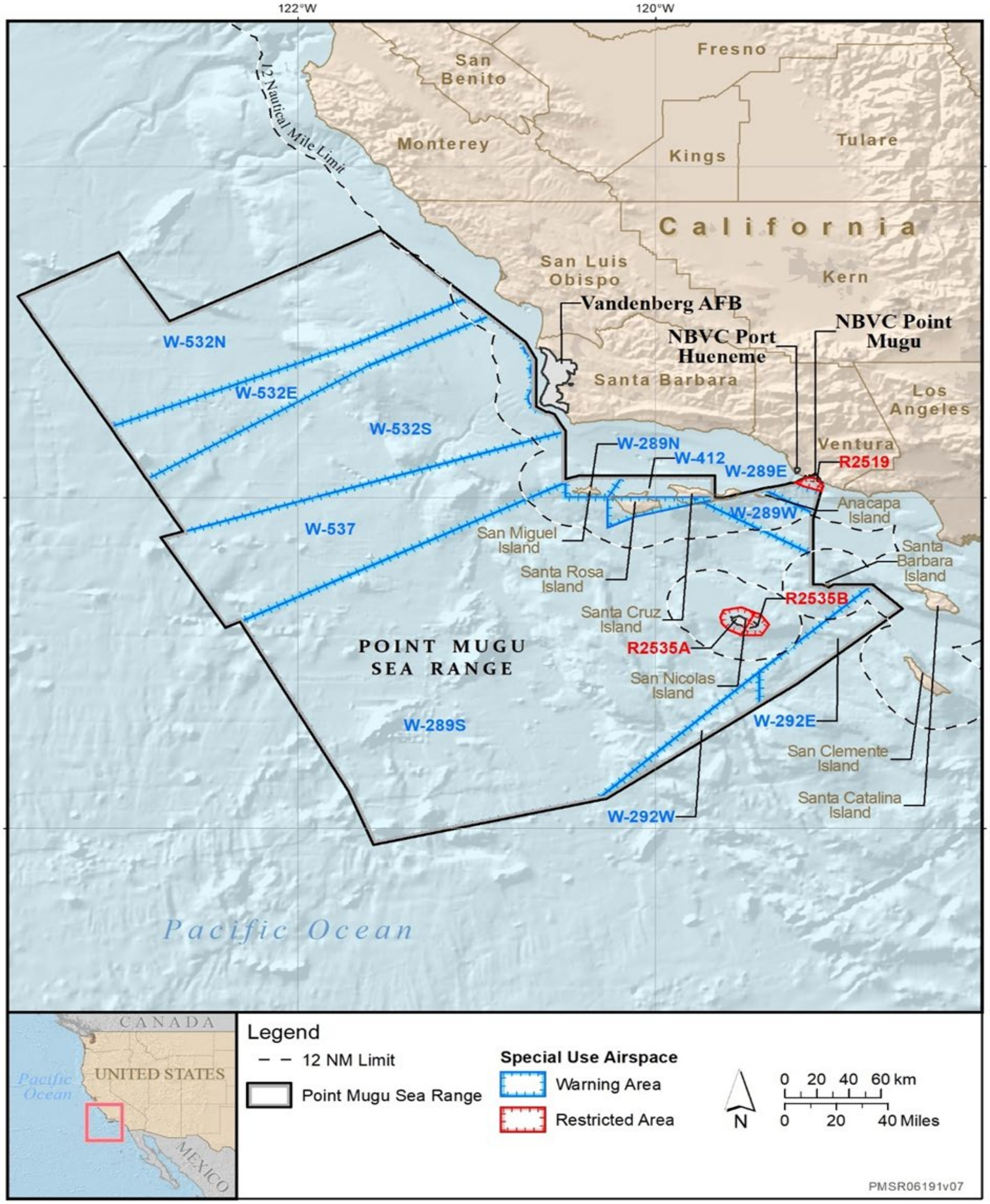

Figure 14. PMSR action area.

Within the PMSR, the highest area of concentration for military activities is within Warning Area W-289S, as shown by the oval in Figure 15. Based on information provided by the Navy, impact area W-289S accounted for 77 percent of all ordnance/munitions (e.g., gunnery, missiles, rockets, bombs) used within the PMSR from fiscal year 2016 through 2020 (U.S. Department of the Navy 2021c).

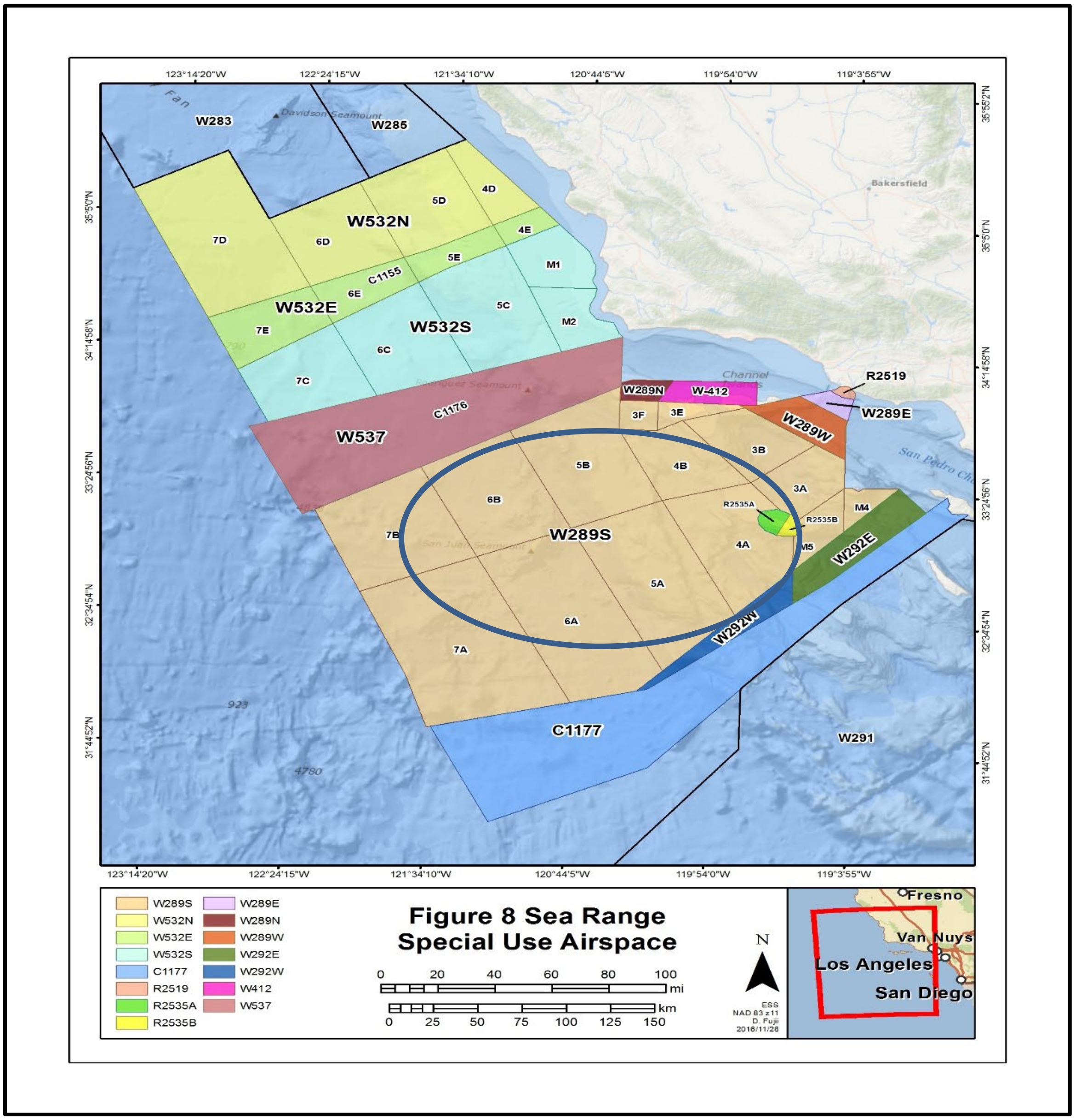

Figure 15. Highest area of concentration for PMSR activities as indicated by the oval within Warning Area 289S (U.S. Department of the Navy 2021c).

4.2 Point Mugu Sea Range Controlled Airspace

The 36,000 mi^2 of PMSR-controlled airspace consists of three Restricted Areas and 11 Warning Areas (Figure 14). The Warning Areas can be further subdivided into specific OPAREAs to safely accommodate simultaneous operations, or to minimize impacts to commercial and civil air traffic. PMSR scheduled aircraft flying in the PMSR airspace take off and land at a variety of installations in the western United States. Aircraft may also launch and land on aircraft carriers and other ship platforms as components of test events. PMSR airspace is located within the greater airspace controlled by the Los Angeles Air Route Traffic Control Center. The Los Angeles Air Route Traffic Control Center is the controlling agency, which releases control of aircraft into and out of the PMSR to PMSR control for the primary purpose of testing and selected training; therefore, when the PMSR is functioning as the using agency for the PMSR-controlled airspace, it is responsible for all civilian and military aircraft traffic services within the released airspace.

4.3 Naval Base Ventura County Range Areas and Facilities

Naval Base Ventura County (NBVC) is a regionalized naval installation composed of three operating facilities—Port Hueneme, Point Mugu, and SNI. All three installations provide support to the PMSR and, for purposes of the proposed action, the action area only includes offshore areas of NBVC Port Hueneme, NBVC Point Mugu, and NBVC SNI.

4.3.1 Naval Base Ventura County Port Hueneme

NBVC Port Hueneme is located 60 miles northwest of Los Angeles and 4 miles south of the city of Oxnard (Figure 16). NBVC Port Hueneme provides port and docking facilities for PMSR support ships, target surface craft, the Navy's Self Defense Test Ship, and Fleet units using PMSR for testing and combat system qualification trials. The action area includes the port where support vessels and targets are located and transit to and from the PMSR. No changes from current activities or testing activity support are being proposed at NBVC Port Hueneme.

4.3.2 Naval Base Ventura County Point Mugu

NBVC Point Mugu encompasses 4,486 acres of coastal land in Ventura County, California, approximately 50 miles north of Los Angeles. It includes the Laguna Peak complex located 1.5 miles east of Point Mugu. NBVC Point Mugu has two Class B runways that support testing and training activities on PMSR. Aircraft sorties and range support aircraft that originate from the Point Mugu airfield for testing and training activities are analyzed as part of the proposed action. Surveillance and metric radar systems are located at NBVC Point Mugu, and the PMSR Communications Center is located on the station. Restricted airspace (R-2519) and its corresponding surface danger zone preclude public and nonparticipating aircraft and vessels entry into the area when active (Figure 16). Permanently restricted waters extending approximately 100 to 300 yd offshore of NBVC Point Mugu are closed to the public. NAWCWD also operates control rooms, and target and test launch pads that directly contribute to activities in the PMSR.

The action area includes the restricted waters extending from NBVC Point Mugu that underlie R-2519, due to activities conducted from the proposed Directed Energy (DE) Systems Integration Laboratory (DESIL), the Launch Complex Building 55, and the Alpha, Bravo, Charlie, and Nike Zeus launch pads (Figure 16).

4.3.3 San Nicolas Island

SNI is located approximately 62 miles southwest of Point Mugu, California, and is owned by the Navy (Figure 17). The island covers a total of 13,370 acres and is approximately 9 mi long and 3.6 mi wide. Restricted airspace (R-2535A/B) and corresponding surface danger zones extend out to 3 NM offshore of SNI (Alpha, Bravo, and Charlie) and preclude public and commercial aircraft and vessel entry into this area when active (Figure 17).

Due to its remote location, SNI can be used to simulate shipboard launches of missiles and serve as a target for a spectrum of inert weapons. The island is extensively instrumented with metric tracking radar, electro-optical devices, telemetry, and communications equipment necessary to support long-range and over-the-horizon weapons and combat systems testing. SNI provides test facilities that include buildings, launch areas, and the Land Impact Site, which is the only target area on the island.

The action area for SNI activities analyzed as part of this opinion includes activities that would occur from the proposed DE Test Facility , and aerial target or missile launches at the existing Alpha Launch Complex and the Building 807 Launch Complex. The Alpha Complex, comprised of the Coyote and Upper Launch pads, is typically used for launching the GQM-163A supersonic target (commonly referred to as "Coyote"). The Building 807 Launch Complex is used to launch both targets and missiles. The Building 807 Launch Complex is comprised of what are commonly referred to as the Tomahawk and Rolling Airframe Missile Launch Pads (Figure 17).

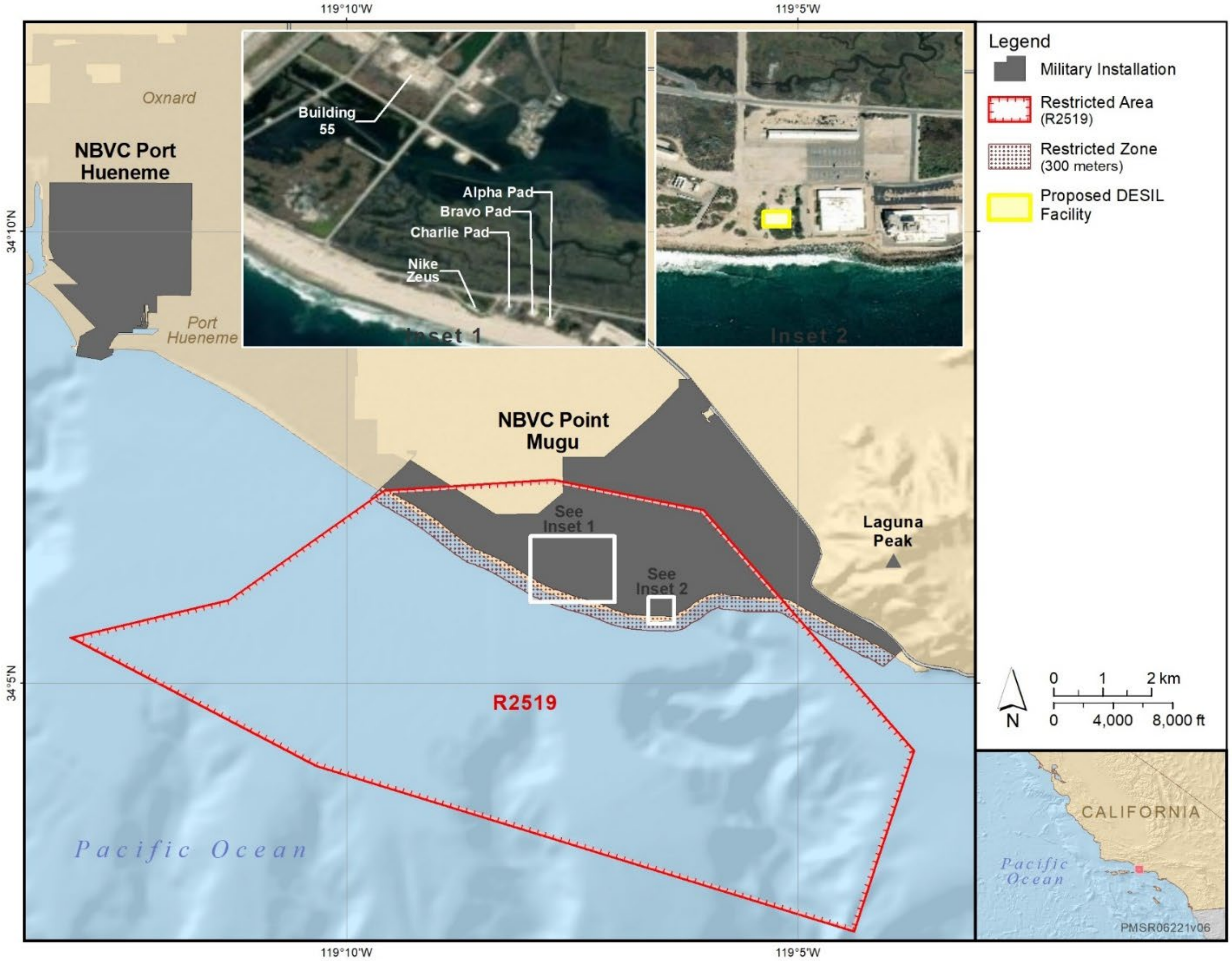

Figure 16. Naval Base Ventura County Point Mugu and Port Hueneme.

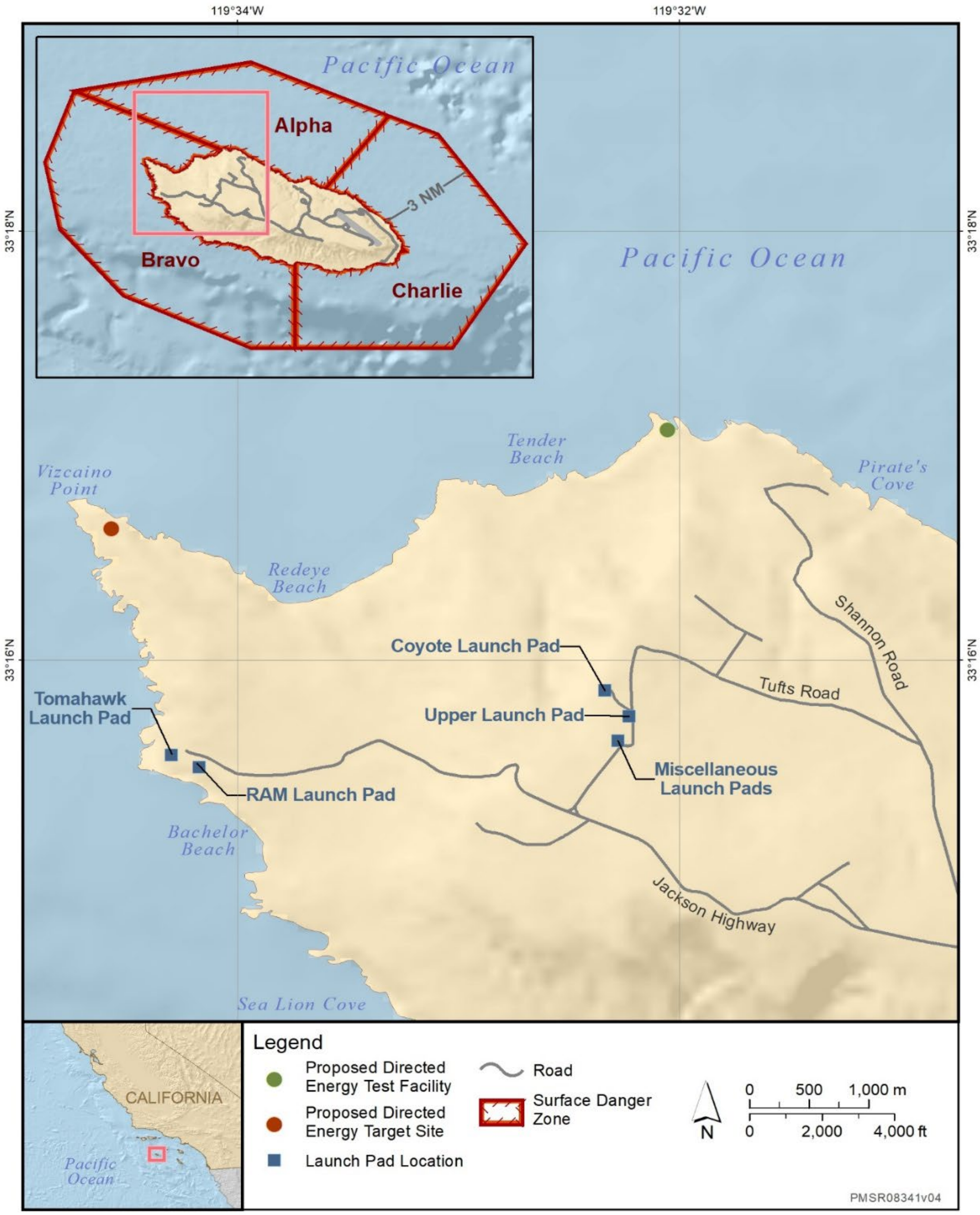

Figure 17. San Nicolas Island.

5 POTENTIAL STRESSORS

Stressors are any physical, chemical, or biological agent, environmental condition, external stumulus or event that may induce an adverse response. The potential stressors we expect to result from the proposed action are acoustic stressors, explosive stressors, energy stressors, physical disturbance and strike stressors, entanglement stressors, and ingestion stressors. In addition to the effects of these stressors on ESA-listed species, we consider effects of stressors through impacts to species' habitat (including water quality or sediments) or prey. Further discussion of each of the stressors expected to result from the proposed action is below.

5.1 Acoustic Stressors

Acoustic stressors include incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique energetic characteristics.

5.1.1 Explosives

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging to ESA resources. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive warhead, the type of explosive material, the boundaries and characteristics of the propagation medium, and, in water, the detonation depth. The NEW, the explosive power of a charge expressed as the equivalent weight of trinitrotoluene, accounts for the first two parameters.

As mentioned in Section 2.2.1, there are no fully underwater explosives proposed for use in the PMSR. All explosives used during testing and training activities at the PMSR would detonate in air, with a subset of those occurring at or near the water's surface (near being defined here as at a height within 10 m above the surface). Explosions occurring in-air or at or near the surface at PMSR include detonations of bombs, missiles, rockets, and naval gun shells. Some typical types of explosive munitions that would be detonated in-air during Navy activities are shown in Table 16. Various bombs, missiles, rockets, and naval gun shells may also be inert or non-explosive, depending on the objective of the testing or training activity in which they are used. Testing of and training with high-explosive munitions that could detonate in the air or at or near the water's surface, sends energy into the water and could result in potential impacts on marine species. Most testing or training with explosives would occur greater than three NM from shore.

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher frequency components of explosive broadband noise can propagate.

Bombs and projectiles that detonate at or near the water surface, which are considered for underwater impacts, would also release some explosive energy into the air. 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.

Missiles, rockets, projectiles, and other cased weapons will produce casing fragments upon detonation. These fragments may be of variable size and are ejected at supersonic speed from the detonation. The casing fragments will be ejected at velocities much greater than debris from any target due to the proximity of the casing to the explosive material. Unlike detonations on land targets, in-air detonations during Navy testing and training would not result in other propelled materials such as crater debris.

Table 16. In-Air Explosive Munitions Used During Navy Activities (U.S. Navy 2021)

Weapon Type[1]	Net Explosive Weight (lb.)	Typical Altitude of Detonation (ft.)
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-162 Evolved Sea Sparrow (ESSM)	36	> 15,000
AGM-114 Hellfire	18	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-120 AMRAAM	17	> 15,000
Projectile – Large- Caliber[2,3]		
5"54/62 caliber HE-ET	7	< 100
5"54/62 caliber Other	8	< 3,000

[1] Mission Design Series and popular name shown for missiles.

[2] While most medium and large-caliber projectiles used during Navy testing and training activities do not contain high explosives, the Navy conservatively estimated the majority (~65%) of these projectiles to be high explosive.

[3] Used against an airborne target (>100 feet above water surface)

Notes: lb = pound(s), ft = feet, AMRAAM = Advanced Medium-Range Air-to-Air Missile, HE-ET = HighExplosive-Electronic Time, > = greater than, < = less than.

5.1.2 Vessel Noise

Potential impacts of vessel noise on ESA-listed species include masking of other biologically relevant sounds, physiological stress, and changes in behavior. Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and SPLs at a source will vary according to speed, burden, capacity and length (Kipple and Gabriele 2007; Mckenna et al. 2012; Richardson et al. 1995c). Because of the number of vessels involved in Navy testing and training activities, the vessel speed, and the use of course changes as a tactical measure with the associated sounds, the available evidence leads us to expect marine mammals and sea turtles to treat Navy vessels as stressors. The available evidence suggests that unit- and intermediate-level exercises and testing activities would represent different stress regimes because of differences in the number of vessels involved, vessel maneuvers, and vessel speeds.

Naval vessels (including ships and small craft) produce low-frequency, broadband underwater sound, though the exact level of noise produced varies depending on the nature, size, and speed of the ship. Mckenna et al. (2012) determined that container ships produced broadband source levels around 188 dB re 1 μPa rms and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 μPa rms (Richardson et al. 1995c; Urick 1983a). The average acoustic signature for a Navy vessel is 163 dB re 1 μPa rms, while the average acoustic signature for a commercial vessel is 175 dB re 1 μPa rms (Mintz and Filadelfo 2011b). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 hertz (Hz) and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz; (Mintz and Filadelfo 2011b; Richardson et al. 1995b; Urick 1983b). Vessels ranging from 135 to 337 m (Nimitz-class aircraft carriers, for example, have lengths of about 332 m) generate peak source sound levels from 169 to 200 dB re 1 μPa rms between 8 Hz and 430 Hz. Sound produced by vessels will typically increase with speed. During training and testing, speeds of most large naval vessels (greater than 60 ft) generally range from 10 to 15 knots. Navy ships will, on occasion, operate at higher speeds within their specific operational capabilities.

As described in more detail in Section 5.3.1 below (*Vessel Strike*), Navy vessel traffic makes up an extremely small amount of overall vessel traffic (i.e., much less than one percent) in the action area. Navy vessels may represent an even smaller amount of overall vessel traffic noise in the action area because many Navy ships incorporate quieting technology that other vessels (e.g., commercial ships) do not (Mintz and Filadelfo 2011b). For example, surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) are designed to be very quiet to evade enemy detection. The Navy implements a "Buy Quiet" policy for equipment aboard ships which requires designers and engineers to obtain noise emission data before purchasing to choose the quietest available. The Navy also researches and implements technology improvements that minimize noise. For example, propellers used on Navy ships have been subject to design improvements to reduce excitation. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz and Filadelfo 2011b). The average acoustic signature for a Navy vessel is 163 dB re 1 μPa, while the average acoustic signature for a commercial vessel is 175 dB re 1 μPa (Mintz and Filadelfo 2011a). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (MacGillivray et al. 2019; Mintz and Filadelfo 2011a; Richardson et al. 1995a; Urick 1983b). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (Mckenna et al. 2012). Small craft will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed (MacGillivray et al. 2019; Wladichuk et al. 2019).

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the action area. Activities involving vessel movements occur intermittently and are variable in duration.

5.1.3 Aircraft Noise

Many Navy activities involve some level of activity from aircraft that include helicopters, maritime patrols, and fighter jets. Low-flying aircraft produce sounds that marine mammals and sea turtles can potentially hear when they occur at or near the ocean's surface. Helicopters generally tend to produce sounds that can be heard at or below the ocean's surface more than fixed-wing aircraft of similar size, and larger aircraft tend to be louder than smaller aircraft (Richardson et al. 1995a). Underwater sounds from aircraft are loudest just below the surface and directly under the aircraft. Sounds from aircraft would not have physical effects on marine animals but represent acoustic stimuli (primarily low-frequency sounds from engines and rotors) that have been reported to affect the behavior of some marine mammals and sea turtles. There are few studies of the responses of marine animals to air traffic and the few that are available have produced mixed results. Some investigators report responses while others report no responses.

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training and testing activities throughout the action area, contributing both airborne and underwater sound to the ocean environment. Sounds in air are often measured using A-weighting, which adjusts received sound levels based on human hearing abilities. Aircraft used in training and testing generally have turboprop or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Aircraft may transit to or from vessels at sea throughout the action area from established airfields on land. The majority of aircraft noise would be generated at NBVC Point

Mugu airfield, which is immediately adjacent to the Study Area. Takeoffs and landings occur as well on vessels across the Study Area. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 17 provides source levels for some typical aircraft used in the Study Area and depicts comparable airborne source levels for the F-35, EA-18G, and F/A-18 during takeoff.

Sound generated in air is transmitted to water primarily in a narrow area directly below the source. A sound wave propagating from any source must enter the water at an angle of incidence of about 13 degrees or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick 1983a). Water depth and bottom conditions strongly influence how the sound from airborne sources propagates underwater. At lower altitudes, sound levels reaching the water surface would be higher, but the transmission area would be smaller (i.e., sound would radiate out as a cone from the aircraft, with the area of transmission at the water surface being larger at increasing distances). As the sound source gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases.

Table 17. Representative Aircraft Sound Characteristics (U.S. Navy 2022).

Noise Source	Sound Pressure Level
In-Water Noise Level	
F/A-18 Subsonic at 1,000 ft (300 m) Altitude	152 dB re 1 µPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 ft (3,000 m) Altitude	128 dB re 1 µPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 ft (25 m) Altitude	Approximately 125 dB re 1 µPa at 1 m below water surface[2]*
Airborne Noise Level	
F/A-18 Under Military Power	143 dBA re 20 µPa at 13 m from source[3]
F/A-18 Under Afterburner	146 dBA re 20 µPa at 13 m from source[3]
F-35 Under Military Power	145 dBA re 20 µPa at 13 m from source[3]
F-35 Under Afterburner	148 dBA re 20 µPa at 13 m from source[3]
H-60 Helicopter Hovering at 82 ft (25 m) Altitude	113 dBA re 20 µPa at 25 m from source[2]
H-65 Helicopter Hovering at 82 ft (25 m) Altitude	113 dBA re 20 µPa at 25 m from source[2]**
F-35 Takeoff Through 1,000 ft (300 m) Altitude	119 dBA re 20 µPa^{2}s[4]*** (per second of duration)
EA-18G Takeoff Through 1,622 ft (500 m) Altitude	115 dBA re 20 µPa^{2}s [5]** (per second of duration)

Sources: [1]Eller and Cavanagh (2000) [2]Bousman and Kufeld (2005); [3]U.S. Naval Research Advisory Committee (2009), [4]U.S. Department of the Air Force (2016), [5]U.S. Department of the Navy (2012)

* estimate based on in-air level

**modeled at the greater H-60 level

***average sound exposure level

Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s), ft. = feet

5.1.3.1 Fixed-wing aircraft

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties (a flight mission made by an individual aircraft) would occur above 3,000 ft. Air combat maneuver altitudes generally range from 5,000 to 30,000 ft, and typical airspeeds range from very low (less than 200 knots) to high subsonic (less than 600 knots). Sound exposure levels at the sea surface from most air combat maneuver overflights are expected to be less than 85 A-weighted decibels re 20 µPa (based on an F/A-18 aircraft flying at an altitude of 5,000 ft and at a subsonic airspeed (400 knots)). Exposure to fixed-wing aircraft noise in water would be brief (seconds) as an aircraft quickly passes overhead.

5.1.3.2 Helicopters

In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al. 1995a). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air and is estimated to be 125 dB re 1 µPa at 1 meter below water surface for a UH-60 hovering at a 82 ft (25 m) altitude (Bousman and Kufeld 2005).

5.1.3.3 Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are not intentionally generated below 30,000 ft unless over water and are generally conducted more than 30 NM from inhabited coastal areas or islands. Deviation from these guidelines may occur for tactical missions that require supersonic flight, phases of formal training requiring supersonic speeds, research and test flights that require supersonic speeds, and for flight demonstration purposes when authorized by the Chief of Naval Operations.

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the louder the shock waves (Navy 2017b). Aircraft maneuvers that result in changes to acceleration, flight path angle, or heading can also affect the strength of a boom. In general, an increase in flight path angle (lifting the aircraft's nose) will diffuse a boom while a decrease (lowering the aircraft's nose) will focus it. In addition, acceleration will focus a boom while deceleration will weaken it. Any change in horizontal direction will focus or intensify a boom by causing two or more wave fronts that originate from the aircraft at different times to coincide exactly (Navy 2017b). Atmospheric conditions such as wind speed and direction, and air temperature and pressure can also influence the sound propagation of a sonic boom.

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing the sonic boom intensity that is experienced at the sea or shore level. The width of the boom "carpet" or area exposed to a sonic boom beneath an aircraft is about one mi for each 1,000 ft of altitude. For example, an aircraft flying supersonic, straight, and level at 50,000 ft can produce a sonic boom carpet about 50 mi. wide. The sonic boom, however, would not be uniform, and its intensity at the water surface would decrease with greater aircraft altitude. Maximum intensity is directly beneath the aircraft and decreases as the lateral distance from the flight path increases until shock waves refract away from the ground or water surface and the sonic boom attenuates. The lateral spreading of the sonic boom depends only on altitude, speed, and the atmosphere and is independent of the vehicle's shape, size, and weight. The ratio of the aircraft length to maximum cross-sectional area also influences the intensity of the sonic boom. The longer and more slender the aircraft, the weaker the shock waves. The wider and more blunt the aircraft, the stronger the shock waves can be (Navy 2017b).

In air, the energy from a sonic boom is concentrated in the frequency range from 0.1 to 100 Hz. The underwater sound field due to transmitted sonic boom waveforms is primarily composed of low-frequency components (Sparrow 2002), and frequencies greater than 20 Hz have been found to be difficult to observe at depths greater than 33 ft (10 m) (Sohn et al. 2000b). F/A-18 Hornet supersonic flight was modeled to obtain peak SPLs and energy flux density at the water surface and at depth (Laney and Cavanagh 2000). These results are shown in Table 18.

Table 18. Sonic boom underwater sound levels modeled for supersonic flight from a representative aircraft (U.S. Navy 2022).

*Mach Number**	*Aircraft Altitude (km)*	*Peak SPL (dB re 1 µPa)*			*Energy Flux Density (dB re 1 µPa²-s)¹*		
		At surface	*50 m Depth*	*100 m Depth*	*At surface*	*50 m Depth*	*100 m Depth*
1.2	1	176	138	126	160	131	122
	5	164	132	121	150	126	117
	10	158	130	119	144	124	115
2	1	178	146	134	161	137	128
	5	166	139	128	150	131	122
	10	159	135	124	144	127	119

* Mach number equals aircraft speed divided by the speed of sound.

Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s)

[1] Equivalent to SEL for a plane wave.

5.1.4 Weapons Firing, Launch and Impact Noise

The Navy trains and tests using a variety of weapons. Depending on the weapon, noise may be produced at launch or firing, while in flight, or upon impact. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by in-air explosives were discussed in Section 5.1.1.

Small- to medium-caliber rounds up to but not including the 57 millimeter non-explosive round could be used throughout the PMSR. Noise associated with large-caliber weapons firing and the impact of non-explosive inert munitions or kinetic weapons would typically occur at locations greater than 12 NM from shore in warning areas or special use airspace for safety reasons. Examples of some types of weapons noise resulting from the proposed action are shown in Table 19.

Firing a gun produces a muzzle blast in air that propagates away from the gun with strongest directivity in the direction of fire. Because the muzzle blast is generated at the gun, the noise decays with distance from the gun. The muzzle blast has been measured for the largest gun analyzed in the draft EIS, the five-inch large-caliber naval gun. At a distance of 3,700 ft from the gun, which was fired at a 10 degree elevation angle, and at 10 degrees off the firing line, the in-air received level was 124 dB re 20 µPa SPL peak for the atmospheric conditions of the test (U.S. Department of the Navy 1981). Measurements were obtained for additional distances and angles off the firing line, but were specific to the atmospheric conditions present during the testing.

As the pressure from the muzzle blast from a ship-mounted large-caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. Most sound enters the water in a narrow cone beneath the sound source (within about 13 to 14 degrees of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5-inch large-caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 µPa, measured 5 ft below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla and Stiegler 2003a). The unweighted SEL would be expected to be 15 to 20 dB lower than the peak pressure, making the highest possible SEL in the water about 180 to 185 dB re 1 microPascal squared second (μPa^2-s) directly below the muzzle blast. Configuration of the 5-inch gun on Navy ships also affects how much sound from the muzzle blast could enter the water. On cruisers, when swung out to either side, the barrel of the gun extends beyond the ship deck and over water. On destroyers, when swung out to either side, the barrel of the gun is still over the ship's deck. Other gunfire arrangements, such as with smaller-caliber weapons or greater angles of fire, would result in less sound entering the water. The sound entering the water would have the strongest directivity directly downward beneath the gun blast, with lower sound pressures at increasing angles of incidence until the angle of incidence is reached where no sound enters the water.

Table 19. Examples of some types of weapons noise from PMSR activities (U.S. Navy 2022).

Noise Source	*Sound Level*
In-Water Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	Approximately 200 dB re 1 µPa peak directly under gun muzzle at 1.5 m below the water surface[1]
Airborne Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	178 dB re 20 µPa peak directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 µPa at 4.5 m[2]
RIM 116 Surface-to-Air Missile	122–135 dBA re 20 µPa between 2 and 4 m from the launcher on shore[3]
Tactical Tomahawk Cruise Missile	92 dBA re 20 µPa 529 m from the launcher on shore[3]

Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 20 µPa = decibel(s) referenced to 20 micropascals, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s)
Sources: [1]Yagla and Stiegler (2003b); [2]U.S. Department of the Army (1999); [3]U.S. Department of the Navy (2013)

Large-caliber gunfire also sends energy through the ship structure and into the water. This effect was investigated in conjunction with the measurement of the five-inch gun firing described above. The energy transmitted through the ship to the water for a typical round was about six percent of that from the muzzle blast impinging on the water (U.S. Department of the Navy 2000). Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

Supersonic projectiles, such as a fired gun shell or kinetic energy weapon, create a bow shock wave along the line of fire. A bow shock wave is an impulsive sound caused by a projectile exceeding the speed of sound. The bow shock wave itself travels at the speed of sound in air. The projectile bow shock wave created in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65 degrees) behind the projectile in the direction of fire (Pater 1981). Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location. Measurements of a five-inch projectile shock wave ranged from 140 to 147 dB re 20 µPa SPL peak taken at the ground surface at 0.59 NM distance from the firing location and 10 degrees off the line of fire for safety (approximately 190 m from the shell's trajectory; (U.S. Department of the Navy 1981). Hyperkinetic projectiles may travel up to and exceed approximately six times the speed of sound in air, or about 6,500 ft/sec. For a hyperkinetic projectile sized similar to the five inch shell, peak pressures would be expected to be several dB higher than those described for the five-inch projectile above, following the model (U.S. Department of the Navy 1981). Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location.

Missiles and targets can be rocket or jet propelled, and are launched from shore, vessels, or aircraft in PMSR special use airspace (such as warning areas, air traffic control, and restricted areas). Target launches are done from launch facilities on Point Mugu and SNI, as well as air launched from PMSR support aircraft. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Examples of launch noise sound levels are shown in Table 19.

Any object dropped in the water would create a noise upon impact, depending on the object's size, mass, and speed. Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. A significant portion of an object's kinetic energy would be lost to splash, any deformation of the object, and other forms of non-mechanical energy (McLennan 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

5.2 Energy Stressors

Energy stressors include in-air electromagnetic devices and lasers, each of which is described further in the sections below.

5.2.1 Electromagnetic Devices

Sources of electromagnetic energy in the air include kinetic energy weapons, communications transmitters, radars, and electronic countermeasures transmitters. Electromagnetic devices on Navy platforms operate across a wide range of frequencies and power. On a single ship, the source frequencies may range from 2 megahertz to 14,500 megahertz, and transmitter maximum average power may range from 0.25 watts to 1,280,000 watts. It is assumed that most Navy platforms associated with the proposed action will be transmitting from a variety of in-air electromagnetic devices at all times that they are underway, with very limited exceptions. Most of these transmissions (e.g., for routine surveillance, communications, and navigation) will be at low power. High-power settings are used for a small number of activities including ballistic missile defense training, missile and rocket testing, radar and other system testing, and signature analysis operations. Many high-power systems have restrictions on how close to shore they may be used or how they may be directed, in order to avoid impacting civilian infrastructure or personnel. The number of Navy vessels or aircraft in the action area at any given time varies and is dependent on local testing or training requirements. Because these stressors are operated at power levels, altitudes, and distances from people and animals to ensure that energy received is well below levels that could disrupt behavior or cause injury, and because most in-air electromagnetic energy is reflected by water, in-air electromagnetic energy is not considered a stressor to the ESA-listed species analyzed in this opinion (i.e., no effect), and is not discussed further.

5.2.2 Lasers

The devices discussed here include lasers (the maximum power of up to 1 megawatt and wavelengths from 180 nanometers to 14,000 nanometers) that can be organized into two categories: (1) low-energy lasers, and (2) high-energy lasers. Low-energy lasers are used to illuminate or designate targets, measure the distance to a target, guide weapons, and aid in communication. The highest potential level of exposure of ESA-listed species considered in this opinion to low-energy lasers would be from an airborne laser beam directed at the ocean's surface. An assessment of the use of low-energy lasers by the Navy determined that low-energy lasers, including those involved in PMSR testing and training activities, have an extremely low potential to impact marine biological resources (U.S. Department of the Navy 2010a). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (Campbell et al. 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich 2004). Based on the parameters of the low-energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine species. However, an animal's eye would have to be exposed to a direct laser beam for at least 10 seconds or longer to sustain damage. The U.S. Department of the Navy (2010) assessed the potential for damage based on species-specific eye/vision parameters and the anticipated output from low-energy lasers, and determined that no animals were predicted to incur damage.

High-energy lasers would be employed from surface ships, helicopters, or land-based facilities and are designed to create small but critical failures on air and surface targets. High-energy laser weapons are a newer activity in the PMSR and are expected to be used at short ranges (i.e., line-of-sight). The Navy has proposed 624 annual, directed energy training and testing events that include high-energy laser weapons as part of PMSR activities. As with low-energy lasers, the greatest potential for impacts to ESA-listed species are to the eyes of these species. If a high-energy laser beam were to enter the water, it would have an extremely low potential to impact marine species due to its relatively low intensity at large distances and the highly aversive effect at close range for animals with vision (Zorn et al. 2000).

There are safeguards on high-energy laser platforms that reduce the probability of the laser striking the water. These safeguards include the following: 1) the high energy laser platform has provisions that prevent misfiring (i.e., firing when not intended) that all but eliminate the possibility of that event; 2) the high-energy laser platforms have built-in constraints that only permit firing when it is locked onto a target. It also automatically interrupts firing if the target track on a target is lost; 3) operators are trained to stop firing when the laser aim point moves off of the selected target; and 4) SNI will be used as a backstop for some events to prevent any chance of a laser beam traveling farther than the test requires and into an uncontrolled/uncleared area.

5.3 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors described in the sections below include vessel strike, military expended materials, and in-water devices.

5.3.1 Vessel Strike

Vessels used by the Navy during training and testing activities include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 ft (5 m) to over 1,000 ft (300 m). Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 40 ft [12 m] in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat or retrieval of a target when a vessel would be dead in the water or moving slowly ahead to maintain steerage.

The number of military vessels in the action area at any given time varies and is dependent on local testing or training requirements. Most activities include either one or two vessels and may last from a few hours up to two weeks. The locations and number of hours of military vessel usage for testing and training activities have not appreciably changed in the last decade and are not expected to change significantly in the foreseeable future. Table 20 provides examples of the types of vessels, length, and speeds typically used in Navy testing and training activities.

Table 20. Representative vessel types, lengths, and speeds (U.S. Navy 2021).

Type	Example(s)	Length	Typical Operating Speed
Aircraft Carrier	Aircraft Carrier (CVN)	>1,000 ft	10–30 knots
Surface Combatant	Guided Missile Cruisers and Destroyers, Littoral Combat Ships (LCS)	300–700 ft	10–40 knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	300–900 ft	10–15 knots
Support Craft/Other	High-Speed Maneuvering Surface Target (HSMST) or QST-35	15–140 ft	0–40 knots
Test Ship	Self Defense Test Ship	0–600 ft	0–15 knots

Other	Coast Guard Cutter (WMSL)	418 ft	28 knot (max)
Submarines	Fleet Ballistic Missile Submarines (SSBN)	300–600 ft	8–13 knots

Notes: > indicates greater than, ft. = feet

The current baseline Navy vessel usage data provided in Table 21 and

Table 22 are representative of data gathered from ship combat systems evaluations, strategic weapons systems test events, and testing and training events conducted on the PMSR. Note that events are not always conducted independently of each other, as there are instances where a testing or training activity could occur on a vessel while another testing or training activity is being conducted on the same vessel simultaneously, with each counted as an "event" with "hours" as presented below. The amount of military vessel traffic in PMSR has been lower than that in the adjacent Navy Hawaii-Southern California Training and Testing (HSTT) action area (Figure 18). These usage levels are expected to occur in their respective areas for the forseeable future.

Table 21. Representative baseline and proposed annual vessel usage on the PMSR (U.S. Navy 2021).

Vessel	Ship Type	Baseline		Proposed Action	
		Events	Hours	Events	Hours
CG	Guided Missile Cruiser	66	410	41	275
DDG-51	Guided Missile Destroyer	54	198	36	132
LHA	Amphibious Assault Ship	41	202	40	200
SDTS	Self-Defense Test Ship	51	190	50	190
WMSL-751/OPC	Coast Guard Cutter	6	28	6	28
LCS Variant (LCS 1)	Littoral Combat Ship	4	43	40	360
LCS Variant (LCS 2)		41	362	40	360
FF	Future Frigate	0	0	40	360
DDG 1000 Zumwalt Class	Guided Missile Destroyer	0	0	3	30
LHD	Amphibious Assault Ship	4	13	4	13
LPD	Amphibious Transport Deck	4	13	4	13
LSD	Dock Landing Ship	4	13	4	13
CVN	Nuclear-Powered Aircraft Carrier	6	16	6	16
SSBN	Ballistic Missile Submarine	19	93	19	95
	Total	**300**	**1,581**	**333**	**2,085**

Table 22. Representative annual range support boat usage on the PMSR (U.S. Navy 2021).

Range Support Boat	Baseline	Proposed Action
ATLS-9701	23	23
Contract Vessel	36	24
Diane G	65	78
SL-120	74	74

Total	**198**	**199**

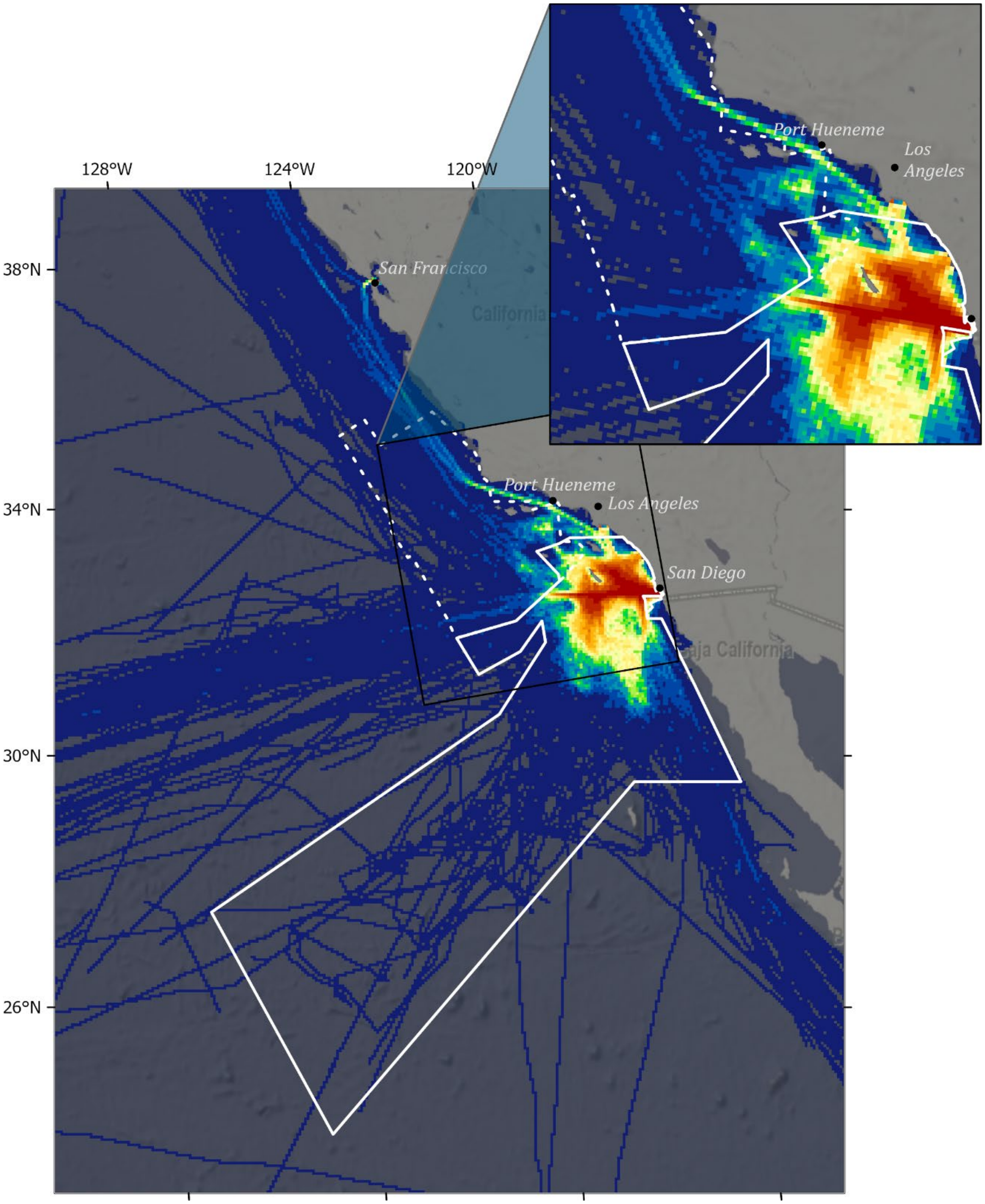

Figure 18. Military (U.S. Navy and U.S. Coast Guard) vessel traffic within the Southern California portion of HSTT from 2014 to 2018. Dark blue represents relatively low vessel traffic while red

represents relatively high vessel traffic. The solid white line represents the border of HSTT, while that of PMSR is the dotted white line (U.S. Department of the Navy 2021c).

The occasional presence of Navy vessels in the PMSR action area is an extremely small component of the overall vessel traffic in the waters in and around the PMSR. The majority of large vessels are present due to Traffic Separation Scheme's lanes for the ports of Los Angeles/Long Beach that run through both at the northern and southern portions of the PMSR. The two ports of Los Angeles and Long Beach are adjacent to one another, and together they form the busiest commercial port hub in the United States and the sixth-busiest commercial port traffic in the world (Port of Los Angeles 2017). In 2016, there were 4,277 ships visiting these ports resulting in over 8,400 large commercial ship transits of these nearshore waters (American Association of Port Authorities 2017; McKenna et al. 2015; Mckenna et al. 2012; Port of Los Angeles 2017; U.S. Army Corps of Engineers 2017). This large number of vessel port calls at Los Angeles/Long Beach does not account for a substantial number of additional commercial vessels transiting offshore of Point Mugu that may have stopped at or be bound for other major U.S. ports such as Seattle/Tacoma, San Francisco, or Port Hueneme. Those vessels are otherwise only transiting through the PMSR action area and therefore are not part of the overall port statistics. In addition to the commercial vessels transiting to and from the ports of Los Angeles and Long Beach and the commercial vessels transiting along the Pacific coast to ports north and south, there is also a substantial volume of fishing and recreational vessel traffic in the area (Mintz and Filadelfo 2011a; Mintz 2016; Mintz and Parker 2006; U.S. Department of the Navy 2018a).

5.3.2 Military Expended Materials

Military expended materials that may cause physical disturbance or strike include: (1) all sizes of non-explosive practice munitions, (2) fragments from high-explosive munitions, (3) expendable targets and target fragments, and (4) expended materials other than munitions, such as expended bathythermographs. Table 23 presents a comparison of military expended material during ongoing activities with the numbers as part of the Navy's proposed action that can potentially affect ESA-listed species such as non-explosive practice munitions (small-, medium-, and large-caliber missiles, rockets, bombs), fragments from explosives, and countermeasures (flares, chaff). The number of military expended materials under the proposed action in Table 23 is based on the highest potential annual level of increased tempo for planned operations, as identified during interviews with range test managers; test and scheduled training mission requirements; or existing National Environmental Policy Act documents for flight operations, vessel operations, aerial targets, surface targets, and ordnance.

Research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016) and an intensively used live fire range in the Mariana Islands (Smith and Marx Jr. 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life. Findings from these studies indicate that there were no adverse impacts on the local ecology from the presence of degrading munitions and there was no bioaccumulation of munitions-related chemicals in local marine species.

The island of Farallon de Medinilla in the Commonwealth of the Northern Mariana Islands has been used as a target area since 1971. Although outside the action area for this consultation, we use this island as an example of the anticipated effects from this stressor. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long term look at potential impacts on the marine life from training and testing involving the use of munitions (Smith and Marx Jr. 2016). Munitions use has included high-explosive rounds from gunfire, high-explosives bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, and bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the Navy training activities (Smith and Marx Jr. 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

Table 23. Comparison of the number of military expended materials between baseline activities and the proposed action (U.S. Navy 2021).

Military Expended Materials	Baseline	Proposed Action
Missiles		
Air-to- Air	53	190
Air-to-Surface	99	150
Surface-to-Air	54	152
Surface-to-Surface	8	20
Subsurface-to-Surface	11	40
Subsurface-to-Air	5	18
Gun Ammunition		
Small caliber (0.50 cal, 7.62 mm)	8,000	216,200
Medium caliber (20 mm, 25 mm, 30 mm, 35 mm)	1,470	52,000
Large caliber (57 mm, 76 mm, 5")	2,200	13,030
Bombs and Rockets		
Bombs	22	30
Rockets (2.75" unguided)	30	40
Targets		
Aerial Targets	92	176
Surface Targets	499	522
Countermeasures		
Flares*	28	10
Chaff*	20	16
Total	**12,591**	**282,594**

*Not counted in the total number of MEM as this item would not contribute to impacts on the seafloor and would break down to fibrous parts that, although ingestible, would not entangle or physically impact resources in the action area.

5.3.3 In-Water Devices

In-water devices include towed devices, including surface targets such as the Mobile Ship Target, Fast Attack Craft Target, High-Speed Maneuvering Surface Target, Low-Cost Modular Target, and QST-35. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters, unmanned underwater vehicles, and surface ships. In-water devices are generally smaller than most Navy vessels, ranging from several inches to about 50 ft, and can operate anywhere from the water surface to the benthic zone.

5.4 Entanglement Stressors – Decelerators and Parachutes

The Navy proposes to utilize decelerators and parachutes, which could pose an entanglement risk to ESA-listed species. Entanglement could occur at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with decelerators and parachutes could potentially result in negative sub-lethal effects and mortality.

Decelerators/parachutes used during testing and training activities are classified into four different categories based on size: small, medium, large, and extra-large. Aerial targets (drones) such as the BQM series use large (between 30 and 50 ft in diameter) and extra-large (80 ft in diameter) decelerators/parachutes. Large and extra-large decelerators/parachutes are also made of cloth and nylon, with suspension lines of varying lengths (large: 40 to 70 ft in length (with up to 28 lines per decelerator/parachute); extra-large: 82 ft in length (with up to 64 lines per decelerator/parachute). The majority of targets deployed in PMSR are BQM-177, with parachutes of around 48 feet in diameter (C. Scott, NAWCWD Range Sustainability Office, pers. comm. to R. Salz, NMFS HQ, April 6, 2021).

Some aerial targets also use a small drag parachute (six ft in diameter) to slow their forward momentum prior to deploying the larger primary decelerator/parachute. Unlike the small- and medium-sized decelerators/parachutes, drone decelerators/parachutes do not have weights attached and may remain at the surface or suspended in the water column for around 20 minutes prior to eventual settlement on the seafloor (C. Scott, NAWCWD Range Sustainability Office, pers. comm. to R. Salz, NMFS HQ, April 5, 2021). When practical, the majority of parachutes are recovered during target recovery. In 2019, around 69 parachutes were deployed in PMSR, 63 of which were recovered (C. Scott, NAWCWD Range Sustainability Office, pers. comm. to R. Salz, NMFS HQ, April 6, 2021).

5.5 Ingestion Stressors

Some of the expended materials resulting from PMSR activities are small enough to be ingested by marine mammals, sea turtles, and fish. These include: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerators/parachutes. Solid metal materials, such as small-caliber projectiles or fragments from high-explosive munitions, sink rapidly to the seafloor. Lighter plastic items may be caught in currents and gyres or entangled in floating kelp and could remain in the water column for hours to weeks or indefinitely before sinking (e.g., plastic end caps (from chaff cartridges) or plastic pistons (from flare cartridges).

5.5.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles and flechettes (small metal darts) from some non-explosive rockets would be small enough for marine animals to ingest, depending on the animal. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 inches in diameter. Flechettes from some non-explosive rockets are approximately 2 inches in length. Each non-explosive flechette rocket contains approximately 1,180 individual flechettes that are released. These solid metal materials would quickly move through the water column and settle to the seafloor.

5.5.2 Fragments from High Explosive Munitions

Many different types of high-explosive munitions can result in fragments that are expended at sea during training and testing activities. Types of high-explosive munitions that can result in fragments include torpedoes, neutralizers, grenades, projectiles, missiles, rockets, buoys, sonobuoys, countermeasures, mines, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the NEW and munition type. These solid metal materials would quickly sink through the water column and settle to the seafloor.

5.5.3 Target Related Materials

At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, many of which are designed to be recovered for reuse. However, if they are used during activities that use high-explosives then they may result in fragments and ultimate loss of the target. Expendable targets that may result in fragments would include air-launched decoys, surface targets (e.g., marine markers, cardboard boxes, and 10-ft diameter red balloons), and mine shapes. Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for many years.

5.5.4 Chaff

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff, which is stored in canisters, is either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud that mask the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (Navy 2017b). Chaff is released or dispensed from cartridges that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002; Navy 2017b). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 mi from the point of release, with the plume covering more than 400 mi (Arfsten et al. 2002).

The chaff concentrations that marine animals could be exposed to following the discharge of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom.

Baseline activity levels in PMSR consist of 20 annual events utilizing chaff while the proposed action consists of 16 annual chaff events.

5.5.5 Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft. The flare device consists of a cylindrical cartridge approximately 1.4 inches in diameter and 5.8 inches in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic compression pad or piston (0.45 to 4.1 grams depending on flare type). The flare pads and pistons float in sea water and may remain at the surface.

Baseline activity levels in PMSR consist of 28 annual events utilizing flares while the proposed action consists of 10 annual flare events.

5.6 Secondary Stressors

The proposed action may result in secondary stressors that affect ESA-listed marine mammals, sea turtles, and fish indirectly through impacts to species habitat (including water quality or sediments) or prey. Potential secondary stressors include (1) explosives and byproducts, (2) metals, and (3) chemicals from flares and propellants.

Explosions can leave explosive byproducts in the water that could impact water quality. Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Navy 2019b). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment.

6 SPECIES AND DESIGNATED CRITICAL HABITAT THAT MAY BE AFFECTED

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area that may be affected by the proposed action along with their regulatory status (Table 24). Section 6.1 identifies those species and critical habitats that may be affected but are not likely to be adversely affected by the proposed action because the effects of the proposed action, evaluated by each stressor, were deemed insignificant, discountable[4], or fully beneficial.

In Section 6.2, we provide a summary of the biology, ecology, and population status of those species that are likely to be adversely affected by one or more stressors created by the proposed action and detail information on their life histories in the action area, if known. The species that are likely to be adversely affected by the proposed action are carried forward in our effects analysis (Section 8).

Table 24. ESA-listed species and designated (or proposed) critical habitat that may be affected by the proposed action.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Invertebrates			
Black Abalone (*Haliotis cracherodii*)	E – 74 FR 1937	76 FR 66805*	-- --
White Abalone (*Haliotis sorenseni*)	E – 66 FR 29046	-- --	73 FR 62257
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998 10/2018
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) – Western North Pacific DPS	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E – 81 FR 62259	86 FR 21082	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	86 FR 21082	11/1991

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[4] When the terms "discountable" or "discountable effects" appear in this document, they refer to potential effects that are found to support a "not likely to adversely affect" conclusion because they are extremely unlikely to occur. The use of these terms should not be interpreted as having any meaning inconsistent with our regulatory definition of "effects of the action."

Species	ESA Status	Critical Habitat	Recovery Plan
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000*	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Mammals – Pinnipeds			
Guadalupe Fur Seal (*Arctocephalus townsendi*)	T – 50 FR 51252	-- --	-- --
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – Central North Pacific DPS	T – 81 FR 20057	-- --	01/1998 U.S. Pacific
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359
Loggerhead Turtle (*Caretta caretta*) – North Pacific DPS	E – 76 FR 58868	-- --	01/1998 - U.S. Pacific
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	63 FR 28359 05/1998 – U.S. Pacific
Fishes			
Steelhead (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487*	77 FR 1669
Giant manta ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Scalloped hammerhead shark (*Sphyrna lewini*) – East Pacific DPS	T – 79 FR 38213	-- --	-- --

* Indicates that critical habitat for this species does not overlap with the action area.

6.1 Species and Critical Habitat Not Likely to be Adversely Affected

NMFS uses two criteria to identify the ESA-listed species and designated critical habitat that are not likely to be adversely affected by the proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or designated critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. An ESA-listed species or designated critical habitat that co-occurs with a stressor of the action but is not likely to respond to the stressor is also not likely to be adversely affected by the proposed action.

The probability of an effect on a species or designated critical habitat is a function of exposure intensity and susceptibility of a species to a stressor's effects (i.e., probability of response). An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial, insignificant* or *discountable*.

Beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. *Insignificant* effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. *Discountable* effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species), but it is extremely unlikely to occur (USFWS and NMFS 1998).[5]

We applied these criteria to the ESA-listed species in Table 24 above. We summarize our results below for ESA-listed species and critical habitat that are not likely to be adversely affected by any stressor created by the proposed action.

6.1.1 Black Abalone

The current distribution of black abalone ranges approximately from Point Arena in northern California to Bahia Tortugas and Isla Guadalupe in Mexico (Butler et al. 2009). Although the geographic range of black abalone extends to northern California, the most abundant populations historically have occurred in the Channel Islands (Butler et al. 2009).

6.1.1.1 Occurrence in the PMSR Action Area

Black abalone live on rocky substrates in the high to low intertidal zone (with most animals found in the middle and lower intertidal) within the shallow water portions of the action area. They occur among other invertebrate species, including California mussels (*Mytilus californianus*), gooseneck barnacles (*Pollicipes polymerus*), and sea anemones (e.g., giant green anemone (*Anthopleura xanthogrammica*)). Of the species of abalone in the waters of California, the black abalone inhabits the shallowest areas. It is rarely found deeper than 6 m (20 ft), and smaller individuals generally inhabit the higher intertidal zones. Complex surfaces with cracks

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[5] When the terms "discountable" or "discountable effects" appear in this opinion, they refer to potential effects that are found to support a "not likely to adversely affect" conclusion because they are extremely unlikely to occur. The use of these terms should not be interpreted as having any meaning inconsistent with our regulatory definition of "effects of the action."

and crevices may be crucial habitat for juveniles, and appear to be important for adult survival as well (Butler et al. 2009).

SNI is one of the only locations in Southern California where black abalone have been increasing and where multiple recruitment events have occurred since 2005 (Butler et al. 2009). Black abalone monitoring sites were established on SNI in 1980 and first sampled in 1981 (Kenner 2018). During the first 10 years of monitoring, black abalone were very densely aggregated at the sites, with mean densities ranging from about 4 to 24 per square meter and with some quadrats having over 100 abalone stacked several deep. During 2015 intertidal surveys, a total of 1,548 black abalone were counted and measured at three sites at SNI (Graham et al. 2016a). In 2018, a total of 2,016 abalone were counted at nine sites at SNI, the highest count since 1996 (Kenner 2018). In 2019, a total of 2,022 abalone were counted at SNI (Kenner 2020). These are positive signs for the black abalone population at SNI. After several years of fairly regular growth, the monitored population size is now at about 8.7 percent of the pre-withering syndrome average (Kenner 2020).

6.1.1.2 Effects Analysis for Black Abalone

The stressors associated with the proposed action that could potentially affect black abalone include explosives, entanglement stressors, physical disturbance and strike, ingestion stressors, and effects to black abalone habitat.

Roberts et al. (2016) and Edmonds et al. (2016) report that marine invertebrates are generally not sensitive to most sounds that would result from the proposed activities involving explosives, but likely have mechanical receptors that may be connected to the central nervous system that can detect some movements or vibrations that are transmitted through substrate. Black abalone only occur on the seafloor on sub-tidal and intertidal rocky substrates, and there are no underwater explosions under the proposed action. Black abalone would not likely be exposed to surface explosions and associated underwater impulsive sounds from high-explosive munitions (including bombs and missiles). All of the black abalone habitat in the action area is not in areas where the Navy tests or trains with explosives. This species is not found in offshore areas where ordnance would be used, which is most frequently greater than 12 NM from shore and in water depths greater than 200 ft. Because the number of detonations for proposed testing and training activities under the proposed action is very small, and testing and training activities would take place in areas where this species does not occur, the probability of this species being exposed to detonation effects is extremely low (i.e., extremely unlikely). Therefore, we consider the effects from PMSR explosives use on the black abalone to be discountable.

Parachutes and decelerators used by the Navy as part of the proposed action could potentially be encountered by black abalone on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality and adverse sub-lethal effects if they are encountered by abalone. The primarily large and extra-large decelerators and parachutes proposed for use in the PMSR may pose a higher degree of risk for black abalone because these parachutes are larger and have long lines (large chutes have 28 cords, approximately 40 to 70 ft long; extra-large parachutes have 64 cords, up to 82 ft long), associated with them. However, the chance of an encounter is remote given the small number (i.e., less than ten annually) of the parachutes proposed to be deployed that would not be recovered. Given the vast area over which any one of these decelerators and parachutes would be deployed and the limited number of non-recovered items annually, the chances of a black abalone becoming entangled is extremely low (i.e., extremely unlikely). Therefore, we consider the effects from entanglement stressors on black abalone to be discountable.

Physical disturbance or strikes by vessels, military expended materials, and in-water devices on black abalone is possible at the seafloor. However, disturbance or strike impacts from vessels are extremely unlikely because the monitoring locations of the black abalone habitat around SNI are located in shallow water and are known to the Navy. In these and other areas, impacts from vessels would only occur in the unlikely event that a Navy vessel ran aground. Disturbance or strike impacts on this species by military expended materials and in-water devices are extremely unlikely because these materials do not generally sink rapidly enough to cause strike injury to abalone and the chances that military expended material would fall into specific cracks and crevices where black abalone are found are extremely low. These materials would also not be expected to affect black abalone because of the limited amount of items that would be expended in water depths less than 20 ft. It is conceivable for an item expended offshore to drift shoreward and reach water depths where black abalone may be present. The majority of military expended material in nearshore and offshore waters surrounding Tanner Bank is chaff and flares, which have a small potential for impacts. The probability of physical disturbance or strikes from military expended materials affecting black abalone is very low (i.e., extremely unlikely) because of the predominant use of these materials is outside of black abalone habitat. Therefore, we consider the effects from PMSR physical disturbance or strikes by vessels, military expended materials, and in-water devices on the black abalone to be discountable.

Potential impacts of ingestion on black abalone would be limited to individuals accidentally ingesting small fragments of military expended material that traveled from the surface and through the water column to the bottom. The entrapment response used by black abalone to trap prey items may be stimulated by tactile rather than chemical cues (VanBlaricom et al. 2009). Therefore, black abalone have the potential to accidentally ingest these materials as they scrape algae or biofilm (a thin layer of microorganisms) off hard substrates in shallow water. However, materials are primarily expended far from shore, in the open ocean, and likely would not drift into nearshore habitats where black abalone occur. Therefore, the probability of effects on black abalone from ingestion of military expended materials is extremely unlikely and we consider the effects from this stressor on black abalone to be discountable.

Effects of explosives and unexploded ordnance on black abalone via sediment are possible near the ordnance. However, the relatively low solubility of most explosives and their degradation products indicate that concentrations of these byproducts in the marine environment are relatively low and readily diluted. Because most ordnance is deployed as projectiles, multiple unexploded or low-order detonations would accumulate on spatial scales of 1 to 6 ft. (0.3 to 1.8 m); therefore, potential impacts are likely to remain local and widely separated. Given these conditions, the possibility of effects to black abalone is extremely unlikely and we consider the effects from this stressor on black abalone to be discountable.

Metals are introduced into seawater and sediments as a result of testing and training activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials. Effects of metals on black abalone via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Black abalone may be exposed by contact with the metal, contact with trace amounts in the sediments or water, and ingestion of sediments. Ingested metals are toxic at substantially lower effective concentrations than metals dissolved or suspended in the water. Given the small size of black abalone compared to most military expended materials, direct ingestion of metals is unlikely. Because metals often concentrate in sediments, potential adverse effects are much more likely via sediment than via water. However, black abalone do not feed directly on sediment and sediments would have to be relatively fine in order to be consumed. Metal fragments will likely be too large to be ingested and are therefore unlikely to cause injury or mortality to black abalone. As a threat to black abalone, heavy metals are considered to be "low" (VanBlaricom et al. 2009). For these reasons, we consider effects from metals to black abalone to be extremely unlikely and thus insignificant.

Several Navy testing and training activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants from rockets, missiles, and torpedoes. The greatest risk to black abalone from flares, missiles, and rocket propellants is perchlorate, which is highly soluble in water, persists in the environment, and is known to impact metabolic processes in many plants and animals. Lethal potassium perchlorate concentration 50 values of 72, 5, and 56 millimoles per liter have been obtained for marine algae, zooplankton, and earthworms respectively (Acevedo-Barrios et al. 2018). Black abalone may be exposed by direct contact with a chemical found in the sediments or water or through accidental ingestion of sediments containing trace amounts of a chemical. For perchlorate, these pathways are limited given that rapid dilution within the water column would be expected and missile and rocket propellant is mostly, if not completely, expended before the munition enters the water. Military expended materials will also be used predominantly outside of black abalone habitat. Additionally, perchlorate does not readily absorb into sediments. The principal toxic components of torpedo fuel, propylene glycol dinitrate and nitrodiphenylamine, do readily absorb into sediments but are readily degraded by physical and biological processes. For these reasons, we consider effects from chemicals to black abalone to be extremely unlikely and thus insignificant.

Principal components of military expended materials containing materials other than metal, chemicals, and explosives include aluminized fiberglass (chaff); carbon or Kevlar fiber (missiles); and plastics (e.g., canisters, targets, sonobuoys components, decelerators/parachutes). Chaff has been extensively studied, and no toxic effects are known to occur in the marine environment (Arfsten et al. 2002). Glass, carbon, and Kevlar fibers have no known potential toxic effects on marine invertebrates. Plastics contain chemicals that could affect black abalone (Derraik 2002; Mato et al. 2001; Teuten et al. 2007). Black abalone may be exposed by contact with the plastic, contact with residual plastic chemical byproducts in the sediment or water, or ingestion of sediments containing plastic byproducts. Black abalone are small relative to Navy military expended materials or fragments of these materials, and direct ingestion of plastics is unlikely. In addition, military expended materials will predominantly be used outside of black abalone habitat. Therefore, we consider the effects from military expended materials containing materials other than metals, chemicals, and explosives on the black abalone to be extremely unlikely and thus insignificant.

In summary, given the limited likelihood of co-occurrence with training and testing stressors, and the nature of the stressors analyzed, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the black abalone.

6.1.2 White Abalone

Except for some isolated survivors, the species is distributed only around the Channel Islands and along various banks within the action area (Hobday and Tegner 2000; Rogers-Bennett et al. 2002). The species is known to occur off San Clemente, Santa Catalina, and Santa Barbara Islands and at Tanner and Cortes Banks (approximately 50 mi southwest of San Clemente Island). Both these banks are underwater mountains that occur off the coast of southern California. One study documented 5 mi^2 of available white abalone habitat at Tanner Bank, 4 mi^2 at Cortes Bank, and 3 mi^2 on the western side of San Clemente Island (Butler et al. 2006).

6.1.2.1 Occurrence in the PMSR Action Area

White abalone in the Southern California Bight typically inhabit depths ranging from about 20 to 60 m (66 to 197 ft), with the highest densities occurring between 40 and 50 m (131 and 164 ft; (Butler et al. 2006). This species has historically been reported to occur within the subtidal waters of SNI (U.S. Department of the Navy 2015c). Though limited documentation post-1980 exists on the white abalone population at SNI, this species has experienced dramatic declines throughout its range. Except for some isolated survivors, the species is known to be distributed only around the southern Channel Islands and along various banks outside the action area (Hobday and Tegner 2000; Rogers-Bennett et al. 2002).

6.1.2.2 Effects Analysis for White Abalone

The stressors associated with the proposed action that could potentially affect white abalone include explosives, entanglement stressors, physical disturbance and strike, ingestion stressors, energy stressors, and indirect effects to white abalone via their habitat.

Roberts et al. (2016) and Edmonds et al. (2016) report that marine invertebrates are generally not sensitive to most sounds that would result from the proposed activities involving explosives, but likely have mechanical receptors that may be connected to the central nervous system that can detect some movements or vibrations that are transmitted through substrate. White abalone would only occur on the seafloor and there are no underwater explosions in the proposed action. White abalone are the deepest living abalone species on the west coast and occur at depths up to almost 200 feet. This species would potentially be exposed to noise from surface explosions, but the likelihood of explosions affecting white abalone is very low. Surface explosions most frequently occur during the day at offshore locations more than 12 nautical miles from shore. Locations of known white abalone habitat or habitat capable of supporting white abalone based on substrate and depth are not areas where Navy ordnance would be used (U.S. Navy 2021). Therefore, white abalone would not likely be exposed to surface explosions and associated underwater impulsive sounds from high-explosive munitions (including bombs and missiles) and we consider the effects from PMSR explosives use on the white abalone to be extremely unlikely and thus discountable.

Parachutes and decelerators used by the Navy as part of the proposed action could potentially be encountered by white abalone on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality and adverse sub-lethal effects if they are encountered by abalone. The primarily large and extra-large decelerators and parachutes proposed for use in the PMSR may pose a higher degree of risk for white abalone because these parachutes are larger and have long lines (large chutes have 28 cords, approximately 40 to 70 feet long; extra-large parachutes have 64 cords, up to 82 feet long), associated with them. However, the chance of an encounter is remote given the small number (i.e., less than ten annually) of the parachutes proposed to be deployed that would not be recovered. Given the vast area over which any one of these decelerators and parachutes would be deployed and the limited number of non-recovered items annually, the chances of a white abalone becoming entangled is extremely low. Therefore, we consider the effects from entanglement stressors on white abalone to be extremely unlikely and thus discountable.

Physical disturbance or strikes by vessels, military expended materials, and in-water devices on white abalone is possible at the seafloor. However, disturbance or strike impacts from vessels are extremely unlikely because they would occur if a Navy vessel ran aground on an area where white abalone, a benthic sessile species with a low population density in the action area, happened to be located. Disturbance or strike impacts on this species by military expended materials and in-water devices are extremely unlikely because these materials do not generally sink rapidly enough to cause strike injury to abalone. It would be possible for military expended materials to fall in offshore waters known to support white abalone (Butler et al. 2006). The potential to impact white abalone is decreased by the low abalone population density and the widely dispersed use of expendable materials. The majority of military expended material in nearshore and offshore waters surrounding Tanner Bank is chaff and flares, which have a small potential for impacts. Therefore, we consider the effects from PMSR physical disturbance or strikes by vessels, military expended materials, and in-water devices on the white abalone to be extremely unlikely and thus discountable.

Potential impacts of ingestion on white abalone would be limited to individuals accidentally ingesting small fragments of military expended material that traveled from the surface and through the water column to the bottom. White abalone have the potential to accidentally ingest these materials as they scrape algae or biofilm (a thin layer of microorganisms) off hard substrates in shallow water. However, it is extremely unlikely that military expended material would drift and fall into offshore waters known to support white abalone, since the closest known white abalone populations are between 5 and 8 miles from the southern boundary of the action area. Therefore, the probability of effects on white abalone from ingestion of military expended materials is extremely unlikely and we consider the effects from this stressor on white abalone to be discountable.

Indirect impacts of explosives and unexploded ordnance on white abalone via sediment are possible near the ordnance. However, the relatively low solubility of most explosives and their degradation products indicate that concentrations of these byproducts in the marine environment are relatively low and readily diluted. Because most ordnance is deployed as projectiles, multiple unexploded or low-order detonations would accumulate on spatial scales of 1 to 6 feet. (0.3 to 1.8 meters); therefore, potential impacts are likely to remain local and widely separated. Given these conditions, the possibility of indirect impacts on white abalone is extremely unlikely and we consider the effects from this stressor on white abalone to be discountable.

Metals are introduced into seawater and sediments as a result of testing and training activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials. Many metals bioaccumulate and some physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Indirect impacts of metals on white abalone via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. White abalone may be exposed by contact with the metal, contact with trace amounts in the sediments or water, and ingestion of sediments. Ingested metals are toxic at substantially lower effective concentrations than metals dissolved or suspended in the water. Given the small size of white abalone compared to most military expended materials, direct ingestion of metals is unlikely. Because metals often concentrate in sediments, potential adverse indirect impacts are much more likely via sediment than via water. However, white abalone do not feed directly on sediment and sediments would have to be relatively fine in order to be consumed. Metal fragments will likely be too large to be ingested and are therefore unlikely to cause injury or mortality to white abalone. For these reasons, we consider effects from metals to white abalone to be extremely unlikely and thus insignificant.

Several Navy testing and training activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants from rockets, missiles, and torpedoes. The greatest risk to white abalone from flares, missiles, and rocket propellants is perchlorate, which is highly soluble in water, persists in the environment, and is known to impact metabolic processes in many plants and animals. Lethal potassium perchlorate concentration 50 values of 72, 5, and 56 millimoles per liter have been obtained for marine algae, zooplankton, and earthworms respectively (Acevedo-Barrios et al. 2018). White abalone may be exposed by direct contact with a chemical found in the sediments or water or through ingestion of sediments containing trace amounts of a chemical. For perchlorate, these pathways are limited given that rapid dilution within the water column would be expected and missile and rocket propellant is mostly, if not completely, expended before the munition enters the water. Military expended materials will also be used predominantly outside of white abalone habitat. Additionally, perchlorate does not readily absorb into sediments. The principal toxic components of torpedo fuel, propylene glycol dinitrate and nitrodiphenylamine, do readily absorb into sediments but are readily degraded by physical and biological processes. For these reasons, we consider effects from chemicals to white abalone to be extremely unlikely and thus insignificant.

Principal components of military expended materials containing materials other than metal, chemicals, and explosives include aluminized fiberglass (chaff); carbon or Kevlar fiber (missiles); and plastics (e.g., canisters, targets, sonobuoys components, decelerators/parachutes). Chaff has been extensively studied, and no indirect toxic effects are known to occur in the marine environment (Arfsten et al. 2002). Glass, carbon, and Kevlar fibers have no known potential toxic effects on marine invertebrates. Plastics contain chemicals which could indirectly affect white abalone (Derraik 2002; Mato et al. 2001; Teuten et al. 2007). White abalone may be exposed by contact with the plastic, contact with residual plastic chemical byproducts in the sediment or water, or ingestion of sediments containing plastic byproducts. White abalone are small relative to Navy military expended materials or fragments of these materials, and direct ingestion of plastics is unlikely. In addition, military expended materials will predominantly be used outside of black abalone habitat. Therefore, we consider the effects from military expended materials containing materials other than metals, chemicals, and explosives on the white abalone to be extremely unlikely and thus insignificant.

In summary, given the extremely low limited likelihood of co-occurrence with training and testing stressors, and the nature of the stressors analyzed, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the white abalone.

6.1.3 North Pacific Right Whale

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20 and 60 degrees latitude. Prior to exploitation by commercial whalers, concentrations of right whales in the North Pacific where found in the Gulf of Alaska, Aleutian Islands, south central Bering Sea, Sea of Okhotsk, and Sea of Japan. There has been little recent sighting data of right whales occurring in the central North Pacific and Bering Sea. Since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months. Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell Jr. et al. 2001; Shelden et al. 2005; Wade et al. 2006; Zerbini et al. 2010). There are far fewer sightings of North Pacific right whales in the Gulf of Alaska than the Bering Sea (Brownell Jr. et al. 2001; Wade et al. 2011a; Zerbini et al. 2010). In addition to sighting data

(Matsuoka et al. 2013; Wade et al. 2011a; Wade et al. 2011b), passive acoustic data have indicated the presence of North Pacific right whales in the Gulf of Alaska (Mellinger et al. 2004b; Sirovic et al. 2015). No right whales were detected from more than 5,324 hours of passive acoustic data obtained from Navy-funded monitoring devices in the north-central Gulf of Alaska (Baumann-Pickering et al. 2012; Debich et al. 2013), but calls were detected in 2013 during two days (21 June and 3 August) from a device located at Quinn Seamount (Sirovic et al. 2015).

6.1.3.1 Occurrence in the PMSR Action Area

The likelihood of an individual Eastern North Pacific right whale being present in the PMSR action area is extremely low given that they have rarely been detected south of the Bering Sea. There have only been a few detections of right whales outside of the Bering Sea in modern times. In June 2013, a single right whale was sighted in the waters off Haida Gwaii (Canada), and a passive acoustic monitoring device at Quinault Canyon (Washington) detected two right whale calls within a two-hour period within nine days of the sighting to the north (Sirovic et al. 2015). In October 2013, off the Strait of Juan de Fuca (Washington), another (different) single right whale was seen with a group of humpback whales (U.S. Department of the Navy 2015a). In April 2017, a right whale was sighted off the coast of La Jolla, California, the second sighting off La Jolla since 1988 (Gotfredson 2017).

6.1.3.2 Effects Analysis for North Pacific Right Whale

The extremely low population numbers of North Pacific right whale in the North Pacific Ocean over the past five decades and the rarity of reports from these waters suggests that there is a very low probability that North Pacific right whales would be exposed to the proposed action, its component activities, and the associated stressors considered in this consultation. This is because, in all portions of the PMSR action area, it is extremely unlikely that North Pacific right whales would be encountered and the potential for any stressor to cause an effect to this species is extremely unlikely and therefore discountable. Therefore, we conclude that the proposed action may affect, but is not likely to adversely affect the North Pacific right whale.

6.1.4 Gray Whale – Western North Pacific DPS

Eastern and western North Pacific gray whales were once considered geographically separated along either side of the ocean basin, but recent photoidentification, genetic, and satellite tracking data refute this. Two western North Pacific gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south to the Washington State and Oregon coasts in one case (Mate et al. 2011) and to the southern tip of Baja California and back to Sakhalin Island in another (IWC 2012). Comparisons of eastern and western North Pacific gray whale catalogs have thus far identified 23 western gray whales occurring on the eastern side of the basin during winter and spring (Weller et al. 2013). Burdin et al. (2011) found an additional individual. During one field season off Vancouver Island, western gray whales were found to constitute 6 of 74 (8.1 percent) of photoidentifications (Weller et al.

2012a). In addition, two genetic matches of western gray whales off Santa Barbara, California have been made (Lang et al. 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al. 2012b).

Gray whales of the Western North Pacific DPS primarily occur in shallow waters over the U.S. West Coast, Russian, and Asian continental shelfs and are considered to be one of the most coastal of the great whales (Jefferson et al. 2015; Jones and 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 feet deep (Jones and Swartz 2009; Weller et al. 2012a). The breeding grounds consist of subtropical lagoons in Baja California, Mexico, and suspected wintering areas in southeast Asia (Alter et al. 2009; Jones and Swartz 2009; Mate et al. 2015b; Urban-Ramirez et al. 2003; Weller et al. 2012a).

6.1.4.1 Occurrence in the PMSR action area

In surveys of the northern feeding grounds off Russia, 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 during those months. Given their small population size and limited number of sightings off the U.S. west coast, the occurrence of Western North Pacific gray whales in the PMSR action area is rare.

6.1.4.2 Effects Analysis for Western North Pacific Gray Whale

Because it is very unlikely that Western North Pacific gray whales would be encountered in the PMSR action area, the potential for any stressor to cause an effect to this species is extremely unlikely and therefore discountable. Therefore, we determine that the proposed action may affect, but is not likely to adversely affect the Western North Pacific gray whale.

6.1.5 Sei Whale

In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20 degrees to 23 degrees North (Gambell 1985b; Masaki 1977).

6.1.5.1 Occurrence in the PMSR action area

Sei whales are distributed in offshore waters in the PMSR action area (Carretta et al. 2017b). A total of 10 sei whale sightings were made during systematic ship surveys conducted off central and northern California, Oregon, and Washington 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 Southern California Bight during 15 aerial surveys conducted from 2008 through 2012 (Smultea et al. 2014) or during any systematic ship surveys conducted by NMFS (Barlow 2010; Barlow 2016).

6.1.5.2 Effects Analysis for Sei Whale

The stressors associated with the proposed action that could potentially affect the sei whale include acoustic stressors (explosives, vessel noise, aircraft noise, weapons firing, launch, and impact noise), physical disturbance and strike (vessels and military expended materials), entanglement stressors, ingestion stressors, energy stressors, and effects to sei whales via effects to their habitat or prey.

Sei whales may be exposed to sound or energy from explosions associated with training activities occurring throughout the year. However, given the relatively sparse distribution of sei whales throughout the action area, the Navy's quantitative analysis using the number of explosives per year under the proposed action estimates no adverse effects to sei whales. Considering these results and the mitigation measures that would be implemented as described in Section 3.5, we consider the effects to sei whales from acoustic stressors resulting from explosives to be discountable.

Sei whales could be exposed to vessel noise from testing and training activities anywhere within the action area that the species is present; however, no significant behavioral or physiological reactions are expected. Sei whales have been observed ignoring the presence of vessels entirely and even passing close to the vessel (Reeves et al. 1998). Furthermore, Navy vessels (including small boats) avoid approaching marine mammals within 500 yd, which would make reactions unlikely in a mysticete such as a sei whale. Exposure to vessel noise could lead to short-term masking and minor behavioral responses. In addition, the mitigation measures that will be implemented (Section 3.5) will further minimize the exposure of sei whales to this stressor. Therefore, we consider the effects to sei whales from acoustic stressors resulting from vessel noise to be insignificant.

Sei whales could be exposed to aircraft noise from testing and training activities anywhere within the action area that the species is present; however, no significant behavioral or physiological reactions are expected. Mysticetes either ignore or occasionally dive in response to aircraft overflights, meaning exposure to aircraft noise could lead to short-term, minor behavioral responses. Therefore, we consider the effects to sei whales from acoustic stressors resulting from aircraft noise to be insignificant.

Sei whales may be exposed to weapon firing, launch, and impact noise during testing and training activities throughout the year; however, no significant behavioral or physiological reactions are expected. Exposure to weapon noise could lead to short-term masking and minor behavioral responses, but would be limited due to the short duration and sporadic nature of weapon firing and the low likelihood that a sei whale would be in close enough proximity to detect the sound from weapon firing above the water. Therefore, we consider the effects to sei whales from acoustic stressors resulting from weapons firing, launches, and impacts to be insignificant.

In over 20 years of reporting by the Navy, there have been no known Navy vessel strikes to marine mammals in the PMSR action area. The absence of Navy vessel strikes associated with

Navy activities occurring at the PMSR can be attributed to a number of factors related to the differences between Navy vessel design and operation and that of commercial vessels, as well as the Navy's mitigation measures for vessel movement (see Section 3.5.1.6). Activities involving Navy vessel movement would be widely dispersed throughout the action area. However, because Navy vessels and sei whales overlap in space and time, the potential for a strike to occur cannot be ruled out entirely. Given the relatively sparse offshore distribution of sei whales and the absence of any known previous Navy vessel strikes to whales associated with testing and training at PMSR, we consider vessel strikes to sei whales to be extremely unlikely to occur and thus discountable.

Sei whales may also be exposed to physical disturbance and strike stressors from military expended materials and in-water devices. However, the Navy's Statistical Probability Analysis for Estimating Military Expended Material and Direct Strike Impacts (U.S. Navy 2022) indicates that even for the marine mammal species with the highest density in the action area and using conservative assumptions, the probability of any marine mammal, including a sei whale, being struck during testing and training activities by military expended materials is so low as to be extremely unlikely to occur. Thus, the effects of military expended materials on sei whales would be discountable.

Parachutes and decelerators used by the Navy as part of the proposed action could be encountered by sei whales at the sea surface, in the water column, or on the seafloor. Entanglement of an animal in a parachute assembly at the surface or within the water column may be less likely for highly mobile animals, because the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a whale encounters them. Most parachutes used in the PMSR are in the large to extra-large size range. Large and extra-large decelerator and parachutes have multiple long lines attached to them, are unweighted, and could potentially remain suspended in the water column for an extended period of time, thus increasing the entanglement risk. However, the large majority (over 90 percent) of parachutes deployed within PMSR are recovered after use (see Section 3.4.4 for details). The chance of an encounter is remote given the small number (i.e., less than ten annually) of the large or extra-large parachutes deployed that would not be recovered, and the anticipated low abundance of sei whales in the action area. There have been no known instances of entanglement of any marine mammals involving the use of wires and cables decelerators/parachutes associated with any Navy testing and training activities. Given the vast area over which any one of these large decelerators and parachutes would be deployed and the limited number of them deployed annually, the chances of a sei whale encountering them and becoming entangled is so low as to be extremely unlikely to occur. Therefore, we consider the effects from entanglement stressors on sei whales to be discountable.

Sei whales occurring in the action area have the potential to ingest military expended materials resulting from PMSR activities. The Navy expends the following types of materials during training and testing in the action area that could be ingested: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, and fragments from targets, chaff, flare casings (including plastic end caps and pistons). Sei whales are an open ocean, pelagic species that feeds in the water column in areas where military expended materials could be found. However, given the relatively sparse distribution of sei whales in the action area, we consider the chances of a sei whale being in the vicinity of military expended materials as extremely low. Therefore, we consider the effects from ingestion stressors on sei whales to be extremely unlikely and thus discountable.

Sei whales are extremely unlikely to be exposed to high-energy laser weapons based on 1) the relatively low number of events per year, 2) the very localized potential impact area of the laser beam, 3) the temporary duration of potential impact (seconds), 4) the low probability of whales at or near the surface at the exact time and place a laser misses its target, 5) the low probability of a laser missing its target; and 6) the relatively low density of sei whales in PMSR areas where activities using lasers are conducted. Therefore, the effects from high-energy laser weapons on the sei whale, including eye damage, are extremely unlikely and thus discountable.

It is extremely unlikely that sei whales would be impacted by toxic metals or chemicals expended during PMSR activities given the vast open ocean area over which these potential stressors would be released. Metals deposited on the sea floor will be buried in sediment and slowly degrade over time. Since sei whales feed primarily in the water column they would not likely come into contact with metals in marine sediments. The only chemical of concern to sei whales from flares, missiles, and rocket propellants is perchlorate, which is highly soluble in water, persists in the environment, and is known to impact metabolic processes in many plants and animals. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on sei whale prey (e.g., copepods, krill, cephalopods, and small schooling fish), given the number of events producing military expendable items and the size of the action area. Therefore we consider the effects of the proposed action on sei whales and their habitat to be insignificant.

We conclude that the proposed action may affect, but is not likely to adversely affect the sei whale.

6.1.6 Loggerhead Sea Turtle – North Pacific DPS

Loggerhead sea turtles are circumglobal, and are found in the temperate and tropical regions of the Indian, Pacific and Atlantic Oceans. The species was first listed as threatened under the ESA in 1978. On September 22, 2011, the NMFS designated nine DPSs of loggerhead sea turtle. The only loggerhead DPS occurring within the action area, and therefore considered in this biological opinion, is the North Pacific DPS.

6.1.6.1 Occurrence in the PMSR Action Area

Pacific loggerheads appear to use the entire North Pacific Ocean during development (Briscoe et al. 2016; Polovina et al. 2000b). Offshore, juvenile loggerheads forage in or migrate through the North Pacific Subtropical Gyre as they move between North American developmental habitats and nesting beaches in Japan (Briscoe et al. 2016). Loggerhead sea turtles are known to occur in areas where sea surface temperature ranges between 10°C and 28.7°C; however, mean sea surface temperatures, which are more indicative of preferred habitat, ranged between 16.3° and 24°C (Eguchi et al. 2018). Below 15°C, loggerheads become lethargic and inactive, and when temperatures fall to 10°C, they become cold-stunned (Mrosovsky, 1980). Average annual sea surface temperature in the action area ranges from about 12°C up to 14°C with cooler waters located closer to shore and to the north of the PMSR, and warmer waters, ranging up to 16°C, found farther offshore and southwest of the PMSR. Sea surface temperatures in the PMSR are generally cooler than temperatures preferred by loggerhead sea turtles, except for periods (e.g., during El Niño conditions) when water temperatures can be as much as 4° to 5°C warmer than during "normal" conditions. Occurrence of loggerheads in PMSR would largely be expected during summer and fall months when water temperatures are more likely to be within their preferred range. Some or all of the loggerhead turtles found off southern California may be part of a central Pacific foraging group that moves between the eastern and central Pacific as thermal corridors open (e.g., Abecassis et al., 2013). Allen et al. (2013) found that loggerheads bycaught in California-based fisheries originated from the Central North Pacific based on stable isotope analysis.

In 2015, Eguchi et al. (2018) conducted an aerial survey of the southern California Bight, extending approximately from Pt. Conception to south of the U.S.-Mexico border and offshore as far as 123 N. The surveyed area overlaps with the southeast portion of the PMSR. Over 200 loggerheads were encountered during the survey, which coincided with anomalously high sea surface temperatures and a strong El Niño. While some of the sightings overlapped with the PMSR, the majority were further south or inshore of the range (Figure 19). El Niño conditions in the eastern North Pacific coupled with other large scale ocean-atmosphere circulations in the western tropical Pacific resulted in anomalously warm sea surface temperatures in the region and affected the ranges of numerous marine species (Bond et al. 2015).

Eguchi et al. (2018) estimated an offshore density of 0.24 loggerheads per km^2 for the large survey area that overlaps partially with the southeast portion of the PMSR. This density is comparable to the density estimated off the Baja Peninsula (Seminoff et al. 2014). However, only a small portion of the survey area overlaps with the PMSR T and did not include the northern portion of PMSR where loggerhead occurrence would be more rare due to colder water temperatures.. The average density of loggerheads throughout the entire PMSR during the survey period was likely much lower than 0.24 loggerheads per km^2, since the large majority of the PMSR area is north of the loggerhead hotspot. In general, based on sightings data and information on preferred sea surface temperatures, we would expect loggerhead occurrence to be very rare in portions of the PMSR that are north of 33 degrees N latitude. On a finer spatial scale, relatively high densities of loggerheads (comparable to those reported by Eguchi et al.) could occur within the southernmost portion of the PMSR (south of 33 degrees N latitude) during marine heatwave periods.

Loggerhead sea turtle presence off Southern California has also been documented as bycatch in the California drift gillnet fishery, although the large majority of reported captures were outside of the action area (i.e., southeast of the PMSR). Observer data recorded 16 loggerhead captured as bycatch in this fishery from 1990-2006 during anomalously warm ocean conditions (Welch et al. 2019), but no observed captures from 2007-2019 (based on 1,474 observed sets) (Carretta 2021). Thus, loggerhead bycatch in this fishery is extremely rare, particularly in recent years.

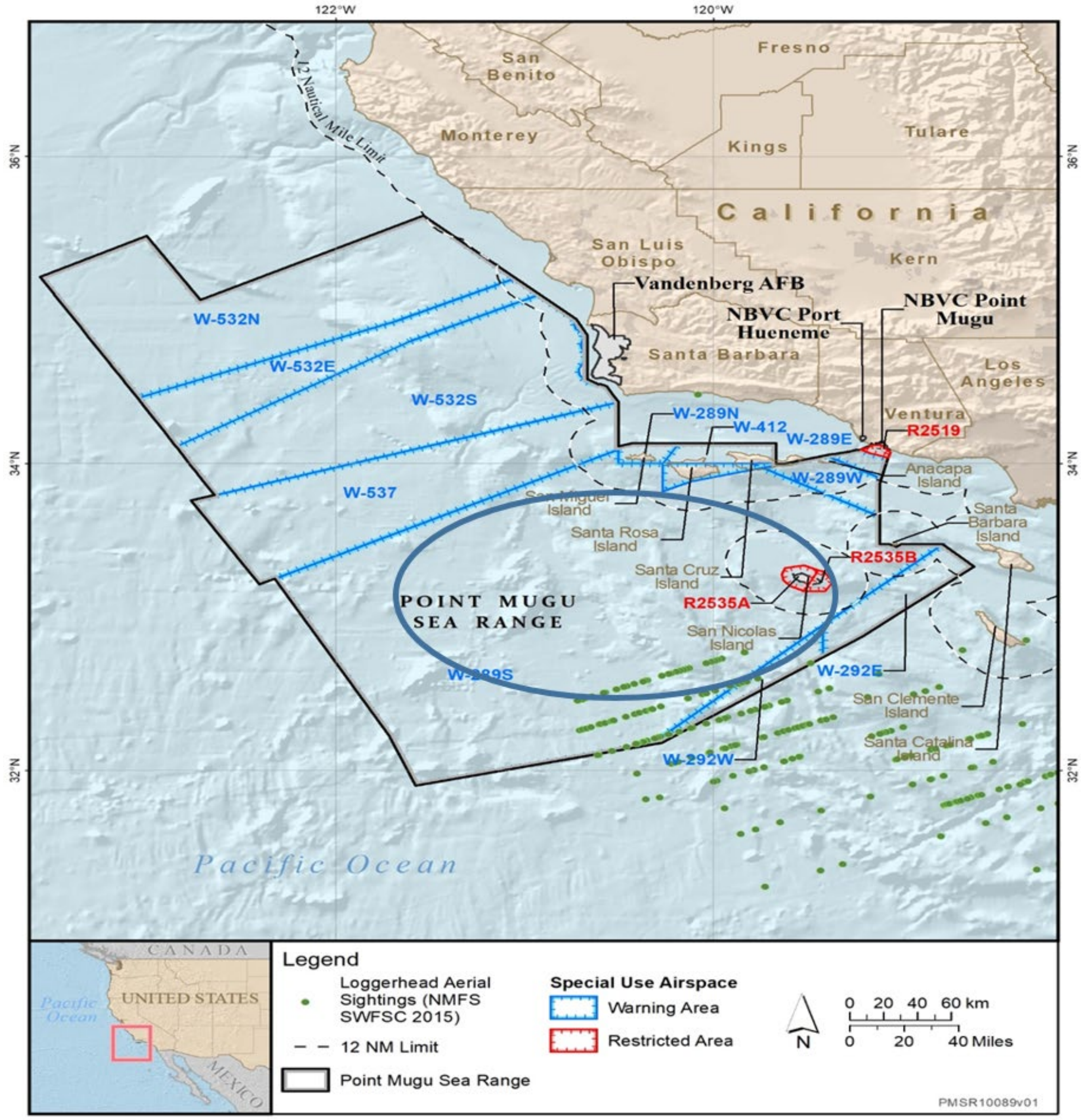

Figure 19. Loggerhead sea turtle sightings locations from NMFS 2015 aerial survey (Eguchi et al. 2018) in relation to the PMSR boundary and warning areas. Oval represents highest area of concentrated use for PMSR activities.

The higher density and abundance of loggerheads in the southern California Bight would only be expected during similar environmental conditions. A previous aerial survey (3,650 kms of trackline) in the same region conducted in September and October 2011 during La Niña (anomalously cold) conditions encountered no loggerheads. In August 2018, a third aerial survey was conducted off of southern California and two loggerheads were spotted over more than 1,000 km of trackline (NMFS 2020c). Additionally, a line transect shipboard survey of the California Current Ecosystem was conducted from June to December 2018. During this survey, which occurred during mild El Niño conditions (i.e., from 0.5 to 0.9 degrees above normal), there were no sightings of loggerhead sea turtles (Moore 2021). It should be noted that the reliability of loggerhead sightings data from shipboard surveys is highly dependent on sea state. However, with the exception of the 2014/2015 marine heatwave, loggerhead sightings in the southern California Bight have been extremely rare in recent years. While loggerhead presence in the action area has likely been relatively rare during relatively normal offshore water temperatures in the past, increasing ocean temperatures associated with climate change may, over time, allow foraging loggerheads to expand their range on a more regular basis (Eguchi et al. 2018).

6.1.6.2 Effects Analysis for Loggerhead Sea Turtle North Pacific DPS

As discussed above, sea surface temperatures in the PMSR are generally cooler than temperatures preferred by loggerhead sea turtles. During a "typical year" of ocean temperatures (i.e., rarely exceeding 16°C) loggerhead occurrence in the action area would be extremely rare. As such, we anticipate the likelihood of exposure to stressors resulting from the proposed action would be extremely low (i.e., discountable) during most years. "Transient" loggerheads from nearshore Baja California Peninsula, as well as those from the pelagic Central North Pacific foraging groups, may be found within the southern California Bight when environmental conditions are optimal (T. Eguchi, NMFS SWFSC personal communication to R. Salz, NMFS OPR, October 8, 2021). This behavior has only been documented once, during the 2014/2015 record-breaking marine heatwave that affected much of the Northeast Pacific Ocean. However, on a global scale, the occurrence probabilities of the duration, intensity, and cumulative intensity of most documented, large, and impactful marine heatwaves have increased more than 20-fold as a result of anthropogenic climate change (Laufkötter et al. 2020). Therefore, we cannot rule out the possibility that another marine heatwave of this scope and magnitude could occur in Northeast Pacific Ocean in the reasonably foreseeable future.

If such a marine heatwave does occur again, we would expect loggerhead occurrence in the PMSR to be limited temporally and spatially to coincide with water temperatures that are more likely to be within their preferred range. Occurrence of loggerheads in PMSR would largely be expected during warmer water months in late summer and early fall. Based on loggerhead sightings, bycatch data, and telemetry studies, we would not expect loggerheads to be evenly distributed throughout the PMSR during marine heatwave periods. Rather, we anticipate loggerhead sea turtles would be concentrated in the southeast portion of the PMSR (i.e., south of 33 degrees N latitude, and east of 121 degrees W longitude) as shown in Figure 19. This area corresponds with Navy Warning Area W-289S and subareas 5A and 6A, as shown on the map of the action area (Section 4, Figure 15). We recognize that this expected distribution of loggerheads within the PMSR during future marine heatwaves is somewhat tenuous since it is based on a single aerial survey, and on the assumption that future marine heatwaves would be similar spatially to the 2014/2015 event.

While there is some overlap with the loggerhead sightings from the 2015 aerial surveys and W-289S, the southern portions of the two ordnance impact use subareas (5A and 6A) that overlap with the loggerhead sightings are near the southern boundary of the PMSR, where impacts are less likely to occur due to large hazard patterns and safety concerns (C. Scott, Navy, NAWCWD Range Sustainability Office, pers. comm., to R. Salz, NMFS, Office of Protected Resources, September 21, 2021). Based on Navy activities from 2017 through 2020 (i.e., fiscal years) subareas 5A and 6A combine for about 25 percent of ordnance impacts within the PMSR (U.S. Department of the Navy 2021b). However, during the 2015 aerial survey loggerheads were only sighted in a relatively small portion of subareas 5A and 6A (i.e., near the southern boundary), and these fringe areas near the southern boundary are less likely to be used by the Navy for explosive activities. Therefore, even during a marine heatwave event such as the one documented in 2014/2015, we anticipate the potential for spatial overlap between loggerhead sea turtles and explosives within PMSR would occur for a very small percent of the explosives used in subareas 5A and 6A.

As described in Section 3.5.1, the Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive gunnery activities, missiles and rockets, and bombs. In addition, the Navy has proposed to implement a new awareness notification message for loggerhead sea turtles that would be trigerred during periods of elevated sea surface temperatures when loggerheads are more likely to be found within the PMSR (see Section 3.6 for details). This awareness notification message would further reduce the likelihood of loggerhead sea turtle exposure to the effects of explosives within the PMSR.

In summary, based on the following factors we find that it is extremely unlikely that loggerhead sea turtles would be exposed to stressors from explosives within the PMSR: 1) Very limited spatio-temporal overlap anticipated between loggerheads and Navy explosives (i.e., only during years coinciding with marine heatwave periods similar to conditions observed during the 2014/2015 event, and to warmer water months during such years), 2) Anticipated location of loggerheads near the southern boundary of the PMSR where explosive impacts are less likely to occur due to large hazard patterns and safety concerns, 3) Mitigation measures aimed at avoiding or minimizing impacts on sea turtles from Navy explosives, and 4) An awareness notification message for loggerheads during periods of elevated sea surface temperatures when loggerheads are more likely to be found within the PMSR. Therefore, we consider the effects from explosive use as part of the proposed action on loggerhead sea turtles, including secondary effects on loggerhead habitat, prey, and water quality, to be discountable.

Besides explosives, loggerhead sea turtles could potentially be exposed to other stressors resulting from the Navy's proposed action (see Section 5). However, for the same reasons described for explosives above, we anticipate very limited spatio-temporal overlap between Navy activities and loggerhead sea turtles within the PMSR. As such, we find it extremely unlikely that loggerhead sea turtles would be exposed to stressors from lasers, vessel strike, in-water devices, strike from military expended materials, entanglement in parachutes or decelerators, ingestion of expended materials, or secondary effects on loggerhead habitat, prey, and water quality from metals, chemicals, and other expended materials. Thus, we consider the effects from these stressors on loggerhead sea turtles (including secondary effects on habitat, prey, and water quality) to be discountable. For other stressors, while loggerhead sea turtles may be exposed, we anticipate the effects of such exposure to be insignificant. These include the effects of vessel noise, aircraft noise, and weapons noise. For a more detailed discussion of the stressors not likely to adversely affect ESA-listed sea turtles see Section 8.1.2. Although Section 8.1.2 specifically addresses the effects of the proposed action on leatherback sea turtles, the analysis and conclusions for all stressors in this section are also relevant to loggerhead sea turtles.

In summary, loggerhead sea turtle occurrence within the action areas is only anticipated during marine heatwaves, the last of which occurred during 2015. Based on aerial survey sightings data from 2015, during heatwave periods loggerhead sea turtle occurrence is only anticipated in a very small portion of the PMSR, along the southern boundary. Given the factors discussed above, we find it extremely unlikely that loggerhead sea turtles would be exposed to many of the stressors resulting from the proposed action including explosives, physical disturbance and strike stressors, entanglement stressors, and ingestion stressors. While loggerheads may be exposed to acoustic stressors (i.e., noise from vessels and aircraft, and weapons firing noise), the effects of such exposure are likely to be insignificant. Based on the best available information, we consider the effects from stressors associated with the proposed action on the North Pacific DPS of loggerhead sea turtle to be either discountable or insignificant, depending on the particular stressor. Therefore, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the North Pacific DPS of loggerhead sea turtle.

6.1.7 Green Sea Turtle

The green sea turtle is globally distributed and commonly inhabits nearshore and inshore waters, occurring throughout tropical, subtropical and, to a lesser extent, temperate waters. The species was listed under the ESA on July 28, 1978. On April 6, 2016, NMFS listed eleven DPSs of green sea turtles as threatened or endangered under the ESA. The DPSs considered in this biological opinion that likely occur within the action area are the threatened Central North Pacific and East Pacific DPSs.

Once abundant in tropical and subtropical waters, green sea turtles worldwide exist at a fraction of their historical abundance as a result of over-exploitation. Green sea turtle populations in the Pacific were subjected to hunting pressure for subsistence and commercial trade, which was largely responsible for the decline in the region. Though the practice has been banned, there are still anecdotal reports of illegal harvest. Incidental bycatch in fishing gear, ingestion of marine debris, and the loss of nesting habitat due to sea level rise are current threats to these populations.

6.1.7.1 Occurrence in the PMSR Action Area

The green sea turtle is generally found in tropical and subtropical coastal and open ocean waters, between 30° N and 30° S. There is no information available for estimating the abundance or density of green sea turtles within the action area. Green sea turtles prefer waters where the sea surface temperature exceeds 22°C (Van Houtan et al. 2015). Average annual sea surface temperature in the action area ranges from about 12°C up to 14°C with cooler waters located closer to shore and to the north of the PMSR, and warmer waters, ranging up to 16°C, found farther offshore and southwest of the PMSR. Given their preference for warmer and shallower waters, occurrence of green sea turtles in the offshore, colder waters of the PMSR is expected to be extremely rare. Green sea turtles have been reported as bycatch in the California drift gillnet fishery. Carretta (2021) estimates about four total green sea turtles were incidentally captured in this fishery for the period 1990 through 2000, and about two green sea turtles captured from 2001 through 2019. By comparison, based on observer reports, Carretta (2021) estimates significantly larger numbers of leatherback bycatch during this time frame (about 149 from 1990 through 2000, and about 16 from 2001 through 2019). Based on the extremely low number of green sea turtles reported by observers in this fishery, which overlaps with a portion of the action area, and information on their thermal requirements, we anticipate this species to be extremely rare in the action area.

6.1.7.2 Effects Analysis for Green Sea Turtle: Central North Pacific and East Pacific DPSs

As discussed above, there is an extremely low probability of encountering green sea turtles in the action area. Based on the best available information, we anticipate green sea turtle densities are considerably lower as compared to leatherback turtles, which are discussed further in this opinion (Section 8). As such, it is extremely unlikely that green sea turtles would overlap both in time and space with the proposed action. Therefore, we consider the effects from stressors associated with the proposed action on the Central North Pacific and East Pacific DPSs of green sea turtle to be discountable or insignificant, depending on the stressor (see Section 8.1.2 for a full discussion of stressors that may affect, but are not likely to adversely affect leatherback sea turtles for more information).

Given the extremely low abundance of Central North Pacific and East Pacific DPSs of green sea turtle within the PMSR action area and the limited likelihood of co-occurrence with training and testing stressors, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the Central North Pacific DPS or the East Pacific DPS of green sea turtle.

6.1.8 Steelhead – Southern California DPS

On August 18, 1997 NMFS listed the Southern California DPS of steelhead as endangered (62 FR 43937) and reaffirmed the DPS's status as endangered on January 5, 2006 (71 FR 5248). This DPS is comprised of a suite of steelhead populations that inhabit coastal stream networks from the Santa Maria River system south to the U.S. border with Mexico.

West Coast salmon and steelhead stocks have declined substantially from their historic numbers. Multiple factors have contributed to the decline of individual populations. These include the loss of freshwater and estuarine habitat, periodic poor ocean conditions, and a variety of land-use, flood control, and water management practices which have impacted many watershed-wide processes; these include hydrologic and sedimentation processes which create and maintain essential steelhead habitats(National Marine Fisheries Service 2016).

6.1.8.1 Occurrence in the PMSR Action Area

Both outmigrating steelhead and adults returning to spawn are expected to occur in the action area. Density data for Southern California DPS of steelhead within the action area are not currently available. Daly et al. (2014) analyzed NMFS pelagic trawl survey data from off the coast of Oregon and Washington that targeted early marine phase juvenile salmonids to learn more about the distribution of steelhead in marine waters. Juvenile steelhead were consistently caught at the westernmost stations (greater than 55 km from shore) indicating a more offshore distribution for the species. Further, some of the steelhead that were caught in these far offshore waters had only been in saltwater for 1 to 3 days, indicating a rapid offshore migration (Daly et al. 2014). Because of their life history and currently estimated low population abundance, we would anticipate Southern California DPS of steelhead to be widely dispersed and occur in low densities throughout the action area.

6.1.8.2 Effects Analysis for Southern California DPS of Steelhead

The stressors associated with the proposed action that could potentially affect Southern California DPS of steelhead include explosives, entanglement stressors, ingestion stressors, physical disturbance and strike, energy stressors, and effects to steelhead via their habitat or prey.

Potential impacts on ESA-listed steelhead from PMSR testing and training activities involving explosives are possible, but extremely unlikely, primarily due to low population numbers in Southern California (Boughton and Goslin 2006). In addition, the majority of this species' life history occurs outside of the action area where it is not susceptible to potential effects from Navy explosive use. No explosive munitions would detonate underwater as part of the proposed action. Explosives would only detonate at or above the water's surface, and these explosions would occur most frequently greater than 12 NM from shore. While explosive use could overlap with ESA-listed steelhead, the likelihood of exposure would be extremely low given the low abundance of this species in the action area. Therefore, we consider the effects from PMSR explosives use on the Southern California DPS of steelhead to be extremely unlikely and thus discountable.

Parachutes and decelerators used by the Navy as part of the proposed action could be encountered by ESA-listed fish at the sea surface, in the water column, or on the seafloor. Entanglement of an animal in a parachute assembly at the surface or within the water column may be less likely for highly mobile animals, because the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses. Steelhead are not expected to be at a high risk of entanglement given their streamlined form, agility, and generally pelagic existence in the open ocean environment. Most parachutes used in the PMSR are in the large to extra-large size range. Large and extra-large decelerator and parachutes have multiple long lines attached to them, are unweighted, and could potentially remain suspended in the water column for an extended period of time, thus increasing the entanglement risk. However, the large majority (over 90 percent) of parachutes deployed within PMSR are recovered after use (see Section 3.4.4 for details). The chance of an encounter is remote given the small number (i.e., less than ten annually) of the large or extra-large parachutes deployed that would not be recovered, and the anticipated low abundance of Southern California DPS of steelhead in the action area. Given the vast area over which any one of these large decelerators and parachutes would be deployed and the limited number of them deployed annually, the chances of a steelhead encountering them and becoming entangled is extremely low. Therefore, we consider the effects from entanglement stressors on Southern California DPS of steelhead to be extremely unlikely and thus discountable.

ESA-listed fish occurring in the action area have the potential to ingest military expended materials resulting from PMSR activities. The Navy expends the following types of materials during training and testing in the action area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, and fragments from targets, chaff, flare casings (including plastic end caps and pistons). Pelagic species (i.e., steelhead) are more likely to ingest expended materials floating in the water column. Military expended materials that could impact pelagic species that feed in the water column include those items that float or are suspended in the water column for some period of time (e.g., end caps and pistons from chaff cartridges or flares). If an ESA-listed fish accidentally ingested such an item at or near the surface, it would likely expel it after determining it was not a prey item. Expended materials made of metal would sink quickly through the water column before settling on the seafloor. Once the item sinks to the seafloor, it would be unavailable for ingestion by pelagic species. Shiny fragments of sinking munitions in the water column could attract and be ingested by fast, mobile predators that chase moving prey. However, this is an extremely unlikely scenario considering: 1) the small amount of time (i.e., seconds to a few minutes) such objects would be in the water column and, 2) that highly mobile predators would be expected to evacuate an area where an explosion has just occurred. In addition, ESA-listed steelhead are relatively rare and dispersed throughout the action area, which further decreases the likelihood that one would encounter sinking expended materials in the water column. Therefore, we consider the effects from ingestion stressors on the Southern California DPS of steelhead to be discountable.

Given the anticipated low density of the ESA-listed steelhead in the action area, the ability of these species to maneuver to avoid any oncoming vessels, the low number of Navy vessels associated with PMSR activities relative to non-military traffic in the area, and the lack of documented cases of Navy vessels or in-water devices striking this species (or any other fish species) in the action area, it is extremely unlikely that a Navy vessel associated with PMSR activities will strike an ESA-listed steelhead. Any behavioral or stress response from fish avoiding an oncoming vessel or in-water device would be short-term and temporary. Therefore, potential effects on Southern California DPS of steelhead from vessels and in-water devices are discountable (in the case of strikes) or insignificant (in the case of behavioral or stress response).

Similarly, impacts of military expended material strikes on ESA-listed steelhead would be extremely unlikely due to the low occurrence of this species at the surface where military expended material strikes could occur, the extremely rare chance that a fish might be directly struck at the surface and, the ability of most fishes to detect and avoid an object falling through the water below the surface. The potential impacts of military expended material strikes would be short-term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes. Thus, the effects of military expended materials on Southern California DPS of steelhead would be either discountable (in the case of a direct strike) or insignificant (in the case of behavioral changes).

Fish could potentially be exposed to the laser beam from a high energy laser weapon at or near the water's surface, which could result in injury or death. ESA-listed steelhead are extremely unlikely to be exposed to high-energy laser weapons based on 1) the relatively low number of events per year, 2) the very localized potential impact area of the laser beam, 3) the temporary duration of potential impact (seconds), 4) the low probability of fish at or near the surface at the exact time and place a laser misses its target, 5) the low probability of a laser missing its target; and 6) the relatively low density of ESA-listed steelhead in PMSR areas where activities using lasers are conducted. Therefore, the effects from high-energy laser weapons on the Southern California DPS of steelhead considered in this opinion are discountable.

Stressors from PMSR training and testing activities that could result in effects on ESA-listed fish via impacts to habitat, prey, sediment and water quality include explosives and byproducts, metals, and chemicals. Explosives could impact other species in the food web, including prey species that ESA-listed steelhead feed upon. Explosions may reduce available prey items for steelhead by either directly killing prey or by scaring them from the area. In addition, prey species might exhibit a strong startle reaction to explosions that could include swimming to the surface or scattering away from the source. The abundance of fish prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Any of these scenarios would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. Due to the infrequent, sporadic use of explosives, it is not expected their use will have a persistent effect on prey availability or the health of the aquatic food web. As highly mobile, open water predators, salmonids would not likely be adversely affected by such short-term, localized impacts to their prey base in the open ocean. Thus, the effects of explosives on ESA-listed steelhead via impacts on their prey are considered insignificant.

Degradation products of explosives could potentially be toxic to marine organisms at high enough concentation levels. Trinitrotoluene (TNT) and its degradation products have been shown to impact developmental processes in marine invertebrates and are acutely toxic to adults at concentrations similar to real-world exposures (Rosen & Lotufo, 2007a; Rosen & Lotufo, 2007b, 2010). In terms of explosive byproducts, high-order explosions consume most of the explosive material, creating typical combustion byproducts. Explosive byproducts associated with high order detonations present no indirect stressors to marine ESA-listed species because most byproducts are common in seawater and the rest are quickly diluted below appreciable levels. Explosive byproducts are not expected to result in detectable changes in sediment or water quality. Low-order explosives leave more explosive material in the water but this material is not water soluble, degrades quickly, and is quickly dispersed. The levels of explosive materials and byproducts are not detectable above background levels one to two m from a degrading source. As such, the effects of explosive byproducts on ESA-listed fish species considered in this opinion via impacts on water quality are insignificant.

Metals can be introduced into seawater and sediments as a result of Navy training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group 2005). Fish could be exposed to released metals through contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Certain metals are harmful to fish at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others; (Wang and Rainbow 2008). Most metals used in Navy expendables is benign and all corroding metals would either be diluted into the ocean currents or be sequestered in the sediments immediately surrounding the source (Navy 2013a). Concentrations of metals in seawater are considerably lower than concentrations in sediments. As such, it is extremely unlikely (i.e., discountable) that steelhead or their prey would be impacted by toxic metals via the water given the vast open ocean area over which metals would be released. Metals deposited on the sea floor will be buried in sediment and slowly degrade over time. ESA-listed fish species that feed primarily in the water column (i.e., salmonids) would not likely come into contact with metals in marine sediments.

Several PMSR activities introduce chemicals into the marine environment that are potentially harmful to fish in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by steelhead or their prey. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment. Flares and missiles that operationally fail may release perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals if in sufficient concentration. However, such concentrations would be localized and are not likely to persist in the ocean environment. Research has demonstrated that perchlorate does not bioconcentrate or bioaccumulate, which is consistent with the expectations for a water-soluble compound (Furin et al. 2013). Given the dynamic nature of the environment (currents, tides, etc.), long-term impacts from perchlorate in the environment near the expended item are not expected. It is extremely unlikely (i.e., discountable) that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on ESA-listed steelhead, their prey, or their habitat.

In summary, given the extremely low abundance of Southern California DPS of steelhead in general and within the PMSR action area and the limited likelihood of co-occurrence with training and testing stressors, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the Southern California steelhead DPS.

6.1.9 Giant Manta Ray

The giant manta ray is an elasmobranch species that occupies tropical, subtropical, and temperate oceanic waters and productive coastlines. On January 22, 2018, NMFS published a final rule listing the giant manta ray as threatened under the ESA. Giant manta rays are commonly found offshore in oceanic waters, but are sometimes found in shallow waters (less than 10 m) during the day (Lawson et al. 2017; Miller and Klimovich 2017).

6.1.9.1 Occurrence in the PMSR Action Area

There is no information available for estimating the abundance or density of giant manta rays within the action area. We are not aware of any surveys or sightings of giant manta rays in the action area but, based on their life histories and occurrence in other similar environments, we would expect to find them there. An analysis of fish bycatch in the California drift gillnet fishery reported "mantas" as bycatch in three different time periods analyzed: 1990-1997, 1998-2000, and 2001-2013 (Le Fol 2016). We assume that the "manta" category represents giant manta rays as this is the most likely manta to be caught in the California drift gillnet fishery. Based on the Le Fol (2016) analysis, the expanded total number of manta rays captured as bycatch in the drift gillnet fishery from 1990 through 2000 was estimated as 136, or about 12 per year. By comparison, the expanded total number of manta rays captured as bycatch in the drift gillnet fishery from 2001 through 2013 was estimated as 10, or less than one per year. While the area covered by the California drift gillnet fishery overlaps parts of the PMSR, we have no specific location information to indicate how much of the manta bycatch occurred with the PMSR action area.

6.1.9.2 Effects Analysis for Giant Manta Ray

The stressors associated with the proposed action that could potentially affect giant manta ray include explosives, entanglement stressors, ingestion stressors, physical disturbance and strike, energy stressors, and indirect effects to giant manta ray via their habitat or prey.

Potential impacts on giant manta rays from PMSR testing and training activities involving explosives are possible, but extremely unlikely, primarily due to the anticipated low density of this species within the action area. While explosive use could overlap with giant manta rays, the likelihood of exposure is expected to be extremely low given the low abundance of this species in the action area. No explosive munitions would detonate underwater as part of the proposed action, which further reduces the likelihood of manta rays being exposed to this stressor. Therefore, we consider the effects from PMSR explosives use on the giant manta ray to be extremely unlikely and thus discountable.

Parachutes and decelerators used by the Navy as part of the proposed action could potentially be encountered by giant manta rays at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a fish encounters them. Some fish species are more susceptible to entanglement, in general, due to their body shape, size maneuverability, and location in the water column. Compared to many other fish species, the chance of an entanglement is likely greater for giant manta rays, which are known to be susceptible to entanglement in fishing gear (83 FR 2916). A study in Hawaii found ten percent of manta rays (28 individuals out of a sample of 290) had cephalic fins (fins on either side of the mouth) amputated, disfigured, or non-functioning (Deakos et al. 2011), apparently due to entanglement in monofilament fishing line. Other evidence has documented mortality of manta rays from entanglement with anchor and mooring lines (Bigalow and Schroeder 1953; Deakos et al. 2011). Manta ray susceptibility to entanglement is largely due to their unique body shape, particularly their cephalic fins.

The primarily large and extra-large decelerators and parachutes proposed for use in the PMSR may pose a higher degree of risk for manta rays because these parachutes are larger and have long lines (large chutes have 28 cords, approximately 40 to 70 ft long; extra-large parachutes have 64 cords, up to 82 ft long), associated with them. Additionally, large parachutes are not weighted with anything to help them sink rapidly, and could potentially remain suspended in the water column for up to 20 minutes. However, the chance of an encounter is remote given the small number (i.e., less than ten annually) of the parachutes proposed to be deployed that would not be recovered, and the anticipated low abundance of giant manta rays in the action area. Given the vast area over which any one of these decelerators and parachutes would be deployed and the limited number of non-recovered items annually, the chances of a giant manta ray encountering them and becoming entangled is extremely low.

Additionally, available data indicates the entanglements and injuries described for this species are mostly due to exposure to fishing gear such as monofilament lines and large heavy mooring lines. The materials of parachutes and decelerators and lines are not the same, and are considered lighter and more likely to sink over a period of about 20 minutes and ultimately settle on the seafloor. Monofilament lines are hard for fish to see and can float indefinitely in the water column unless they become attached to something that anchors them or causes them to sink. They also can easily form multiple loops. Mooring lines are quite heavy so it is likely more difficult for an animal to release itself should it become ensnared in a mooring line. We are not aware of any prior incidents of fish entanglement in parachutes having been reported (Ocean Conservancy 2010; U.S. Department of the Navy 2001). While NMFS recognizes there is a higher risk of entanglement for giant manta rays than for other fish species, giant manta rays are likely able to visually detect and avoid descending or sinking parachutes in the water column. Visual detection and avoidance is expected to result in a minor behavioral response. Therefore, due to the low probability of a giant manta ray becoming entangled in parachutes and decelerators, it is extremely unlikely that adverse effects from entanglement will occur from this stressor for giant manta rays. Therefore, we consider the effects from entanglement stressors on giant manta ray to be discountable.

Giant manta rays occurring in the action area have the potential to ingest military expended materials resulting from PMSR activities. The Navy expends the following types of materials during training and testing in the action area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, and fragments from targets, chaff, flare casings (including plastic end caps and pistons). Giant manta rays are an open ocean, pelagic species that feeds in the water column in areas where military expended materials could be found. However, as filter-feeders, manta rays are not expected to intentionally ingest munitions, and accidental ingestion of such materials is extremely unlikely for a species that feeds primarily on zooplankton. Therefore, we consider the effects from ingestion stressors on the giant manta ray to be discountable.

Given the anticipated low density of the giant manta ray in the action area, the ability of these species to maneuver to avoid any oncoming vessels, the low number of vessels associated with PMSR activities relative to non-military traffic in the area, and the lack of documented cases of Navy vessels or in-water devices striking this species (or any other fish species) in the action area, it is extremely unlikely that a Navy vessel associated with PMSR activities will strike a giant manta ray. Any behavioral or stress response from fish avoiding an oncoming vessel or in-water device would be short-term and temporary. Therefore, potential effects on giant manta rays from vessels and in-water devices are discountable (in the case of strikes) or insignificant (in the case of behavioral or stress response).

Similarly, impacts of military expended material strikes on giant manta ray would be extremely unlikely due to the low occurrence of this species at the surface where military expended material strikes could occur, the extremely rare chance that a fish might be directly struck at the surface and, the ability of most fishes to detect and avoid an object falling through the water below the surface. The potential impacts of military expended material strikes would be short-term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes. Thus, the effects of military expended materials on giant manta rays would be either discountable (in the case of a direct strike) or insignificant (in the case of behavioral changes).

Giant manta rays could potentially be exposed to the laser beam from a high energy laser weapon at or near the water's surface, which could result in injury or death. Giant manta rays are extremely unlikely to be exposed to high-energy laser weapons based on 1) the relatively low number of events per year, 2) the very localized potential impact area of the laser beam, 3) the temporary duration of potential impact (seconds), 4) the low probability of fish at or near the surface at the exact time and place a laser misses its target, 5) the low probability of a laser missing its target; and 6) the relatively low density of giant manta rays in PMSR areas where activities using lasers are conducted. Therefore, the effects from high-energy laser weapons on the giant manta ray are discountable.

Stressors from PMSR training and testing activities that could result in effects on giant manta ray via impacts to habitat, prey, sediment and water quality include explosives and byproducts, metals, and chemicals. Explosions may temporarily reduce available zooplankton prey for mantas. The abundance of zooplankton prey near the detonation point could be diminished for a short period of time before being repopulated from adjacent waters. This scenario would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. As a highly mobile species, giant manta rays would not likely be adversely affected by such short-term, localized impacts to their prey base in the open ocean. Thus, the effects of explosives on giant manta ray via impacts on their prey are considered insignificant.

As discussed in Section 6.1.8.1 above, the effects of explosive byproducts on ESA-listed fish species considered in this opinion via impacts on water quality are insignificant. It is extremely unlikely (i.e., discountable) that fish would be impacted by toxic metals or chemicals expended during PMSR activities given the vast open ocean area over which these potential stressors would be released. Metals deposited on the sea floor will be buried in sediment and slowly degrade over time. Because manta rays feed primarily in the water column, they would not likely come into contact with metals in marine sediments. It is extremely unlikely (i.e., discountable) that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on giant manta ray, their prey, or their habitat.

In summary, given the extremely low abundance of giant manta rays within the PMSR action area and the limited likelihood of co-occurrence with stressors associated with PMSR training and testing activities, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the giant manta ray.

6.1.10 Scalloped Hammerhead Shark – East Pacific DPS

The scalloped hammerhead shark is found throughout the world and lives in coastal warm temperate and tropical seas. On July 3, 2014, NMFS listed the East Pacific scalloped hammerhead DPS as endangered (79 FR 38213).

Scalloped hammerhead sharks are typically found over continental shelves and the shelves surrounding islands, as well as adjacent deep waters, but are seldom found in waters cooler than 22°C (Compagno 1984). They range from the intertidal and surface waters to depths of up to approximately 1,475-1,675 ft (450-512 m; (Klimley et al. 1993), with occasional dives to even deeper (Jorgensen et al. 2009).

6.1.10.1 Occurrence in the PMSR Action Area

There is no information available for estimating the abundance or density of scalloped hammerhead sharks within the action area. Due to its preference for warmer waters, this species is considered rare in Southern California. We are not aware of any surveys or sightings of scalloped hammerheads in the action area, but based on their life histories and occurrence in other similar environments we would expect to find them there. The likelihood of scalloped hammerhead shark occurrence in the action area may increase during periods of anomalously warm water temperatures.

An analysis of fish bycatch in the California drift gillnet fishery estimated 23 "unidentified hammerhead" as bycatch from 1990-2013, or about one per year (Le Fol 2016). The only two hammerhead shark species we would expect to find off California are the smooth hammerhead and the scalloped hammerhead. The "unidentified hammerhead" category, or at least some portion of it, may represent scalloped hammerhead sharks because smooth hammerhead sharks were reported separately at the species level. However, although they are also considered rare, based on Le Fol (2016) smooth hammerheads sharks are likely more abundant in the drift gillnet fishery area as compared to scalloped hammerheads (an estimated 427 smooth hammerheads as bycatch from 1990-2013). Therefore, "unidentified hammerhead" may also represent smooth hammerheads that the on-board fishery observer could not see well enough to identify to the species level (e.g., shark was released while in the water). While the area covered by the California drift gillnet fishery overlaps parts of the PMSR, we have no specific location information to indicate how much of the "unidentified hammerhead" bycatch occurred with the PMSR action area.

6.1.10.2 Effects Analysis for East Pacific DPS Scalloped Hammerhead Shark

The stressors associated with the proposed action that could potentially affect East Pacific DPS scalloped hammerhead shark include explosives, entanglement stressors, ingestion stressors, physical disturbance and strike, energy stressors, and effects to East Pacific DPS of scalloped hammerhead shark via their habitat or prey.

Potential impacts on scalloped hammerhead sharks from PMSR testing and training activities involving explosives are possible, but extremely unlikely, primarily due to the low anticipated low density of this species within the action area. While explosive use could overlap with scalloped hammerhead sharks, the likelihood of exposure would be extremely low given the low abundance of this species in the action area where this activity would occur. No explosive munitions would detonate underwater as part of the proposed action, which further reduces the likelihood of hammerheads being exposed to this stressor. Therefore, we consider the effects from PMSR explosives use on the scalloped hammerhead shark to be discountable.

Parachutes and decelerators used by the Navy as part of the proposed action could potentially be encountered by ESA-listed scalloped hammerheads at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a fish encounters them. Entanglement of an animal in a parachute assembly at the surface or within the water column may be less likely for highly mobile animals, because the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Some fish species are more susceptible to entanglement, in general, due to their body shape, size maneuverability, and location in the water column. Scalloped hammerhead sharks are not expected to be at a high risk of entanglement in parachutes and decelerators given their speed, mobility and generally pelagic existence in the ocean environment. Most parachutes used in the PMSR are in the large to extra-large size range. Large and extra-large decelerator and parachutes have multiple long lines attached to them, are unweighted, and could potentially remain suspended in the water column for an extended period of time, thus increasing the entanglement risk. However, the large majority (over 90 percent) of parachutes deployed within PMSR are recovered after use (see Section 3.4.4 for details). The chance of an encounter is remote given the small number (i.e., less than ten annually) of the large or extra-large parachutes deployed that would not be recovered, and the anticipated low abundance of East Pacific DPS of scalloped hammerhead sharks in the action area. Given the vast area over which any one of these large decelerators and parachutes would be deployed and the limited number of them deployed annually, the chances of a scalloped hammerhead encountering them and becoming entangled is extremely low. Therefore, we consider the effects from entanglement stressors on East Pacific DPS of scalloped hammerhead shark to be extremely unlikely and thus discountable.

Scalloped hammerheads occurring in the action area have the potential to ingest military expended materials resulting from PMSR activities. The Navy expends the following types of materials during training and testing in the action area that could become ingestion stressors: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, and fragments from targets, chaff, flare casings (including plastic end caps and pistons). Scalloped hammerheads generally occupy nearshore habitats within the action area and would, therefore, be less likely to encounter ingestible expended materials, which are more associated with offshore PMSR activities. In addition, due to the size and composition of most material expended materials, the munitions and fragments would sink fairly rapidly to the seafloor, limiting the time available for encounter and ingestion by hammerhead sharks. Based on these factors and the rare occurrence of this species in the action area in general, we consider the effects from ingestion stressors on the East Pacific DPS of scalloped hammerhead shark to be extremely unlikely and thus discountable.

Given the anticipated low density of the scalloped hammerhead sharks in the action area, the ability of these species to maneuver to avoid any oncoming vessels, the low number of vessels associated with PMSR activities relative to non-military traffic in the area, and the lack of documented cases of Navy vessels or in-water devices striking this species (or any other fish species) in the action area, it is extremely unlikely that a Navy vessel associated with PMSR activities will strike a scalloped hammerhead shark. Any behavioral or stress response from scalloped hammerhead sharks avoiding an oncoming vessel or in-water device would be short-term and temporary. Therefore, potential effects on scalloped hammerhead sharks from vessels and in-water devices are discountable (in the case of strikes) or insignificant (in the case of behavioral or stress response).

Similarly, impacts of military expended material strikes on scalloped hammerhead shark would be extremely unlikely due to the low occurrence of this species at the surface where military expended material strikes could occur, the extremely rare chance that a shark might be directly struck at the surface and, the ability of most fishes to detect and avoid an object falling through the water below the surface. The potential impacts of military expended material strikes would be short-term (seconds) and localized disturbances of the water surface (and seafloor areas within sinking exercise boxes) and are not expected to yield any behavioral changes. Thus, the effects of military expended materials on scalloped hammerheads would be discountable.

Fish could potentially be exposed to the laser beam from a high energy laser weapon at or near the water's surface, which could result in injury or death. Scalloped hammerhead sharks are extremely unlikely to be exposed to high-energy laser weapons based on 1) the relatively low number of events per year, 2) the very localized potential impact area of the laser beam, 3) the temporary duration of potential impact (seconds), 4) the low probability of fish at or near the surface at the exact time and place a laser misses its target, 5) the low probability of a laser missing its target; and 6) the relatively low density of scalloped hammerhead sharks in PMSR areas where activities using lasers are conducted. Therefore, the effects from high-energy laser weapons on the scalloped hammerhead shark are discountable.

Stressors from PMSR training and testing activities that could result in effects on ESA-listed scalloped hammerhead sharks via impacts to habitat, prey, sediment and water quality include explosives and byproducts, metals, and chemicals. Explosions may temporarily reduce available hammerhead prey. The abundance of prey near the detonation point could be diminished for a short period of time before being repopulated from adjacent waters. This scenario would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. As a highly mobile species, scalloped hammerhead sharks would not likely be adversely affected by such short-term, localized impacts to their prey base in the open ocean. Thus, the effects of explosives on scalloped hammerhead shark via impacts on their prey are considered insignificant.

As discussed in Section 6.1.8.1 above, the effects of explosive byproducts on ESA-listed fish species considered in this opinion via impacts on water quality are insignificant. Similarly, it is extremely unlikely that scalloped hammerhead sharks would be impacted by toxic metals or chemicals expended during PMSR activities given the vast open ocean area over which these potential stressors would be released. Metals deposited on the sea floor will be buried in sediment and slowly degrade over time. Since scalloped hammerhead sharks feed primarily in the water column they would not likely come into contact with metals in marine sediments. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on scalloped hammerhead sharks, their prey or their habitat.

In summary, given the extremely low abundance of the East Pacific DPS of scalloped hammerhead shark within the PMSR action area and the limited likelihood of co-occurrence with stressors associated with PMSR training and testing activities, we conclude that Navy training and testing activities in the PMSR action area may affect, but are not likely to adversely affect the East Pacific of DPS of scalloped hammerhead shark.

6.1.11 Humpback Whale Central America DPS and Mexico DPS Critical Habitat

On April 21, 2021, NMFS designated critical habitat for Central America and Mexico DPS humpback whales (86 FR 21082). Critical habitat for the Central America DPS encompasses part of Unit 11 and Units 12 through 18 in Figure 20. This designation includes approximately 48,521 nm^2 of marine habitat off the coasts of Washington, Oregon, and California. Critical habitat for the Mexico DPS encompasses Units 2, 3, 5, 8, part of Unit 11, and Units 12 through 18 in Figure 20. This designation includes 116,098 nm^2 of marine habitat off the coasts of Alaska, Washington, Oregon, and California.

Units 17 and 18 overlap with the PMSR action area. Unit 17, referred to as the "Central California Coast Area," covers an area of 6,697 nm^2 extending from 36 degrees 00 seconds to 34 degrees 30 seconds North latitude. Within those north and south boundaries, Unit 17 begins at the 30-m depth contour and extends 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 humpback whale critical habitat overlapping with the PMSR (Figure 21) and includes the Morro Bay to Point Sal feeding area described above.

This unit of habitat is characterized by NMFS as having a very high conservation value (84 FR 54378).

Unit 18, referred to as the "Channel Islands Area," covers an area of 9,799 nm^2 extending from 34 degrees 30 seconds North latitude, south to a boundary line seaward to the southeast from Oxnard, CA along the 3,700-m depth contour. The shoreward boundary is formed by the 50-m depth contour. Unit 18 is the southernmost portion of humpback whale critical habitat overlapping with the PMSR (Figure 21). This unit includes waters off of Santa Barbara and Ventura counties and the Santa Barbara Channel-San Miguel feeding area.

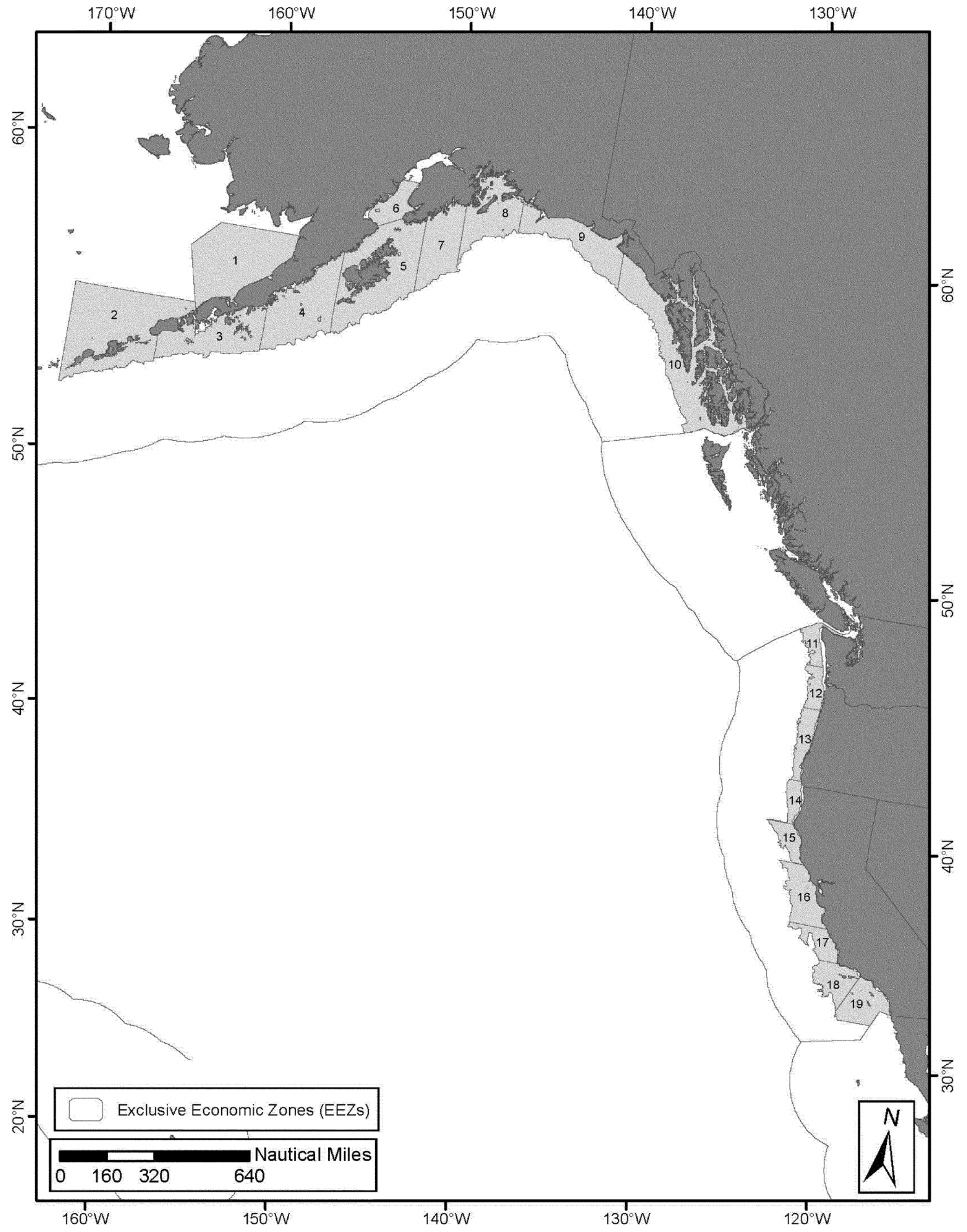

Figure 20. Specific areas (Units 1 to 19) occupied by one or more of the listed humpback whale DPSs. Units 1 through 19 are occupied by the Mexico DPS while Units 11 through 19 are occupied by the Central America DPS.

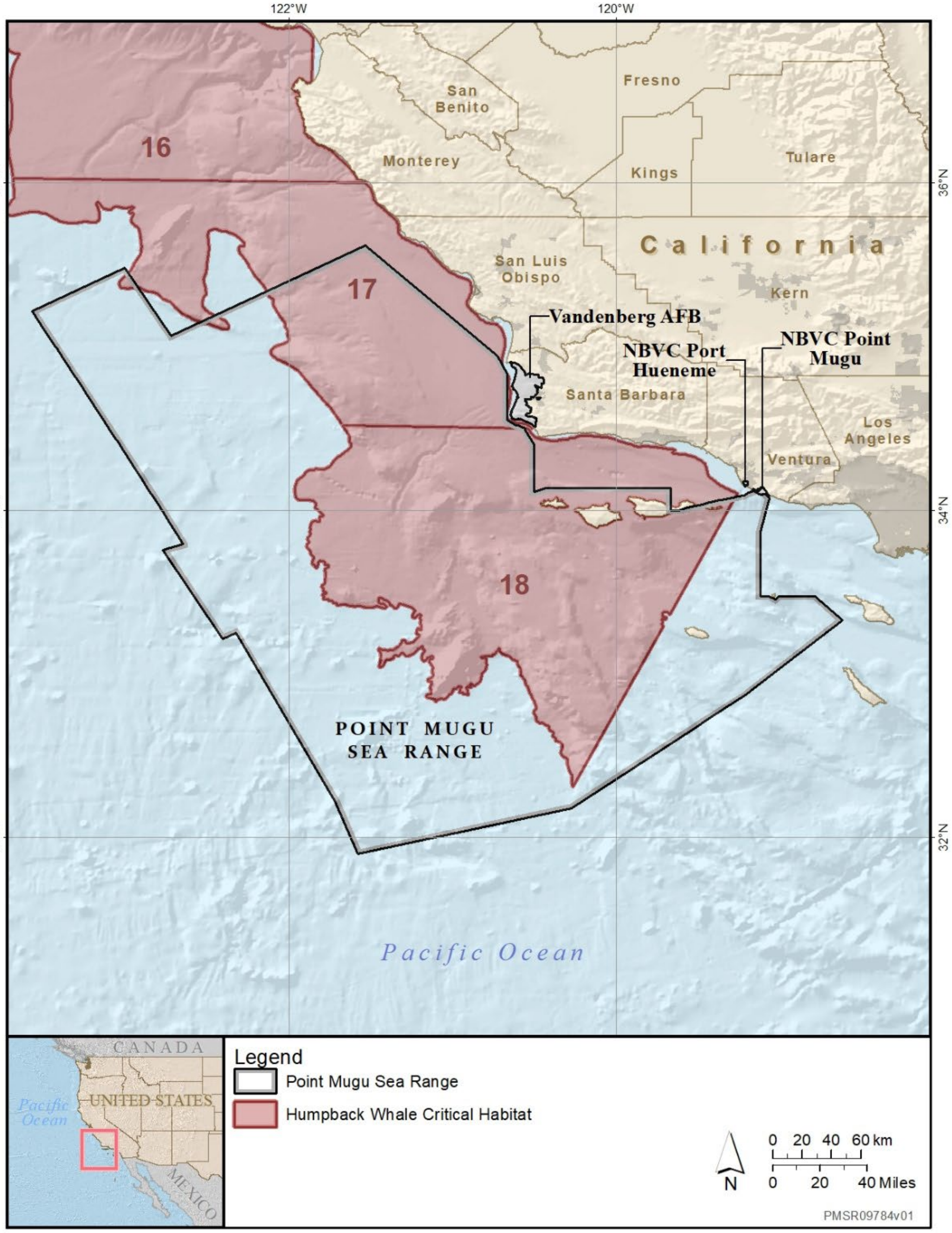

Figure 21. Overlap of humpback whale critical habitat units 17 and 18 with the PMSR action area.

The physical and biological features (PBFs) of recently designated critical habitat for the humpback whale Central America and Mexico DPSs are: euphausiids and small pelagic schooling fishes of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth (86 FR 21082). These schooling prey fishes include species such as capelin, herring, and mackerel. Here, we evaluate the effects of the proposed action on this PBF.

The action area overlaps with a portion of the designated critical habitats for the humpback whale Central America DPS and Mexico DPS (Figure 21). Training and testing activities that would be carried out in this portion of the action area include surface targets and ordnance (see Table 5 and Table 6).

As discussed in a previous NMFS biological opinion for the Navy's Northwest Training and Testing activities (NMFS 2020b), energy, physical disturbance and strike, entanglement, ingestion, and non-impulsive acoustic stressors may affect, but are not likely to adversely affect ESA-listed fishes. It is therefore extremely unlikely that humpback whale prey items (euphausiids and schooling fishes) would be adversely affected by these stressors.

Humpback whale prey items may be adversely affected by explosives if they happen to be in the vicinity of detonations. Adverse effects may include injury, TTS, physiological stress, behavioral reactions, and mortality. Those fish that are killed within the proposed critical habitat would no longer be available to humpback whales as prey items. Adverse effects other than mortality would not be anticipated to remove individuals (prey) from their respective populations, nor would any non-mortal temporary or isolated impacts to prey items be expected to reduce the quality of prey in terms of nutritional content.

Crustaceans, including euphausiids, lack a swim bladder but instead have a statocyst, a sac-like structure with sensory hairs that may be used for orientation. Anatomical damage in invertebrates from low-frequency sounds is limited, but statocyst damage has been observed in cephalopods exposed to sounds from seismic surveys. No evidence of effects from mortality at the population level has been observed in shrimp following seismic airgun exposure and shrimp have not been observed responding to low-frequency sounds, but more research is needed to confirm this (reviewed in Carroll et al. 2017). Despite the lack of evidence regarding adverse effects to euphausiids from low-frequency noise, these organisms may experience adverse effects if they are close enough to a detonation.

If prey items are killed within humpback whale critical habitat, it is likely that only a low number of individuals representing a small portion of prey species' populations will be killed. Although some prey items could be killed within the described mortality ranges during an explosive activity, other prey items would likely be available to humpback whales in the immediate area surrounding the activity, or would return to the area after the activity is complete. Exposure to explosions would be highly dependent on the limited number of explosive activities that overlap with critical habitat and the actual presence of prey species at the time explosive activities occur. Although some individual prey items may be killed, long-term consequences for fish and invertebrate populations and the effect on overall quantity, quality and availability of prey items for humpback whales would be insignificant.

Given the frequency of the events as part of the proposed action, the short duration of these events, the various mitigation measures (including halting of activities until marine mammals are out of the area and are not observed feeding, see Section 3.5.1), the fact that detonations are not proposed to occur in the water column but rather at or near (within 10 m above the surface), and the relatively large number of prey items available throughout the critical habitat, we conclude that any impacts of explosives resulting from PMSR activities on prey availability for the humpback whale Central America and Mexico DPSs would be insignificant. In summary, although explosives would likely result in injury and mortality to humpback whale prey species within critical habitat units, we have no information to indicate that this stressor would have a measureable impact on the occurrence of prey species of sufficient condition, distribution, diversity, abundance and density necessary to support individual, as well as population growth, reproduction, and development of the Central America and Mexico DPSs. The effects of all stressors analyzed on the PBF were found to be insignificant. Therefore, we believe that the proposed action may affect, but is not likely to adversely affect critical habitat for the Central America and Mexico DPSs of humpback whales.

6.1.12 Leatherback Sea Turtle Critical Habitat

Leatherback sea turtle designated critical habitat overlaps with the action area in the northeast portion of the PMSR (Figure 22). The PBF for leatherback sea turtle critical habitat is the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., Chrysaora, Aurelia, Phacellophora, and Cyanea), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks. Here, we evaluate the effects of the proposed action on this PBF.

In general, very little is known about sound detection and the use of sound by aquatic invertebrates (Budelmann 2010). Organisms may detect sound by sensing either the particle motion or pressure component of sound, or both. Aquatic invertebrates, including jellyfish and other leatherback prey, probably do not detect pressure since they are the same density as water and they lack air cavities that would function like the fish swim bladder in responding to pressure (Budelmann 2010). Because any acoustic sensory capabilities, if present at all, are limited to detecting water motion, and water particle motion near a sound source falls off rapidly with distance, aquatic invertebrates are probably limited to detecting nearby sound sources rather than sound caused by pressure waves from distant sources (Navy 2019a). Exposure to acoustic stressors (i.e., vessel noise and weapons noise) would likely either have no effect or very minor effects on leatherback prey species. Impacts, if any, to leatherback prey species would not be expected to occur on a scale necessary to affect the overall prey availability for leatherback turtles. Acoustic stressors are not mentioned by the leatherback Critical Habitat Review Team as an activity that may impact the prey essential feature. Thus, we find that any impacts on leatherback critical habitat through effects to prey acoustic stressors would likely be insignificant.

Leatherback prey species could be affected by physical disturbance and strike stressors including vessel strike, military expended materials, and in-water devices (see Section 5.3 for details on these stressors). However, as with acoustic stressors, it is unlikely that such impacts would occur on a spatial or temporal scale that would result in a measureable impact on the condition, distribution, diversity, abundance or density of prey species necessary for growth and success of leatherback sea turtles. Thus, we find that any impacts on leatherback critical habitat through effects to prey from physical disturbance and strike stressors resulting from the proposed action would likely be insignificant.

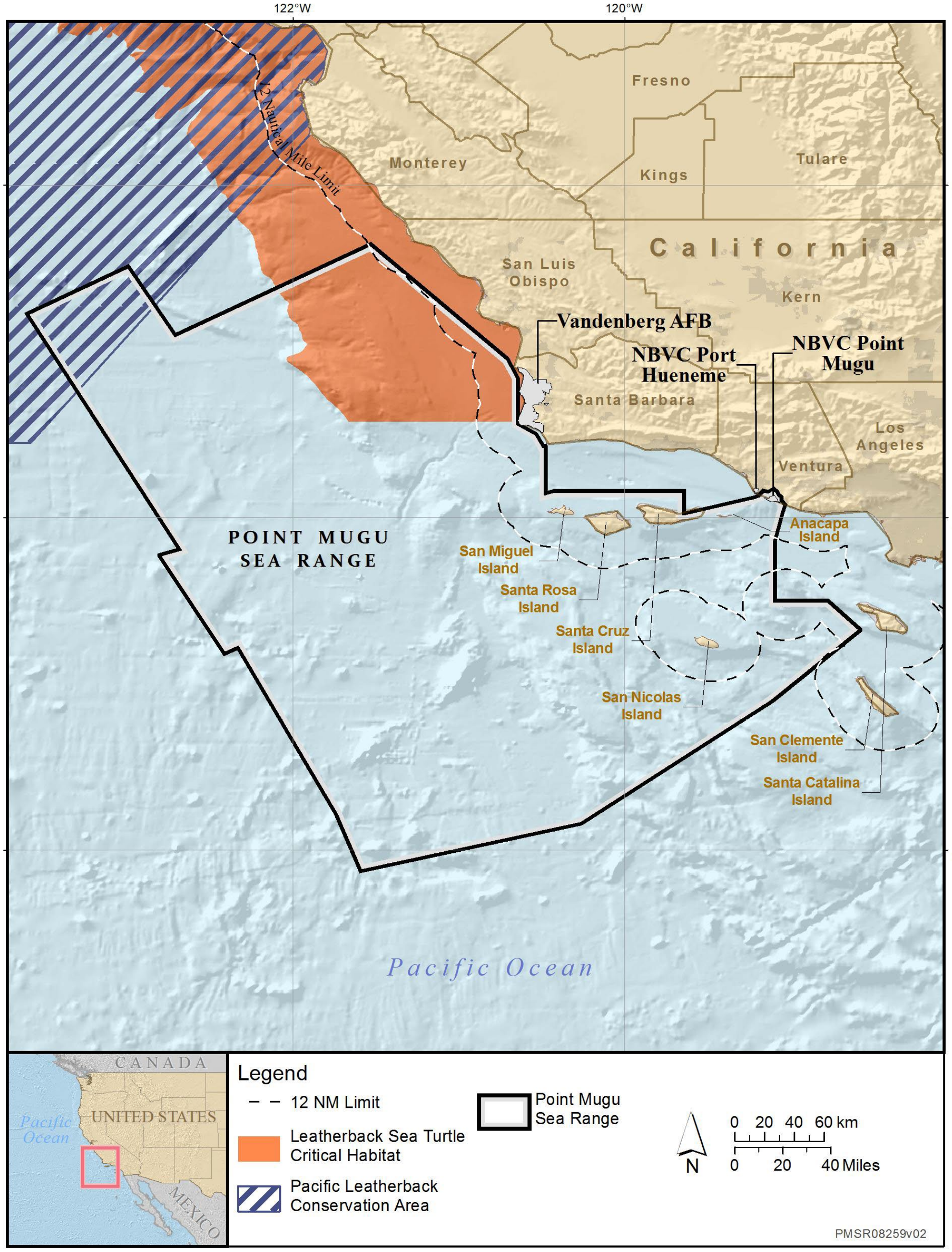

Figure 22. Area of overlap between leatherback sea turtle designated critical habitat and the PMSR (Navy 2021).

6.2 Status of Species Likely to be Adversely Affected

This opinion examines the status of the following ESA-listed species (or DPSs) that are likely to be adversely affected by the proposed action: blue whale, fin whale, humpback whale – Central America and Mexico DPSs, sperm whale, Guadalupe fur seal, loggerhead sea turtle – North Pacific DPS, and leatherback sea turtle.

The evaluation of adverse effects in this opinion begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories in the action area. The status is determined by the level of risk that the ESA-listed species face based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers, or distribution" that is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on NMFS' website: (https://www.fisheries.noaa.gov/species-directory/threatened-endangered).

6.2.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 23). Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and are a mottled gray color that appears light blue when seen through the water.

Information available from the recovery plan (National Marine Fisheries Service 2020), recent SARs (Carretta et al. 2020; Hayes et al. 2019; Muto et al. 2019a), and status review (COSEWIC 2002) were used to summarize the life history, population dynamics and status of the species as follows.

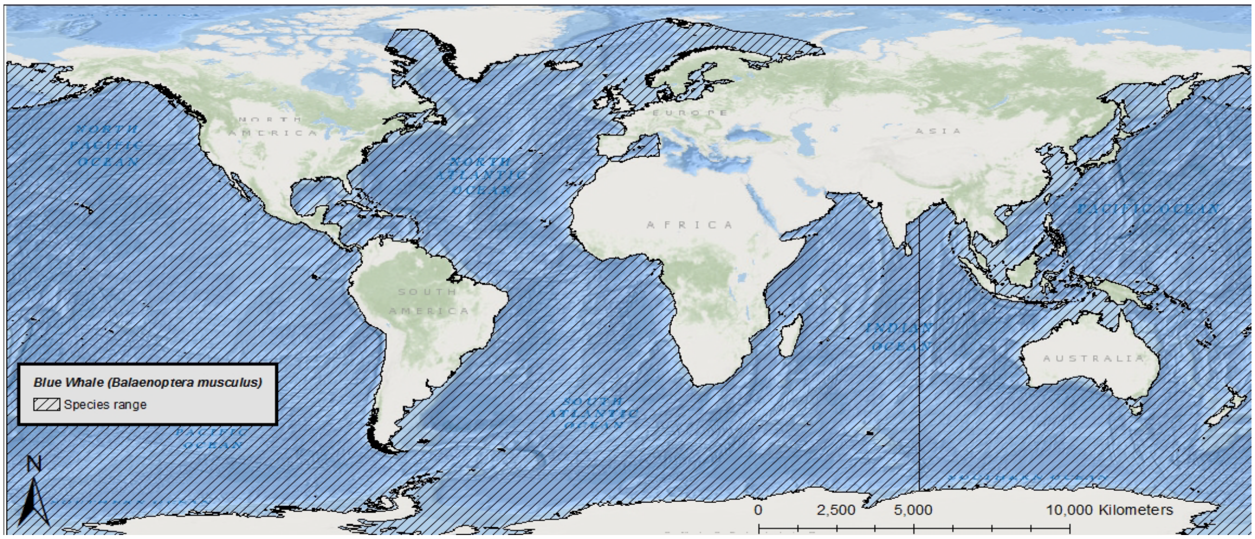

Figure 23. Map identifying the range of the endangered blue whale.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (kg) (7,936.6 lb) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m (295.3 to 393.7 ft).

Distribution

In general, blue whale distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters off eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific. In the Southern Hemisphere, distributions of subspecies (*B. m. intermedia* and *B. m. brevicauda*) seem to be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the

"Antarctic Convergence" (located between 48 degrees South and 61 degrees South latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

The U.S. west coast is known to be a feeding area for blue whales during summer and fall (Bailey et al. 2010; Calambokidis et al. 2009a), although primary occurrence for this species is south of 44 degrees North (Forney et al. 2012; Hamilton et al. 2009; Sirovic et al. 2015). Blue whales feed in the area as late as October, although fewer individuals are seen because the majority of the population migrates south.

Occurrence in the PMSR action area

Based on habitat models derived from line-transect survey data collected between 1991 and 2018 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; Becker et al. 2012b; Becker et al. 2020; Forney et al. 2012). Data from year-round surveys conducted off southern California from 2004 to 2013 show that the majority of 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 addition, predicted mean density of blue whales around southern California is higher during the summer months than fall months, based on survey data from 1991 to 2018 (Becker et al. 2020). 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 (greater than 2,000 m). This species has also frequently been heard on passive acoustic recording devices in Southern California, with most detections occurring from September to December (Baumann-Pickering et al. 2018; Debich et al. 2015b; Lewis and Sirovic 2018; Rice et al. 2017; Rice et al. 2018; Širović et al. 2016; 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. (2015b) found that blue whale vocalizations were more common at coastal sites and near the northern Channel Islands and generally heard between June and January with a peak in September. There was large variation in the spatial distribution among blue whales tagged in Southern California with the distance to shore ranging from less than 1 km and up to 884.8 km and blue whale movement along the Pacific coastline extending south to just 7.4 degrees North latitude (just north of the equator and north to 50 degrees North latitude just off British Colombia, Canada (Mate et al. 2015b).

Tagging data from blue whales 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. 2015a; Mate et al. 2016; Mate et al. 2017). In 2014, tagging data from blue whales indicated the area of highest use for blue whales was between Point Dume and Mugu Canyon, out to approximately 30 kilometers from shore (Irvine et al. 2019; Mate et al. 2015a). 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. Area of highest use in 2015 was off the west end of San Miguel Island, but in 2016 there were very few blue whales present in the Southern California Bight when the high use area shifted to Point Arena in Northern California to the north of San Francisco (Irvine et al. 2019; Mate et al. 2017).

Blue whales in Southern California are generally feeding during their seasonal presence along the U.S. West Coast (Abrahms et al. 2019; Bailey et al. 2009; Calambokidis et al. 2009a; Calambokidis et al. 2015; Mate et al. 2015a). 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 24). 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).

Three biologically important areas (BIAs), regions where aggregations of a certain species engage in biologically important behaviors such as feeding, mating, and migrating, occur within the PMSR action area for blue whales. These include the Point Conception/Arguello, Santa Barbara Channel and San Miguel, and San Nicolas Island feeding areas (Figure 24).

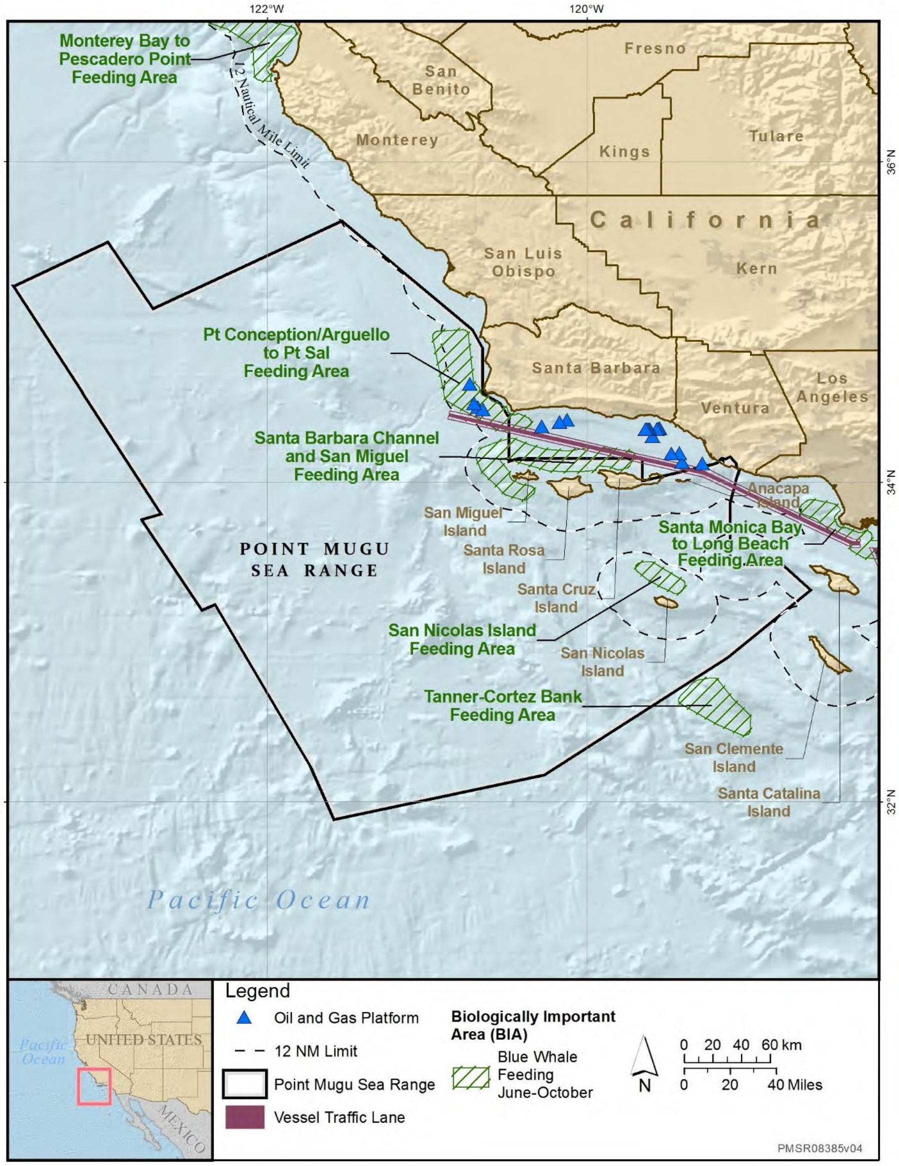

Figure 24. Blue whale biologically important feeding areas identified in the vicinity of the PMSR action area (per (Calambokidis et al. 2015)).

Location data from tags deployed on 171 blue whales between 1993-2008 demonstrated home range and core area presence (Irvine et al. 2014) over a larger area than reflected by the Santa Barbara Channel and San Miguel Island BIA and the Point Conception/Arguello BIA boundaries. Tags were also deployed on blue whales off Southern California in 2014, 2015, and 2016 (Mate et al. 2015a; Mate et al. 2017). 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. 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). The SNI BIA and the Tanner/Cortez Banks BIA were used only minimally by tagged blue whales in 2014, 2015, and 2016 (Mate et al. 2017).

Population Structure

For this and all subsequent marine mammal species in this section, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Futuymda (1986) and Wells and Richmond (1995) and is more restrictive than those uses of 'population' that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see review by Wells and Richmond 1995). The definition we apply is important to ESA section 7 consultations because such concepts as 'population decline,' 'population collapse,' 'population extinction,' and 'population recovery' apply to the restrictive definition of 'population' but do not explicitly apply to alternative definitions. As a result, we do not treat the different whale "stocks" recognized by the International Whaling Commission or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those "stock" distinctions in these narratives.

At least three subspecies of blue whales have been identified based on body size and geographic distribution (*B. musculus intermedia*, which occurs in the higher latitudes of the Southern Oceans, *B. m. musculus*, which occurs in the Northern Hemisphere, and *B. m. brevicauda* which occurs in the mid-latitude waters of the southern Indian Ocean and north of the Antarctic convergence), but this consultation will treat them as a single entity. Readers who are interested in these subspecies will find more information in Gilpatrick et al. (1997), Kato et al. (1995), Omura et al. (1970), and Ichihara (1966).

In addition to these subspecies, the International Whaling Commission's Scientific Committee has formally recognized one blue whale population in the North Pacific (Donovan 1991), although there is increasing evidence that there may be more than one blue whale population in the Pacific Ocean (Barlow 1995; Gilpatrick et al. 1997; Mizroch et al. 1984; Ohsumi and Masaki. 1972). For example, studies of the blue whales that winter off Baja California and in the Gulf of California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick et al. 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (Barlow et al. 1997; Calambokidis et al. 1990; Sears 1987).

Little genetic data exist on blue whales globally. Data from Australia indicates that at least populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al. 2012). Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

Abundance Estimate

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. The minimum population size for blue whales in the eastern north Pacific is 1,050; the most recent SAR abundance estimate is 1,496 whales (Carretta et al. 2020), but the most recently published best estimate is 1,898 whales (Calambokidis and Barlow 2020).

Diving and Social Behavior

Blue whales spend more than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5 to 20 times at 12 to 20 sec intervals before a deep dive of 3 to 30 minutes (min) (Croll et al. 1999a; Leatherwood et al. 1976; Maser et al. 1981; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001a). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001a). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

Blue whales occur singly or in groups of two or three (Aguayo 1974; Mackintosh 1965; Nemoto 1964; Pike and Macaskie 1969; Ruud 1956; Slijper 1962). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Fiedler et al. 1998; Schoenherr 1991). Little is known of the mating behavior of blue whales.

Vocalizations and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Richardson et al. 1995c), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten 1998; McDonald et al. 2001; McDonald et al. 1995b; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls.

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (20 to 80 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 decibels re: 1 μPa at 1 m (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971b; Ketten 1998; McDonald et al. 2001; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Stafford and Moore (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving whales (less than 30 m [98.4 ft]), while deeper diving whales (greater than 50 m [164 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006; Mellinger and Clark 2003; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. D calls are produced in highest numbers during the late spring and early summer and in diminished numbers during the fall, when A-B song dominates blue whale calling (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971b; McDonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Mellinger and Clark 2003; Payne and McVay 1971). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al.

1998), and have only been attributed to males (McDonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to approximately 22.5 Hz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Indian, Pacific, and Southern Oceans. Many possible explanations for the shifts exist but none has emerged as the probable cause.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Edds-Walton 1997; Oleson et al. 2007b; Payne and Webb 1971; Thompson et al. 1992b). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30 to 90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long distance communication occurs (Edds-Walton 1997; Payne and Webb 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Ketten 1997). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001b; Oleson et al. 2007c; Stafford and Moore 2005). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NMFS 2018b).

Natural Threats

Natural causes of mortality in blue whales are largely unknown, but probably include predation and disease. Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1928), which is believed to have caused fin whales to die as a result of renal failure (Lambertsen 1986); see additional discussion under Fin whales). Killer whales and sharks are also known to attack, injure, and kill very young or sick fin and humpback whales and likely hunt blue whales as well (Ford and Reeves 2008; Perry et al. 1999).

Anthropogenic Threats

Three human activities are known to threaten blue whales; shipping, fishing, and whaling. From 1986 to 2020, 10 of the 21 blue whale strikes from vessels occurred in the Los Angeles, Santa

Barbara, Ventura, California area (P. Ruvelas, NMFS WCR, pers. comm., NMHS HQ, July 9, 2021).

Between 2000 and 2020, there were seven confirmed entanglement cases involving blue whales reported to the NMFS West Coast Region (NMFS 2020a).

Historically, whaling represented the greatest threat to every population of blue whales and was the reason why blue whales were listed as endangered. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (Tonnessen and Johnsen 1982). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species.

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 1914, catch increased to 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

Although the IWC banned commercial whaling in the North Pacific in 1966, Soviet whaling fleets continued to hunt blue whales in the North Pacific for several years after the ban. Surveys conducted in these former whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell Jr. 1996). By 1967, Soviet scientists wrote that blue whales in the North Pacific Ocean (including the eastern Bering Sea and Prince William Sound) had been so overharvested by Soviet whaling fleets that some scientists concluded that any additional harvests were certain to cause the species to become extinct in the North Pacific (Latishev 2007). Although whaling currently does not threaten blue whale populations, as its legacy, whaling has reduced blue whales to a fraction of their historic population size and, as a result, this species is more vulnerable to other anthropogenic stressors.

Status and Trends

Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Blue whales are listed as endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA.

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

It is difficult to assess the current status of blue whales globally because: (1) there is no general agreement on the size of the blue whale population prior to whaling; and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population in the North Pacific prior to whaling, although some authors have concluded that their population numbered about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser et al. 1981). These estimates, however, are more than 20 years old.

The current best available abundance estimate for the eastern North Pacific population of blue whales that occur off California, Oregon, and Washington is 1,898 whales, while the minimum population size for eastern North Pacific Ocean blue whales is 1,767 whales (Calambokidis and Barlow 2020). There was a documented increase in the blue whale population size between 1979 and 1994, but there has not been evidence to suggest an increase in the population since then (Barlow 1994; Barlow and Taylor 2001; Carretta et al. 2010). In 2008, Cascadia Research conducted photographic identification surveys to make abundance estimates of blue whales along the U.S. West Coast. The results reflect an upward trend in abundance of blue whales along the U.S. West Coast, although their numbers are highly variable off California, most likely due to the variability of its use as a feeding area (Calambokidis et al. 2009b). Current estimates indicate the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carrying capacity (Carretta et al. 2020). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent, Branch 2007).

The information available on the status and trend of blue whales do not allow us to reach any conclusions about the extinction risks facing blue whales as a species, or particular populations of blue whales. The possible exception is the eastern North Pacific blue whale population which many not have been subject to as much commercial whaling as other blue whale populations and which may be recovering to a stable population level since the cessation of commercial whaling in 1971 (Campbell et al. 2015; Monnahan et al. 2014a; Monnahan et al. 2014b). With the limited data available on blue whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate).

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

See the 2020 Recovery Plan (First Revision to the July 1998 Recovery Plan) (National Marine Fisheries Service 2020) for the blue whale for complete down listing/delisting criteria for each of the following recovery goals:

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere.
2. Estimate the size and monitor trends in abundance of blue whale populations.
3. Identify and protect habitat essential to the survival and recovery of blue whale populations.
4. Reduce or eliminate human-caused injury and mortality of blue whales.
5. Minimize detrimental effects of directed vessel interactions with blue whales.
6. Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales.
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales.
8. Establish criteria for deciding whether to delist or downlist blue whales.

6.2.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachonica* (a pygmy form) in the Southern Hemisphere (Figure 25). Fin whales are the second-largest whale species by length. Fin whales are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. The streamlined appearance can change during feeding when the pleated throat and chest area becomes distended by the influx of prey and seawater, giving the animal a tadpole-like appearance. The basic body color of the fin whale is dark gray dorsally and white ventrally, but the pigmentation pattern is complex. The lower jaw is gray or black on the left side and creamy white on the right side. This asymmetrical coloration extends to the baleen plates as well, and is reversed on the tongue. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990). Fin whales live 70 to 80 years (Kjeld 1982).

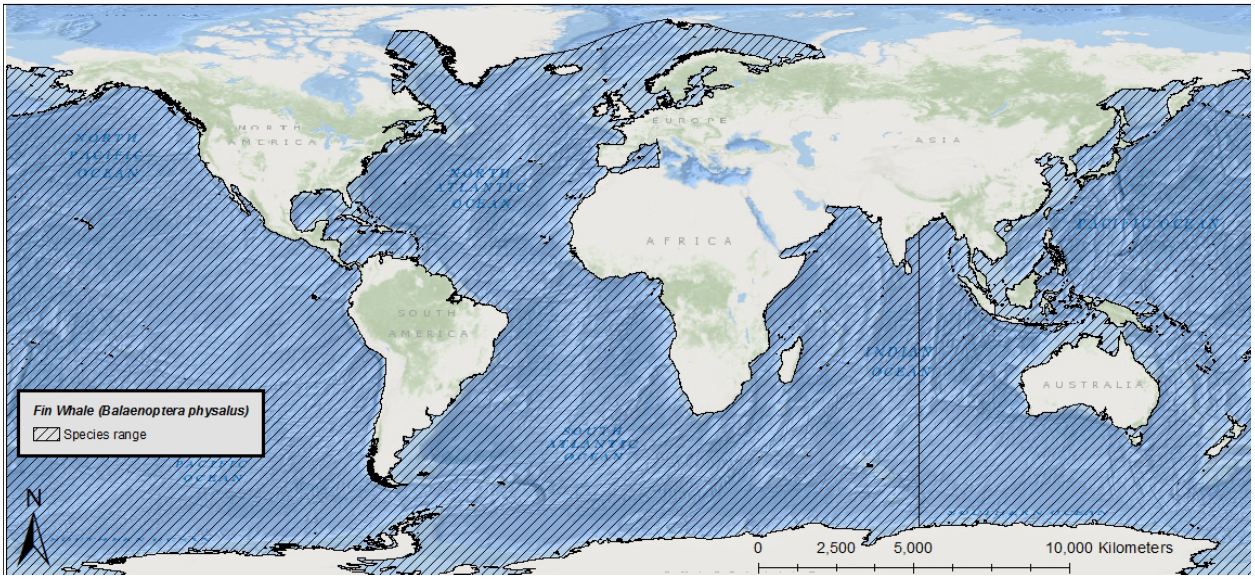

Figure 25. Map identifying the range of the endangered fin whale.

Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Data from historical whaling records in Hecate Strait and Queen Charlotte Sound indicate that most births in the region occurred between mid-November and mid-March, with a peak in January (DFO 2017). Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Acoustic recording data in British Columbia indicate that fin whales are present year-round (Koot 2015). Due to the detection of calling males from November through January, researchers assume that breeding occurs in Canadian Pacific waters in Hecate Strait and Queen Charlotte Sound during that time of year (DFO 2017). Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice. There is a presumed feeding area along the Juan de Fuca Ridge off northern Washington, based on rates of fin whale calls in the area from fall through February (Muto et al. 2019b; Soule and Wilcock 2013).

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean. In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985a). The overall distribution may be based on prey availability. Fin whales are larger and faster than humpback and right whales and are less concentrated in nearshore environments.

Occurrence in the PMSR action area

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. 2012a; Becker et al. 2010; Becker et al. 2016; Becker et al. 2020; 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 and Barlow 1998; Forney et al. 1995; Jefferson et al. 2014; Scales et al. 2017), although their distribution shows seasonal shifts. In 2005 to 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).

Six tags were deployed on fin whales in Southern California in August 2014 and 2015 (Irvine et al. 2019; Mate et al. 2015a). 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 (Irvine et al. 2019; Mate et al. 2015a). Satellite tags deployed on 13 fin whales off Central California in 2016 had only three of those individuals move into the PMSR for a period of time lasting approximately 1 day, 8 days, and 44 days for each (Mate et al. 2017).

Population Structure

Archer et al. (2013) examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial deoxyribonucleic acid (DNA) genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Results of a later single-nucleotide polymorphism analysis indicate that distinct mitogenome matrilines in the North Pacific are interbreeding (Archer et al. 2019). Generally speaking, haplotype diversity was found to be high both within oceans basins, and across, with the greatest diversity found in North Pacific fin whales (Archer et al. 2019). Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

Abundance Estimate

The best current abundance estimate for fin whales in California, Oregon, and Washington waters out to 300 NM is 9,029 (CV=0.12) (Nadeem et al. 2016); the minimum population estimate is 7,970 individuals (Becker et al. 2020).

Diving and Social Behavior

The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5 to 20 shallow dives, each of 13- to 20-second duration, followed by a deep dive of 1.5 to 15 min (Gambell 1985a; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2 to 6 min (Hain et al. 1992; Watkins 1981b). Croll et al. (2001a) reported average fin whale dives of 98 meters and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min. Lafortuna et al. (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known (Panigada et al. 1999).

Individuals or groups of less than five individuals represent about 90 percent of the observations. Barlow (2003) reported mean group sizes of 1.1 to 4.0 during surveys off California, Oregon, and Washington.

Vocalization and Hearing

Fin whales produce a variety of low-frequency sounds in the 10 Hz to 200 Hz range (Edds 1988; Thompson et al. 1992a; Watkins 1981a; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to 2 s) in the 18 Hz to 35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995c) reported the most common sound as a 1 second vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. Au (Au and Green 2000) reported moans of 14 Hz to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 Hz 150 Hz, and songs of 17 Hz to 25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a). Source levels for fin whale vocalizations are 140 to 200 dB re 1μPa-m (see also Clark and Gagnon 2004; as compiled by Erbe 2002). The source depth of calling fin whales has been reported to be about 50 meters (Watkins et al. 1987).

Although their function is still in doubt, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997; Payne and Webb. 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999).

The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing. In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 2 kHz range.

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Fin whales produce a variety of low frequency (< 1 kilohertz) sounds, but the most typically recorded is a 20 Hz pulse lasting about 1 second, and reaching source levels of 189 ± 4 dB re 1 μPam (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson et al. 1995c; Sirovic et al. 2007; Watkins 1981a; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). The seasonality and stereotypic nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981a; Watkins et al. 1987); a notion further supported by recent data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (Navy 2010; Navy 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981a), was also frequently recorded, although these calls are not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific (Sirovic et al. 2012). Source levels of Eastern Pacific fin whale 20-Hz calls has been reported as 189 +/- 5.8 dB re 1uPa at 1m (Weirathmueller et al. 2013). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20 Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992a; Watkins et al. 1987).

Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Edds-Walton 1997; Payne and Webb. 1971). Also, there is speculation that the sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Although no studies have directly measured the sound sensitivity of fin whales, experts assume that fin whales are able to receive sound signals in roughly the same frequencies as the signals they produce. This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than at mid- to high-frequencies (Ketten 1997). Several fin whales were tagged during the Southern California-10 Behavioral Response Study (BRS) and no obvious responses to a mid-frequency sound source were detected by the visual observers or in the initial tag analysis (Southall et al. 2011). Results of studies on blue whales (Goldbogen et al. 2013) (Southall et al. 2011), which have similar auditory physiology compared to fin whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context. In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 2 kHz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NMFS 2018b).

Natural Threats

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04 to 0.06 for northeast Atlantic fin whales. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1983). Adult fin whales engage in flight responses (up to 40 kilometers per hour [km/h]) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Killer whale or shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999).

Anthropogenic Threats

Fin whales have undergone significant exploitation, but are currently protected under the IWC. According to whaling records from Canadian Pacific waters, at least 7,605 fin whales were killed between 1908 to 1967 (Gregr et al. 2000). Fin whales are still hunted in subsistence fisheries off West Greenland. In 2004, five males and six females were killed, and two other fin whales were struck and lost. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005).

Fin whales experience significant injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Carretta et al. 2017c; Douglas et al. 2008; Lien 1994; NMFS 2018a; Perkins and Beamish 1979; Saez 2018; Waring et al. 2007). Based on reports from 2007 to 2014 for waters off the U.S. West Coast, a total of four fin whales were seriously injured by entanglement in fishing gear (Carretta et al. 2018). Between 1969 and 1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). In 1999, one fin whale was reported killed in the Gulf of Alaska pollock trawl fishery and one was killed the same year in the offshore drift gillnet fishery (Angliss and Outlaw 2005; Carretta and Chivers. 2004). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004.

Available data from NMFS indicate that, in waters off the U.S. West Coast between 1991 and 2010, there were 11 reported ship strikes involving fin whales (National Marine Fisheries Service 2011), and from 2010 to 2014 along the U.S. West Coast there were nine reported ship strikes to fin whales (Carretta et al. 2016b). From 1986 to 2020, of the 25 vessel strikes to fin whales along the U.S. West Coast, 13 occurred around Los Angeles (P. Ruvelas, NMFS WCR, pers. comm., NMHS HQ, July, 9, 2021). Since 2002, 10 out of the 12 stranded fin whales in Washington have showed evidence attributed to a large ship strike (Cascadia Research 2017). Jensen and Silber (2004) review of the NMFS's ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawai'i. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008).

The organochlorines dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and polychlorinated diphenyls (PCBs) have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

Climate change also presents a potential threat to fin whales, as habitat and prey availability will likely be affected. While fin whales have a larger feeding range than other species and may therefore not be affected as drastically as species with smaller feeding ranges, the potential impacts of climate change on fin whale recovery remain uncertain (NMFS 2010b). Climate change impacts on fin whales are of concern in the Mediterranean Sea, where fin whales appear to rely exclusively upon northern krill as a prey source. These krill occupy the southern extent of their range and increases in water temperature could result in their decline and that of fin whales in the Mediterranean Sea (Gambaiani et al. 2009).

Status and Trends

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000. The North Pacific population of fin whales was reduced to between 13,620 and 18,680 by 1973 (Ohsumi and Wada 1974).

An overall fin whale population trend in the U.S. Pacific has not been established, but there is evidence that there has been increasing rates in the recent past in different parts of the region. From 1991 to 2014, the estimated average rate of increase for California, Oregon, and Washington waters was 7.5 percent, with the caveat that it is unknown how much of this increase could be attributed to immigration rather than birth and death processes (Carretta 2019).

Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population. Based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

Critical Habitat

NMFS has not designated critical habitat for fin whales.

Recovery Goals

See the 2010 Final Recovery Plan (NMFS 2010b) for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

6.2.3 Humpback Whale – Central America and Mexico DPSs

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 26). Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white.

Information available from the recovery plan (NMFS 1991), the recent SAR (Carretta et al. 2020), the status review (Bettridge et al. 2015b), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age. Every one to five years, females five birth to a single calf, with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015b).

Distribution

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985).

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Tomlin 1967, Nemoto 1957, Johnson and Wolman 1984 as cited in NMFS 1991). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during the winter.

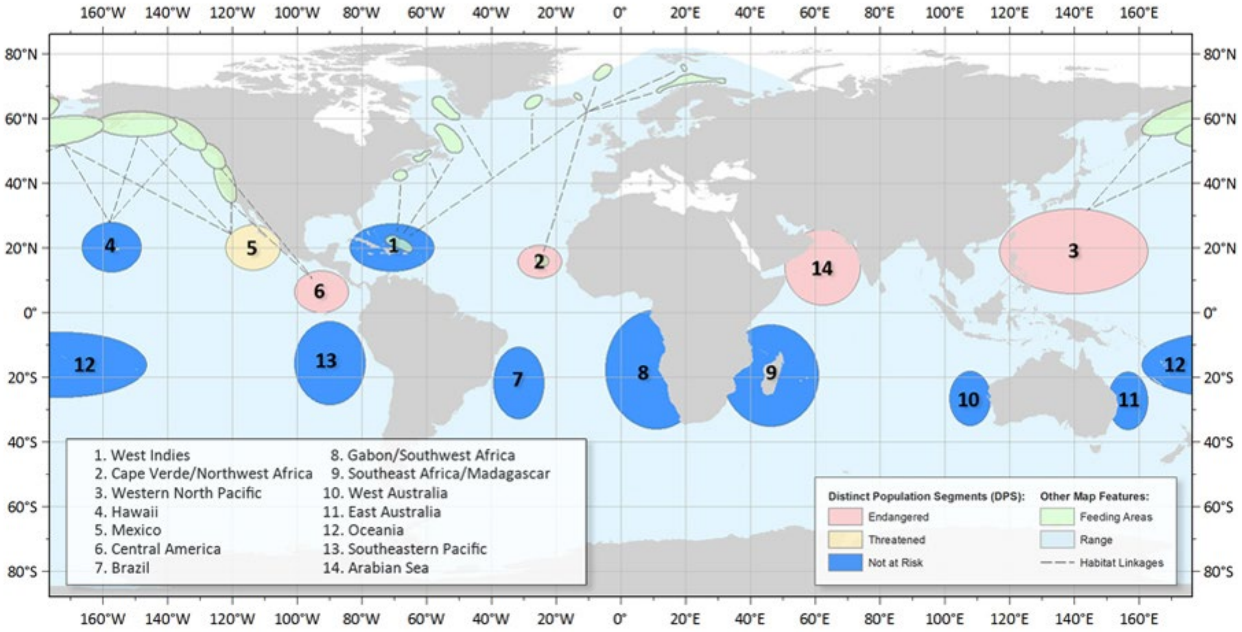

Figure 26. Map showing the distribution of the 14 humpback whale Distinct Population Segments (modified from Bettridge et al. 2015).

Occurrence in the PMSR action area

Off the U.S. West Coast, humpback whales are more abundant in shelf and slope waters (less than 2,000 m deep) and are often associated with areas of high productivity (Becker et al. 2012a; Becker et al. 2010; Becker et al. 2016; Calambokidis et al. 2019; Campbell et al. 2015; Forney et al. 2012; Redfern et al. 2013).

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; Campbell et al. 2015; Clapham 2000; Clapham and Mattila 1990; Dohl 1983; Forney and Barlow 1998; 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 action area farther offshore (Lagerquist et al. 2008; Mate et al. 2017). Humpback whales are expected to use portions of the waters within the PMSR action area as a summer feeding ground (Calambokidis et al. 2015). Peak occurrence during migration occurs in the PMSR action 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 (in all seasons) the majority of the population found north of the Channel Islands (Becker et al. 2017; Calambokidis et al. 2017; Campbell et al. 2015; Forney and Barlow 1998). Based on aerial survey data collected between 2008 and 2012 in the Navy's Southern California (SOCAL) Range Complex, Smultea (2014) determined that humpback whales ranked eighth in relative occurrence of cetaceans and concluded that this species has clearly increased their representation in the 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 action area (Calambokidis et al. 2015). In their designation, these feeding areas (Figure 27) 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). Passive acoustic monitoring at Monterey Bay, California from 2015 to 2018 demonstrated that the timing of humpback whales feeding and migrating in that area is variable, with detections generally occurring from September through May, but with visual sightings occurring mostly during the summer (Ryan et al. 2019).

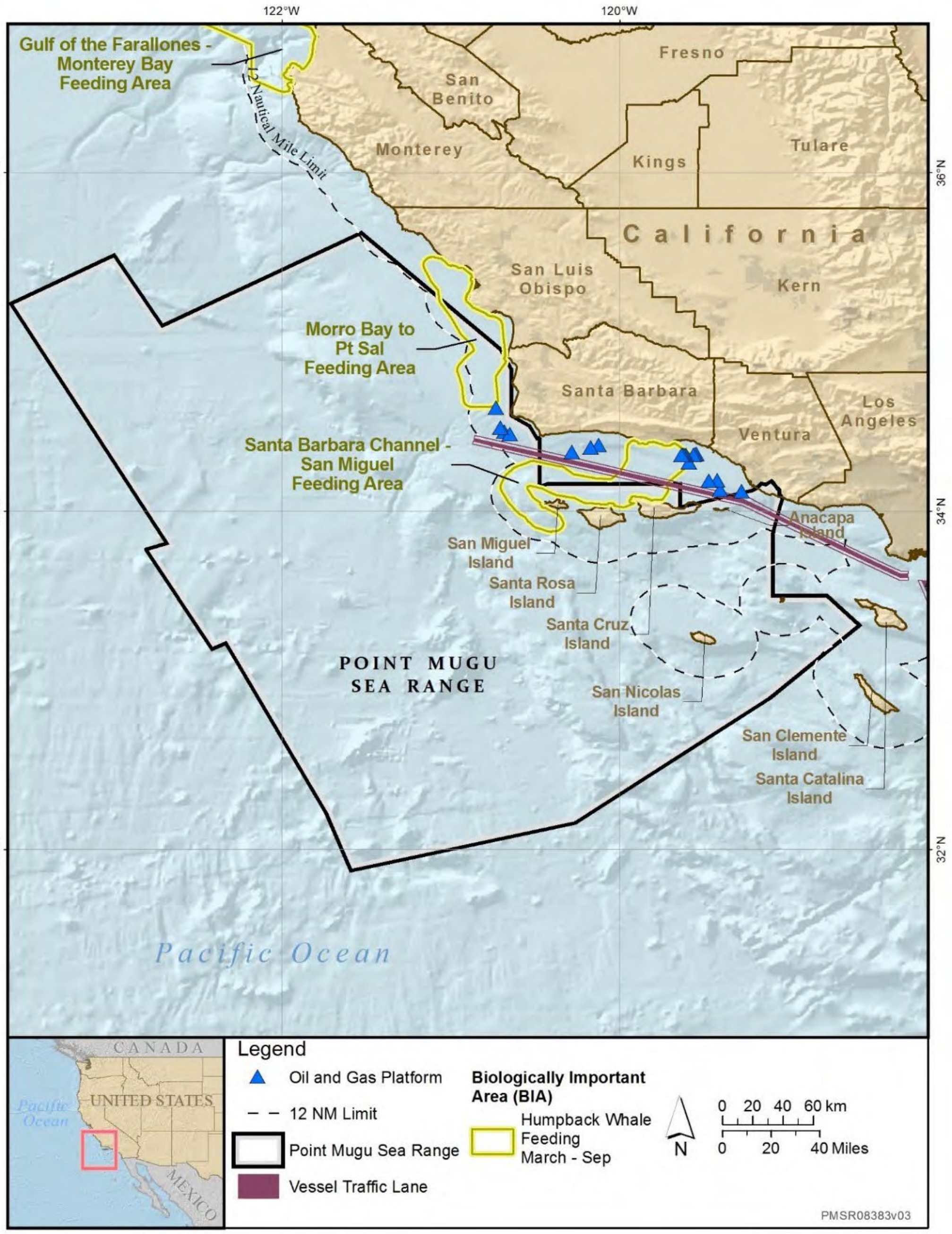

Figure 27. Humpback whale biologically important feeding areas identified in the vicinity of the PMSR action area (per Calambokidis et al., 2015).

Population Structure

During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different "reproductive areas" will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form "open" populations; that is, populations that are connected through the movement of individual animals.

Separate feeding groups of humpback whales are thought to inhabit western U.S. and Canadian waters, with the boundary between them located roughly at the U.S./Canadian border. The southern feeding ground ranges between 32 degrees to 48 degrees N, with limited interchange with areas north of Washington State (Calambokidis et al. 2004; Calambokidis et al. 1996). Humpback whales feed along the coasts of Oregon and Washington from May-November, with peak numbers reported May-September, when they are the most commonly reported large cetacean in the region (Calambokidis and Chandler. 2000; Calambokidis et al. 2004; Dohl 1983; Green et al. 1992). Off Washington State, humpback whales concentrate between Juan de Fuca Canyon and the outer edge of the shelf break in a region called "the Prairie," near Barkley and Nitnat canyons, in the Blanco upwelling zone, and near Swiftsure Bank (Calambokidis et al. 2004). Humpback whales also tend to congregate near Heceta Bank off the coast of Oregon (Green et al. 1992). Additional data suggest that further subdivisions in feeding groups may exist, with up to six feeding groups present between Kamchatka and southern California (Witteveen et al. 2009).

The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua. This DPS feeds almost exclusively offshore of California and Oregon in the eastern Pacific Ocean, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds.

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska, and Bering Sea feeding grounds (81 FR 62259).

Abundance Estimate

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes (Bettridge et al. 2015a). Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Populations at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. Based on surveys from 2004 to 2006, the Central America DPS is estimated to have just below 800 individuals while the Mexico DPS is estimated to have just below 3,000 individuals (Wade 2017). The abundance estimate of humpback whales occurring off the U.S. West Coast is 4,776 individuals (Calambokidis and Barlow 2020). However, sightings of humpbacks off the U.S. West Coast have been increasing in more recent years, and these are likely underestimates (Calambokidis 2017).

Diving and Social Behavior

Maximum diving depths are approximately 170 m, with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1 to 5.1 min in the north Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best. 1995).

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin, herring and mackerel. Like other large mysticetes, they are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with open mouths through the middle. Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific (southeast Alaska), most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (Dolphin 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al. 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

Vocalization and Hearing

Humpback whale vocalization is much better understood than hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144 to 174 dB (Au et al. 2006a; Frazer and Mercado Iii 2000; McCauley et al. 2000b; Richardson et al. 1995c; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz to 10 kHz with most energy below 3 kilohertz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km (4.9 NM) away (Tyack 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas

(Richardson et al. 1995c; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89 Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 µPa at 1 m) (Edds-Walton 1997; Oleson et al. 2007b; Payne and Webb 1971; Thompson et al. 1992a). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Richardson et al. 1995c). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008). Males may also use songs as a way of mutually assisting other males in mating (Darling et al. 2006) and/or as a long-range sonar to detect other whales from a distance (Mercado III 2018). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel. 2002; McSweeney et al. 1989). Au et al. (2006b) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs ('song sessions') sometimes lasting for hours (Payne and McVay 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151 and 189 dB re: 1 µPa-m and high frequency harmonics extending beyond 24 kHz (Au et al. 2006b; Winn et al. 1970). Perazio and Mercado III (2018) found that frequencies from humpback whale songs in the Gulf of Tribugá in the Pacific ranged from 10 Hz to over 10,000 Hz but a frequency band of around 250 to 425 Hz was produced the most often. This suggests that singing humpback whales in this region may prefer to utilize this frequency band. Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kilohertz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986; Simao and Moreira 2005). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

Humpback whale calves have been shown to produce calls with durations of around 200 to 250 milliseconds, mean bandwidths of around 621 to 2004 Hz, and mean center frequencies of around 500 to 600 Hz (Zoidis et al. 2008). While the significance of these calls are unknown, they may serve as contact calls to the calf's mother (Indeck et al. 2020; Zoidis et al. 2008). Humpback whale calves are likely restricted by their physical immaturity in the types of social calls they can produce; it is thought that their vocal repertoire expands with age, as in North Atlantic right whales (Indeck et al. 2020).

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz to 2 kHz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 µPa-m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985; Thompson et al. 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with digital acoustic recording tags (DTAGs) (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: (Stimpert et al. 2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 µPa), with the majority of acoustic energy below 2 kHz.

Recalde-Salas et al. (2020) recorded non-song vocalizations from humpback whales off Western Australia. The frequencies of these sounds ranged from 9 Hz to 6 kHz, the majority being under 200 Hz. These sounds lasted from 0.09 to 3.59 seconds. Some of these vocalizations appeared to be similar to social sounds or feeding calls reported in Alaska.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 Hz to 35 kHz (NMFS 2018b). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006b) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re: 1 µPa-m or frequency sweep of 3.1 to 3.6 kHz. In addition, the system had some low frequency components (below 1 kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Natural Threats

Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992b). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period.

Anthropogenic Threats

Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Entanglement in pot/trap fisheries has been the most common source of injury to humpback whales along the U.S. Pacific coast (Carretta et al. 2016a; Carretta et al. 2017c; NOAA 2017; Saez et al. 2012). Between 1982 and 2017, 184 entangled humpback whales were reported along the west coast of North America, with 165 reports confirmed (Saez et al. 2021). Most of these reports (90) came from Monterey, in central California. There were 54 separate entanglement cases reported for humpback whales along the U.S. West Coast in 2016 (National Oceanic and Atmospheric Administration 2017). For the five-year period between 2011 and 2015 there were 34 cases of entanglement involving pot/trap fisheries and an additional 26 cases of reported interactions with other fisheries (Carretta et al. 2017d). Humpback whales have also been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Helker et al. 2017); some proportion of these entanglements could be to whales from the Mexico DPS and from the Central America DPS, although the latter is unlikely as humpback whales from the Central America DPS rarely feed North of Oregon. An overall minimum estimate of mortality and serious injury due to fisheries in Alaska is 14 humpback whales annually (Muto et al. 2017).

Along the U.S. Pacific coast between 2011 and 2015, there were nine ship strikes involving humpback whales; none were Navy vessels (Carretta et al. 2017a; Carretta et al. 2016b). From 1986 to 2020, of the 22 reported vessel strikes involving humpback whales along the U.S. West Coast, three were reported in Los Angeles County (P. Ruvelas, NMFS WCR, pers. comm., NMHS HQ, July, 9, 2021). The mean vessel collision mortality and serious injury rate in Alaska is 4.3 humpback whales annually
(Muto et al. 2017).

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher PCB levels have been observed in Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

Status and Trends

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA. In 2016, NMFS designated the globally listed humpback whale into 14 DPSs (81 FR 62259). The humpback whales in the action area potentially belong to one of two listed DPSs: the threatened Mexico DPS or the endangered Central America DPS. Both of these DPSs may feed seasonally in the action area.

According to historical whaling records from five whaling stations in British Columbia, 5,638 humpback whales were killed between 1908 and 1967 (Gregr et al. 2000). We have no way of knowing the degree to which a specific DPS of humpback whale was affected by historical whaling. However, it is likely that individuals from both the Mexico and Central America DPSs were taken, based on where the whalers were hunting off British Columbia (i.e., the purported feeding grounds for these population segments). Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whale-watching noise, harmful algal blooms, disease, parasites, and climate change. Due to on-going threats, and the purported low population size, the Central America DPS still faces a risk of extinction. The Mexico DPS has a comparatively larger population than the Central America DPS, but still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

Critical Habitat

See Section 6.1.11.

Recovery Goals

See the 1991 Final Recovery Plan (NMFS 1991) for the Humpback whale for complete down listing/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

6.2.4 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 28).

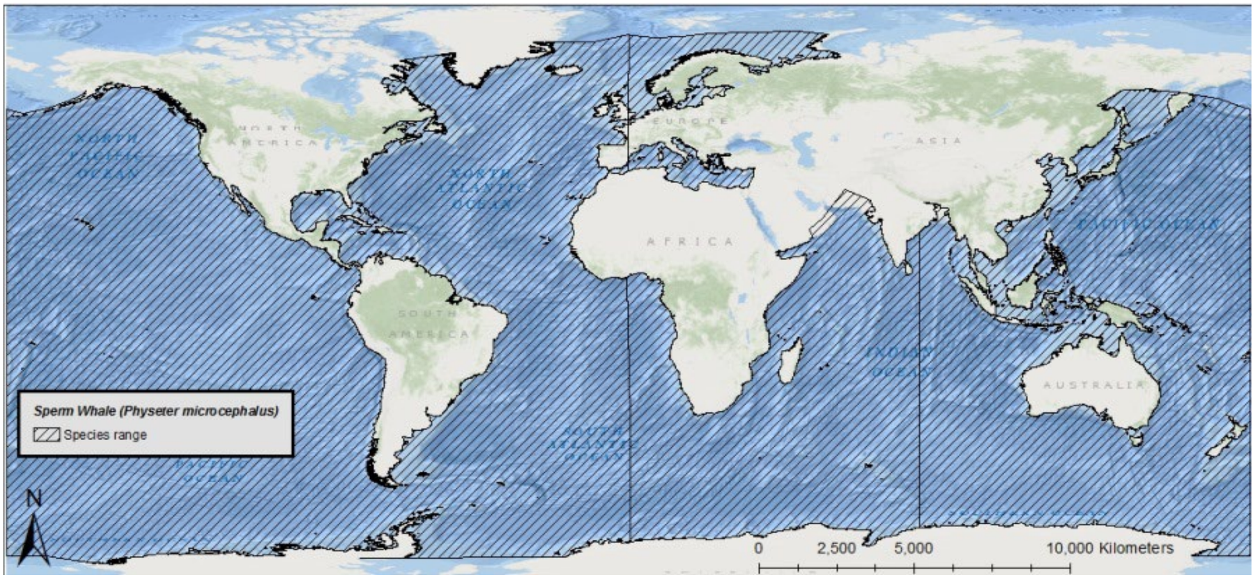

Figure 28. Map identifying the range of the endangered sperm whale.

Sperm whales are the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up to 25 to 35 percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip.

Information available from the recovery plan (NMFS 2010a), recent SARs (Carretta et al. 2020; Hayes et al. 2019; Muto et al. 2019a), and status review (NMFS 2015) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity for sperm whales in the North Pacific is reached between seven and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity between ages 18 and 21, after which they undergo a second growth spurt, reaching full physical maturity at around age 40 (Mizroch and Rice 2013). Data from historical whaling station records from 1908 to 1967 indicate that sperm whales mated in April through June, and calved in July to August in the offshore waters of British Columbia (Gregr et al. 2000). Sperm whales mostly occur far offshore, inhabiting areas with a water depth of 600 m (1,968 ft) or more, and are uncommon in waters less than 300 m (984 ft) deep. However, if there are shelf breaks or submarine canyons close to land, sperm whales can occur there. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid. Other prey includes octopus and demersal fish (including teleosts and elasmobranchs). An analysis of commercial whaling records from the Coal Harbor whaling station in northern Vancouver from 1963 to 1967 looked at sperm whale stomach contents. The samples came late spring through summer (April through September). North Pacific giant squid (*Moroteuhis robusta*) was the most abundant prey item for both males and females, but the secondary prey item differed between sexes. After giant squid, males consumed rockfish (*Sebastes spp*.), while females ate ragfish (*Icosteus spp*.) and other fish (Flinn et al. 2002).

Distribution

Sperm whales are distributed in all of the world's oceans, from equatorial to polar waters, and are highly migratory. Mature males range between 70 degrees North in the North Atlantic and 70 degrees South in the Southern Ocean (Perry et al. 1999; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50 degrees North or South (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring 1993) where adult males join them to breed.

In the Pacific, sperm whales are primarily found in temperate and tropical waters (Merkens et al. 2019; Rice 1989). This species appears to have a preference for deep waters and the continental shelf break and slope (Baird 2013; Jefferson et al. 2015; Rice 1989; Whitehead 2003b; 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 and Praca 2007; Jefferson et al. 2015). Using survey data from 1991 to 2018, high densities of sperm whales have been predicted to occur along the 2,000 m isobath in the California Current Ecosystem in summer (Becker et al. 2020).

Occurrence in the PMSR action area

The range of sperm whales includes areas of higher latitudes in the PMSR action area (Jefferson et al. 2015; Whitehead 2009; Whitehead et al. 2008; Whitehead and Weilgart 2000). Sperm whales are found year-round in California waters, but their abundance is temporally variable, most likely due to the availability of prey species (Barlow 1995; Barlow and Forney 2007; Forney and 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. 2012a; Becker et al. 2010; 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).

Population Structure

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown.

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40 degrees, only adult males venture into the higher latitudes near the poles. Sperm whale distribute widely throughout the North Pacific Ocean, with movements over 5,000 km, likely driven by changes in prey abundance. Males appear to range more broadly than females (Mizroch and Rice 2013).

Sperm whales are seasonal migrants to waters off the coast of Washington and Oregon where their densities are highest during spring and summer; they do not appear to occur in these waters during the winter. Sperm whales also tend to occur in the deeper water at the western edge of the action area. In surveys of waters off Oregon and Washington conducted by Green et al. (1992), no sperm whales were encountered in waters less than 200 m deep, 12 percent of the sperm whales were encountered in waters 200 to 2,000 m deep (the continental slope), and the remaining 88 percent of the sperm whales were encountered in waters greater than 2,000 m deep. In surveys conducted by Forney and her co-workers (Forney 2007), sperm whales were reported from the Olympic Coast Slope transects (west of the Olympic Coast National Marine Sanctuary), but not from surveys conducted over the National Marine Sanctuary or the area immediately west of Cape Flattery.

In the Gulf of Alaska, sperm whales have been sighted along the Aleutian Trench as well as over deeper waters and have been detected acoustically throughout the year (Forney and Brownell Jr. 1996; Mellinger et al. 2004a). Occurrence is higher from July through September than January through March (Mellinger et al. 2004a; Moore et al. 2006). The vast majority of individuals in the region are likely male based upon whaling records and genetic studies; the area is a summer foraging area for these individuals (Allen and Angliss 2010; Reeves et al. 1985; Straley and O'Connell 2005; Straley et al. 2005). Mean group size has been reported to be 1.2 individuals (Wade et al. 2003; Waite 2003). However, female groups may rarely occur at least up to the central Aleutian Islands (Fearnbach et al. 2012).

Abundance Estimate

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997 (NMFS 2015b). The current population estimate for sperm whales in waters off California, Oregon, and Washington, is 1,997 (N_{min}=1,270) (Carretta et al. 2020). There are currently no reliable population abundance estimates for the north Pacific (Muto et al. 2020).

Diving and Social Behavior

Sperm whales are probably the deepest and longest diving mammalian species, with dives to 3 km down and durations in excess of 2 hours (Clarke 1976; Watkins 1985; Watkins et al. 1993). However, dives are generally shorter (25 to 45 min) and shallower (400 to 1,000 meters). Dives are separated by 8 to 11 min rests at the surface (Gordon 1987; Jochens et al. 2006; Papastavrou et al. 1989; Watwood et al. 2006). Sperm whales typically travel ~3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003a). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species, which generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Clarke 1986; Whitehead 2002). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100 to 500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200 to 400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead 2008). However, no sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred miles are common, (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. However, general transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Gaskin (1973) proposed a northward population shift of sperm whales off New Zealand in the austral autumn based on reduction of available food species and probable temperature tolerances of calves.

Sperm whales have a strong preference for waters deeper than 1,000 meters (Reeves and Whitehead 1997; Watkins and Schevill 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40 and 55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet 1996; Jaquet and Whitehead 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000; Davis et al. 2002). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet and Whitehead 1996; Waring et al. 1993). Sperm whales over George's Bank were associated with surface temperatures of 23.2 to 24.9°C (Waring et al. 2004).

Local information is inconsistent regarding sperm whale tendencies. Gregr and Trites (2001) reported that female sperm whales off British Columbia were relatively unaffected by the surrounding oceanography. However, Tynan et al. (2005) reported increased sperm whales densities with strong turbulence associated topographic features along the continental slope near Heceta Bank. Two noteworthy strandings in the region include an infamous incident (well publicized by the media) of attempts to dispose of a decomposed sperm whale carcass on an Oregon beach by using explosives. In addition, a mass stranding of 47 individuals in Oregon occurred during June 1979 (Norman et al. 2004; Rice et al. 1986).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6 to 12 individuals) versus the Pacific (25 to 30 individuals) (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. Another class of sound, "squeals," are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 μPa-m, although lower source level energy has been suggested at around 171 dB re: 1 μPa-m (Goold and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re: 1 μPa-m (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Whitehead and Weilgart 1991). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al. 2005; Miller et al. 2004). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Pavan et al. 2000; Weilgart and Whitehead 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and 1 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NMFS 2018b).

Natural Threats

Sperm whales are known to be occasionally predated upon by killer whales (Jefferson et al. 1991; Pitman et al. 2001) by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic Threats

Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959 to 1983). Other estimates have included 436,000 individuals killed between 1800 and 1987 (Carretta et al. 2005). However, all of these estimates are likely underestimates due to illegal killings and inaccurate reporting by Soviet whaling fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and there are 47 individual cases, probable and unconfirmed, involving collisions between sperm whales and vessels prior to 2008 (Van Waerebeek and Leaper 2008). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

Interactions between sperm whales and longline fisheries in the Gulf of Alaska have been reported since 1995 and are increasing in frequency (Hill and DeMaster 1998; Hill et al. 1999; Rice 1989). Sperm whales have been observed feeding off longline gear (for sablefish and halibut) at 38 surveyed stations (Angliss and Outlaw 2008). Sperm whales have removed an estimated 482 to 1,040 tons of sablefish from the fishery in the Gulf of Alaska from 2001 to 2014 (Peterson and Hanselman 2017). Sperm whales in Alaska may have learned that fishing vessel propeller cavitation (as gear is retrieved) are an indicator that longline gear with fish is present as a predation opportunity (Thode et al. 2007). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the Gulf of Alaska from the sablefish longline fishery (Angliss and Outlaw 2008). The estimated annual number of sperm whales seriously injured or killed from interactions with the California drift gillnet fishery from 2013 to 2017 is 0.4 (Carretta et al. 2020).

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, hexachlorobenzene (HCB), and hexachlorocyclohexanes (HCHs) in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 micrograms of chromium per gram (μg Cr/g) of tissue, with the mean (8.8 μg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals did not appear to accumulate chromium at higher levels.

Status and Trends

The sperm whale is endangered as a result of past commercial whaling. According to historical whaling records from five whaling stations in British Columbia, 6,158 sperm whales were killed between 1908 and 1967 (Gregr et al. 2000). Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, but continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

Critical Habitat

NMFS has not designated critical habitat for sperm whales.

Recovery Goals

See the 2010 Final Recovery Plan (NMFS 2010a) for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

6.2.5 Guadalupe Fur Seal

Guadalupe fur seals are medium-sized, sexually dimorphic otariids that are generally asocial with their conspecifics and other species (Belcher and T.E. Lee 2002; Reeves et al. 2002). Except for adult males, members of this species resemble California sea lions and northern fur seals. Distinguishing characteristics of the Guadalupe fur seal include the digits on their hind flippers (all of similar length), large, long foreflippers, unique vocalizations, and a characteristic behavior of floating vertically with their heads down in the water and their hind flippers exposed for cooling (Reeves et al. 2002).

Life History

Guadalupe fur seals prefer rocky habitats and can be found in natural recesses and caves (Fleischer 1978), using sheltered beaches and rocky platforms for breeding (Arias-del-Razo et al. 2016). Breeding occurs in June through August. Adult males return to the colonies in early June. Female Guadalupe fur seals arrive on beaches in June, with births occurring between mid-June to July (Pierson 1978); the pupping season is generally over by late July (Fleischer 1978). Breeding adult males are polygamous, and may mate with up to 12 females during a single breeding season. Females stay with pups for seven to eight days after parturition, and then alternate between foraging trips at sea and lactation on shore; nursing lasts about eight months (Figureroa-Carranza 1994). Guadalupe fur seals feed mainly on squid species (Esperon-Rodriguez and Gallo-Reynoso 2013); the Gulf of Ulloa on the Pacific side of the Baja California peninsula is an important feeding area (Aurioles-Gamboa and Szteren 2019). Based on a stable isotope analysis of male Guadalupe fur seal carcasses, there appears to be some niche segregation between coastal and oceanic males, possibly based on individual age and size (Aurioles-Gamboa and Szteren 2019). Foraging trips can last between four to 24 days (average of 14 days). Tracking data show that adult females spend 75 percent of their time at sea, and 25 percent at rest (Gallo-Reynoso et al. 1995).

Distribution

Guadalupe fur seals' historic range included the Gulf of Farallones, California to the Revillagigedo Islands, Mexico (Belcher and T.E. Lee 2002; Rick et al. 2009). Currently, they breed mainly on Guadalupe Island, Mexico, 155 miles off of the Pacific Coast of Baja California. A smaller breeding colony, discovered in 1997, appears to have been established at Isla Benito del Este, Baja California, Mexico (Belcher and T.E. Lee 2002) (Figure 29).

There are reports of individuals being sighted in the California Channel Islands, Farallone Islands, Monterey Bay, and other areas of coastal California and Mexico (Belcher and T.E. Lee 2002; Carretta et al. 2002; Reeves et al. 2002). A single female gave birth to a pup on the Channel Islands in 1997. In recent years, a small number of pups (less than 30 per year) have been born at San Benito Archipelago (reviewed in McCue et al. 2020). Guadalupe fur seals are known to travel great distances, with sightings occurring thousands of kilometers away from the main breeding colonies (Aurioles-Gamboa et al. 1999). Their presence along the U.S. west coast has increased; sightings have occurred from central Mexico to southern British Columbia, Canada and rarely in Alaska (reviewed in McCue et al. 2020).

The Guadalupe fur seal population is slowly recovering from the brink of extinction. The current population abundance is approximately 31,000 animals. Of all the fur seal species, this one is the least studied due to their limited geographic locations. The Guadalupe fur seal population does appear to be increasing annually.

Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa and Camacho-Rios 2007), but have occasionally been identified from strandings (Northwest Region Stranding Database; Wilkinson 2013) or in archaeological contexts as far north as northern California, Oregon, and Washington (Etnier 2002; Rick et al. 2009). As described in Section 7.4, Guadalupe fur seals have experienced multiple unusual mortality events (UMEs) since 1989, one of which is still ongoing.

In March 2020, 65 adult, juvenile, and weaned pup Guadalupe fur seals were tagged at Guadalupe Island in support of marine mammal monitoring efforts in Navy training and testing areas in the North Pacific. Around 61 to 100 percent of Guadalupe fur seal home ranges across age classes overlapped with PMSR, but there was less overlap with the continental slope region for non-pups, especially for juvenile females. Residence times were greatest for adult females (mean of 25 days) while those for juvenile males and females were similar (mean of 15 days). Average pup residence time in PMSR was eight days (Norris and Elorriaga-Verplancken 2020).

Given the increased number of strandings in the Pacific Northwest, coupled with their increasing population, it is possible that Guadalupe fur seals are returning to their historic pelagic migration range suggested by the archaeological findings (Etnier 2002; Lambourn et al. 2012; Rick et al. 2009).

Figure 29. Guadalupe fur seal historic range.

Occurrence in the PMSR action area

Adult and juvenile males have occasionally been observed at San Miguel Island, California since the mid-1960s, and in the late 1990s, a pup was born on the island. Rare sightings of individuals have also occurred at Santa Barbara, San Nicolas, and San Clemente Islands (Stewart 1981; Stewart and Yochem 1984; Stewart and Yochem n.d.; Stewart et al. 1993). Between 2006 and 2009 and again in 2012, a lone male established a territory on the south side of San Nicolas (National Marine Fisheries Service 2014; National Oceanic and Atmospheric Administration 2014). Additional NMFS surveys from 2016 to 2019 observed one adult female or young male Guadalupe fur seal on the southwestern side of San Nicolas in July 2019 (Lowry et al. 2021). In

NMFS aerial surveys between 2011 and 2015, Guadalupe fur seals were not observed on any of the Channel Islands other than at San Miguel Island (Lowry et al. 2017).

Guadalupe fur seals can be expected to occur in both deeper waters of the open ocean and coastal waters within the PMSR action area (Hanni et al. 1997; Jefferson et al. 2015; Norris 2017a; Norris 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, and along with satellite tags (n=26) placed on rehabilitated pups/yearlings that had stranded in California that were released from central California (Gallo-Reynoso et al. 2008; Norris 2017a; Norris 2017b; Norris et al. 2015). 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 2017b; Norris 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 kilometers of Guadalupe Island, only one of 10 satellite tagged males traveled north of Point Cabrillo, California (Norris 2017b). The recent sighting of a juvenile male Guadalupe fur seal in the Galapagos Islands (Páez-Rosas et al. 2020), is also consistent with the wide range of the species from the rookeries off Mexico.

Population Structure

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. Gallo-Reynoso (1994) calculated that the population of Guadalupe fur seals in Mexico from thirty years of population and counts and concluded the population was increasing; with an average annual growth rate of 13.3 percent on Guadalupe Island. The 2000 NMFS SAR for Guadalupe fur seals also indicated the breeding colonies in Mexico were increasing; and more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). From 1984 to 2013 at Guadalupe Island, the Guadalupe fur seal population increased at an average annual growth rate of 5.9 percent (range 4.1 to 7.7 percent) (García-Aguilar et al. 2018). Other estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997-2007) indicate that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). However, these estimates are considered too high, and likely result from immigration at Guadalupe Island (Carretta 2019). The estimated annual population growth rate is 5.9 percent (Carretta et al. 2020).

Abundance Estimate

It is difficult to obtain an accurate abundance estimate of Guadalupe fur seals due in part to their tendency to stay in caves and remain at sea for extended lengths of time, making them unavailable for counting. At the time of listing in 1985, the population was estimated at 1,600 individuals, compared to approximately 30,000 before hunting occurred in the 18th and 19th centuries. A population was "rediscovered" in 1928 with the capture of two males on Guadalupe Island; from 1949 on, researchers reported sighting Guadalupe fur seals at Isla Cedros (near the San Benito Archipelago), and Guadalupe Island (Bartholomew Jr. 1950; Peterson et al. 1968). In 1994, the population at Guadalupe Island was estimated at 7,408 individuals (Gallo-Reynoso 1994). There have been other, more recent population abundance estimates for Guadalupe Island, with a considerable amount of variation between them: 20,000 in 2010 (García-Capitanachi et al. 2017), and between 34,000 and 44,000 in 2013 (García-Aguilar et al. 2018). Guadalupe fur seals are also found on San Benito Island, likely immigrants from Guadalupe Island, as there are relatively few pups born on San Benito Island (Aurioles-Gamboa et al. 2010). There were an estimated 2,504 seals on San Benito Island in 2010 (García-Capitanachi et al. 2017). Based on information presented by (García-Aguilar et al. 2018), and using a population size to pup count ratio of 3.5, the minimum population estimate is 31,019 (Carretta et al. 2020).

Vocalization and Hearing

Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to several tens of kilohertz and it is believed that these sounds serve social functions such as mother-pup recognition and reproduction. Source levels for pinniped vocalizations range from approximately 95–190 dB re 1 μPa (Richardson et al. 1995c).

Underwater hearing in otariid seals is adapted to low frequency sound and less auditory bandwidth than phocid seals. Hearing in otariid seals has been tested in California sea lions (Kastak and Schusterman 1998) and northern fur seals (Babushina et al. 1991; Moore and Schusterman 1987). Based on these studies, Guadalupe fur seals would be expected to hear sounds within the ranges of 50 Hz–75 kHz in air and 50 Hz–50 kHz in water.

Natural Threats

Guadalupe fur seals are known to be preyed on by sharks and killer whales (Belcher and Lee 2002; Jefferson et al. 2008). White sharks are seasonally a common species around Guadalupe Island, but are primarily found off the northwest coast of the island and target elephant seals that use these areas more than Guadalupe fur seals (reviewed in McCue et al. 2021).

Novel, and possibly pathogenic, infectious diseases may be a future threat to Guadalupe fur seals. If there is increased interaction with other species at haulouts, Guadalupe fur seals may have increased exposure to interspecific diseases; diseases not currently found within their range.

Parasites (*Uncinaria* spp.) that cause mortality in large numbers of pups have been found in other species that inhabit this island, and may potentially be passed on to Guadalupe fur seals, although none have been reported. In addition, a parasite (*Parafilaroides decorus*) commonly found in California sea lions was documented for the first time in May 2015, in a male yearling Guadalupe fur seal that stranded in Santa Cruz, California. Guadalupe fur seals have been diagnosed with other parasites, including *Toxoplasma gondii*, *Sarcocystis neurona*, and gastronintestinal parasites. The most common gastrointestinal helminths were tapeworms, nematodes/ascarids, hookworms, and anthocephalans. The diatom genus *Pseudo-nitzschia* produces the neurotoxin domoic acid. While domoic acid intoxication is not well known in Guadalupe fur seals, domoic acid has been detected in market squid (*Loligo opalescens*) and Humboldt squid (*Dosidicus gigas*), two species Guadalupe fur seals prey upon (reviewed in McCue et al. 2021).

Anthropogenic Threats

Although a number of human activities may have contributed to the current status of this species, historic commercial hunting was likely the most devastating. Even with population surveys occurring on an irregular basis in subsequent years, these surveys provide evidence that the Guadalupe fur seal has been increasing after suffering such a significant decline. Although commercial hunting occurred in the past, and has since ceased, the effects of these types of exploitations persist today. Other human activities, such as entanglements from commercial fishing gear, are ongoing and continue to affect these species.

Status and Trends

Commercial sealers in the 19th century decimated the Guadalupe fur seal population, taking as many 8,300 fur seals from San Benito Island (Townsend 1924). Numbers on the total number of fur seals harvested are difficult to ascertain because of the difficulty the hunters had in distinguishing species while hunting (Seagars 1984). These harvests were devastating for the Guadalupe fur seal population, so much so that in 1892, only seven individuals were observed on Guadalupe Island, the location of one of the larger known breeding colonies (Bartholomew Jr. 1950); two years later, a commercial sealer took all 15 remaining individuals that could be found (Townsend 1899).

The species was presumed extinct, until 1926, when a small herd was found on Guadalupe Island by commercial fishermen, who later returned and killed all the seals they could find. In 1928, the Mexican government declared Guadalupe Island as a pinniped sanctuary. In 1954, during a survey of the island, Hubbs (1956) discovered at least 14 individuals. The government of Mexico banned the hunting of Guadalupe fur seals in 1967. Although population surveys occurred on an irregular basis in subsequent years, evidence shows that the Guadalupe fur seal population has been increasing ever since.

The Guadalupe fur seal clearly experienced a precipitous decline due to commercial exploitation, and may have undergone a population bottleneck. Bernardi et al. (1998) compared the genetic divergence in the nuclear fingerprint of samples taken from 29 Guadalupe fur seals, and found an average similarity of 0.59 of the DNA profiles. This average is typical of outbreeding populations. When comparing the amount of unique character fragments found in Guadalupe fur seals to that of other pinnipeds that have experienced bottlenecks (e.g., Hawaiian monk seals), that amount is much higher (0.14 vs. 0.05) in Guadalupe fur seals than Hawaiian monk seals. By using mitochondrial DNA sequence analysis in comparing the genetic diversity of Guadalupe fur seals to northern elephant seals (which did experience a severe bottleneck), Guadalupe fur seals had more haplotypes and a higher number of variable sites. The authors hypothesized that the numbers of Guadalupe fur seals left after harvest may have been underestimated, and the population may not have actually experienced a bottleneck, or the bottleneck may have been of short duration and not severe enough to suppress genetic diversity. Although the relatively high levels of genetic variability are encouraging, it is important to note that commercial harvest still influenced the population. Later studies comparing mt DNA found in the bones of pre-exploitation Guadalupe fur seals against the extant population showed a loss of genotypes, with twenty-five genotypes in pre-harvest fur seals, and seven present today (Weber et al. 2004).

The population has also been influenced by factors leading to strandings and unusual mortality events (see Section 7.4). Of the 169 documented strandings in Washington and Oregon from 2005 through 2016, 139 were yearlings. Strandings were highly seasonal, with most occurring in June consistently throughout the years examined. The three major causes of death could be categorized as emaciation, trauma (fishery-related, blunt force, bullet wounds, and shark attack), and infectious disease from coccidian parasites, including *Toxoplasma gondii* and *Sarcocystis neurona*. These increased strandings may be resulting from increased use of these coastal habitats by a population of Guadalupe fur seals that is reaching a healthy size (D'Agnese et al. 2020).

While some incidental breeding takes place on the San Benito Islands and the Channel Islands, the Guadalupe Island breeding colony supports the population (García-Aguilar et al. 2018). The current abundance of the Guadalupe fur seal represents about one-fifth of the estimated historical population size, and although the population has continued to increase, the species has not expanded its breeding range, potentially affecting its recovery (García-Aguilar et al. 2018). Because that over the last fifty years the population has been increasing since being severely depleted, we believe that the Guadalupe fur seal population is resilient to future perturbations.

Critical Habitat

NMFS has not designated critical habitat for Guadalupe fur seals.

Recovery Goals

NMFS has not prepared a Recovery Plan for Guadalupe fur seals.

6.2.6 Leatherback Sea Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 30). Because only leatherbacks originating from the Western Pacific nesting beaches may be found in the action area, this biological opinion will focus on the effects of the proposed action on the West Pacific population.

Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly.

Life History

Leatherback age at maturity has been difficult to ascertain, with estimates ranging from 5 to 29 years (Avens et al. 2009; Spotila et al. 1996). Females lay up to seven clutches per season, with more than 65 eggs per clutch and eggs weighing greater than eighty grams (Reina et al. 2002; Wallace et al. 2007). Leatherback sex determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell et al. 2005). A significant female bias has been reported in several leatherback populations (Binckley et al. 1998; James et al. 2007; Plotkin 1995). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh about 33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

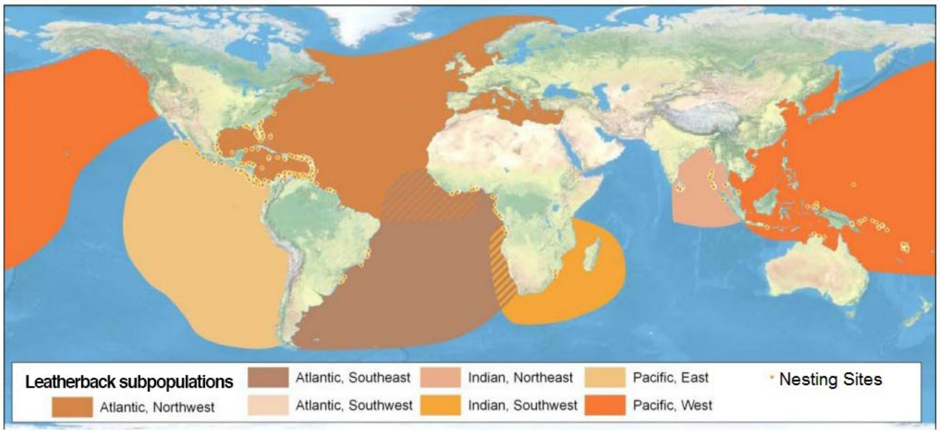

Figure 30. Map identifying the range of the endangered leatherback sea turtle. From NMFS http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.html, adapted from (Wallace et al. 2010).

Diving

The leatherback sea turtle is one of the deepest divers in the ocean, with dives as deep as 3,937 ft (1,200 m), although it spends most of its time feeding at a depth of less than 328 ft (100 m). Leatherback turtles primarily feed on gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas; (Bjorndal 1997; NMFS and USFWS 1998b). The leatherback dives continually and spends short periods of time on the surface between dives (Eckert et al. 1989; Southwood et al. 1999). Typical dive durations averaged 6.9 to 14.5 min per dive, with a maximum of 42 min (Eckert et al. 1996). Sea turtles typically remain submerged for several minutes to several hours depending upon their activity state (Standora et al. 1984). Long periods of submergence hamper detection and confound census efforts. During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 15 ft (5 m) of the surface (Eckert 2002).

Nesting Social Behavior

Male leatherbacks do not return to land after they hatch from their nests whereas mature females return to land only to lay eggs (Spotila 2004). Aside from this brief terrestrial period, which lasts approximately two to three months during egg incubation and hatching, leatherback turtles are rarely encountered out of the water. Hatchling leatherbacks are pelagic, but nothing is known about their distribution during the first 4 years of life (Musick and Limpus 1997).

Hearing

Sea turtles do not have an external ear pinnae or eardrum. Instead, they have a cutaneous layer and underlying subcutaneous fatty layer that function as a tympanic membrane. The subcutaneous fatty layer receives and transmits sounds to the middle ear and into the cavity of the inner ear (Ridgway et al. 1969). Sound also arrives by bone conduction through the skull.

Sound arriving at the inner ear via the columella (homologous to the mammalian stapes or stirrup) is transduced by the bones of the middle ear.

Sea turtle auditory sensitivity is not well studied, though a few preliminary investigations suggest that it is limited to low frequency bandwidths, such as the sounds of waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. It has been suggested that sea turtles may use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al. 1983).

Lenhardt et al. (1983) applied audio frequency vibrations at 250 Hz and 500 Hz to the heads of loggerheads and Kemp's ridleys submerged in salt water to observe their behavior, measure the attenuation of the vibrations, and assess any neural-evoked response. These stimuli (250 Hz, 500 Hz) were chosen as representative of the lowest sensitivity area of marine turtle hearing (Wever and Vernon 1956b). At the maximum upper limit of the vibratory delivery system, the sea turtles exhibited abrupt movements, slight retraction of the head, and extension of the limbs in the process of swimming. Lenhardt et al. (1983) concluded that bone-conducted hearing appears to be a reception mechanism for at least some of the sea turtle species, with the skull and shell acting as receiving surfaces. Sensitivity even within the optimal hearing range was low as threshold detection levels in water are relatively high at 160 to 200 dB re 1 μPa-m, which is the standard reference measure for underwater sound energy in this regard (Lenhardt et al. 1994). Piniak (2012) measured hearing of leatherback turtle hatchlings in water and in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kilohertz in air between 50 Hz and 1.2 kilohertz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 Hz).

Ridgway et al. (1969) used aerial and mechanical stimulation to measure the cochlea in three specimens of green turtle, and concluded that they have a useful hearing span of perhaps 60 to 1,000 Hz, but hear best from about 200 Hz up to 700 Hz, with their sensitivity falling off considerably below 200 Hz. The maximum sensitivity for one animal was at 300 Hz, and for another was at 400 Hz. At the 400 Hz frequency, the green turtle's hearing threshold was about 64 dB in air (approximately 126 dB in water). At 70 Hz, it was about 70 dB in air (approximately 132 dB in water). No audiometric data are available for the leatherback turtle, but based on other sea turtle hearing capabilities, they probably also hear best in the low frequencies.

For exposures to impulsive sound, a recent study on the effects of air guns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds (McCauley et al. 2000b). Loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km, with received levels of 166 dB re 1 μPa-m and 175 dB re 1 μPa, respectively (McCauley et al. 2000b). The sea turtles' response was consistent: above a level of about 166 dB re 1 μPa, the sea turtles noticeably increased their swimming activity. Above 175 dB re 1 μPa, their behavior became more erratic, possibly indicating that they were agitated (McCauley et al. 2000b).

Currently it is believed that the range of maximum sensitivity for sea turtles is 200 to 800 Hz, with an upper limit of about 2,000 Hz (Lenhardt 1994a; Moein et al. 1994). Green turtles are most sensitive to sounds between 200 and 700 Hz, with peak sensitivity at 300 to 400 Hz (Ridgway et al. 1969). They possess an overall hearing range of approximately 60 to 1,000 Hz (Ridgway et al. 1969). Juvenile loggerhead turtles hear sounds between 250 and 1,000 Hz and, therefore, often avoid low-frequency sounds (Bartol et al. 1999a). Finally, sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB re 1 µPa-m (Lenhardt 1994a). Given the lack of audiometric information for leatherback turtles, the potential for TTS among leatherback turtles must be classified as unknown but would likely follow those of other sea turtles. In terms of sound emission, nesting leatherback turtles produce sounds in the 300 to 500 Hz range (Mrosovsky 1972).

Distribution

Leatherback sea turtles are widely distributed throughout the oceans of the world. The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main regional areas may further be divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico, Nicaragua, and Costa Rica (eastern Pacific) and Indonesia, the Solomon Islands, and Papua New Guinea (western Pacific). Genetic studies have been used to identify two discrete leatherback populations in the Pacific Ocean (Dutton 2006): an eastern Pacific Ocean population, which nests between Mexico and Ecuador; and a western Pacific Ocean population, which nests in numerous countries, including Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu. The West Pacific DPS nests throughout four countries with a broad, diverse foraging range. It exhibits metapopulation dynamics and fine-scale population structure (NMFS and USFWS 2020).

Leatherback sea turtles have been documented in Alaska waters as far north as approximately 60º latitude and as far west in the Gulf of Alaska as the Aleutian Islands (Eckert 1993). In contrast with other sea turtles, leatherback sea turtles have physiological traits that allow for the conservation of body heat which enable them to maintain body core temperatures well above the ambient water temperatures (Eckert 1993; Greer et al. 1973; Pritchard 1971). Carapaces of adult leatherbacks are 4 centimeters (cm) thick on average, contributing to the leatherback's thermal tolerance that enables this species to forage in water temperatures far lower than the leatherback's core body temperature (Bostrom et al. 2010). In an analysis of available sightings (Eckert 2002), researchers found that leatherback turtles with carapace lengths smaller than 100 cm (39 in) were sighted only in waters 79 ºF or warmer, while adults were found in waters as cold as 32 ºF to 59 ºF off Newfoundland (Goff and Lien 1988). As a result, they are more capable of surviving for extended periods of time in cooler waters than the hard-shelled sea turtles (Bleakney 1965; Lazell Jr. 1980).

In the Pacific Ocean, leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific between 71° N and 47° S latitude and in all other major pelagic ocean habitats (NMFS and USFWS 1998b). Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Few quantitative data are available concerning the seasonality, abundance, or distribution of leatherbacks in the central northern Pacific Ocean. Satellite tracking studies and occasional incidental captures of the species in the Hawaii-based longline fishery indicate that deep ocean waters are the preferred habitats of leatherback turtles in the central Pacific Ocean (NMFS and USFWS 2007b). The primary migration corridors for leatherbacks are across the North Pacific Subtropical Gyre, with the eastward migration route possibly to the north of the westward migration.

New population modeling conducted by Gaspar and Lalire (2017) compare Pacific juvenile leatherback predicted distributions with passive dispersion (juvenile turtles drifting or following currents) and active dispersion, where juvenile turtles respond to habitat cues (e.g., water temperature) and actively swim to foraging grounds often counter to prevailing currents. This modeling effort suggests that oceanic currents broadly shape the dispersal area of leatherbacks within the North Central Pacific Basin, and habitat-driven movements strongly influence the spatial and temporal distribution of juveniles within this area. Specifically, these habitat-driven movements lead juveniles to gather in the North Pacific Transition Zone and to undertake seasonal north-south migrations. The modeling effort also suggest that juveniles in the North Pacific Transition Zone migrate westward, counter to prevailing currents, thereby increasing residence time. This likely exposes leatherbacks in the Pacific to increased risk of interactions with fisheries, in the central and eastern part of the North Pacific basin. Habitat-driven movements modeled by Gaspar and Lalire (2017) would also reduce the risk of cold-induced mortality. This risk appears to be larger among the juveniles that rapidly circulate into the Kuroshio Current than in other, more southern latitude currents.

Occurrence in the PMSR Action Area

Any leatherback sea turtles found within the PMSR action area would be from the Western Pacific population. Leatherback turtles of the West Pacific DPS nest in tropical and subtropical latitudes primarily in Indonesia, Papua New Guinea, and Solomon Islands, and to a lesser extent in Vanuatu. Leatherbacks from nesting beaches in the Indo-Pacific region have been tracked migrating thousands of km from nesting areas to summer foraging grounds off the coast of northern California (Benson et al. 2007). The waters off the Oregon and California coasts have been repeatedly recognized by scientists and agencies as comprising one of the most important leatherback foraging areas in the Pacific (NMFS and USFWS 1998b).

Leatherback turtles are regularly seen off the western coast of the United States. Stinson (1984) concluded that the leatherback was the most common sea turtle in U.S. waters north of Mexico. Aerial surveys off Washington, Oregon, and California indicate that most leatherbacks occur in waters over the continental slope, with a few over the continental shelf (Eckert 1993). Off the California coast, the highest densities of leatherback sea turtles were found off central California (Benson et al. 2007). Telemetry studies have shown areas of concentration along the central California coast and in the waters of Oregon and Washington (Benson et al. 2011). The data suggest that leatherback sea turtles are most likely to occur in the PMSR action area from April through June, during which time they migrate north to feeding grounds off central California. Although leatherback sea turtle distribution would be expected to shift based on what is known about their habitat preferences, based on the best available information the Navy applied an annual uniform density estimate (0.001 animals per km^2) for the PMSR action area for their quantitative acoustics effects model (see Section 2.3.1).

Leatherback sea turtles have been reported as bycatch in the California drift gillnet fishery. (Martin et al. 2015) estimated leatherback sea turtle bycatch in this fishery for the 20-year period 1990-2009, with a total bycatch range of 104–242 leatherbacks (52–153 estimated deaths). (Carretta 2021) estimated about 149 total leatherback sea turtles were incidentally captured in this fishery for the period 1990 through 2000. In both studies, estimated leatherback entanglements decline each year, reaching low levels after implementation of the Pacific Leatherback Conservation Area in 2001. From 2001 through 2018, (Carretta 2021) estimated a total leatherback bycatch of 16 turtles. While the area covered by the California drift gillnet fishery overlaps parts of the PMSR, the available information is too sparse for estimating abundance or density of leatherbacks within the PMSR action area. Additional information regarding the presence of leatherback sea turtles in the action area comes from satellite tracking studies as shown in Figure 31 and Figure 32 .

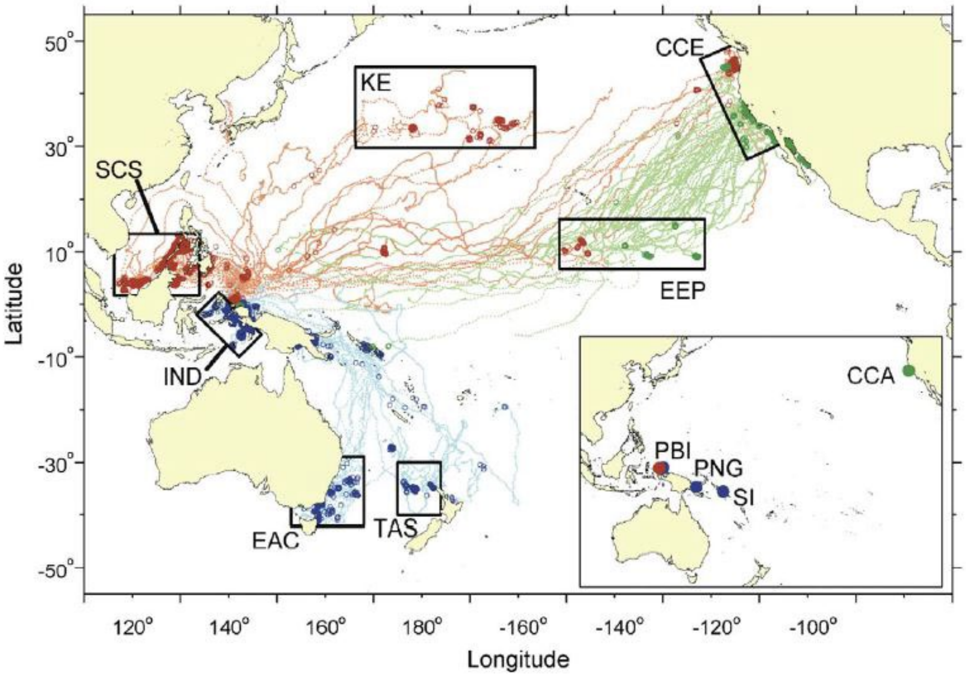

Figure 31. Migratory tracklines of satellite tagged Pacific leatherback sea turtles, including those terminating in the California Coastal Ecosystem (CCE) (Benson et al. 2011).

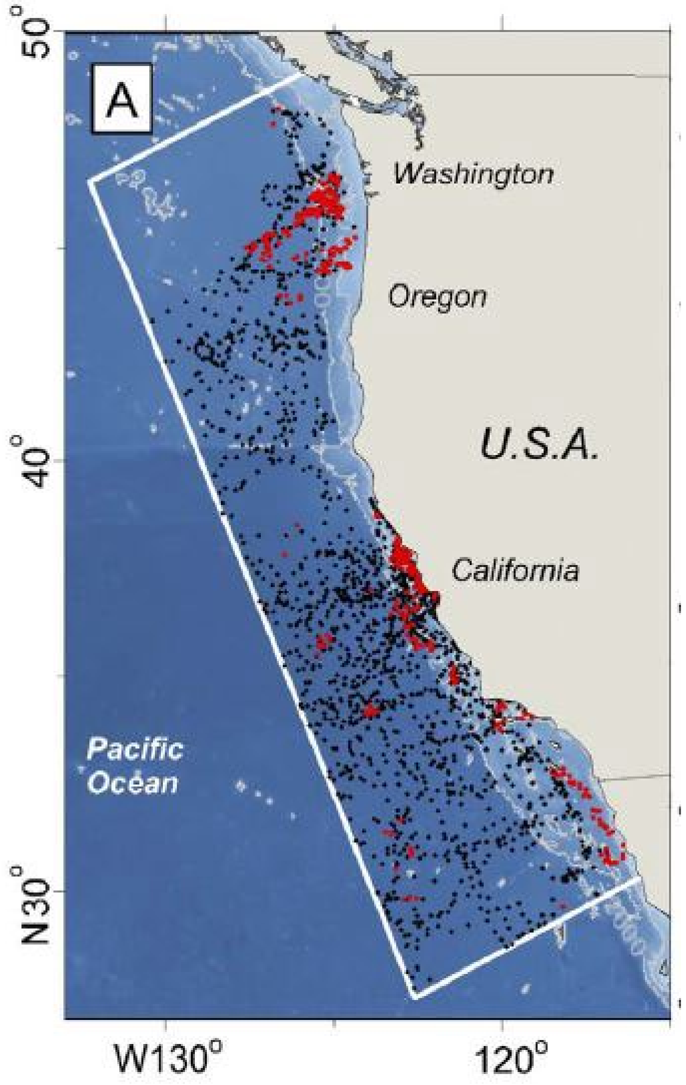

Figure 32. Leatherback sea turtle foraging behavior along the U.S. West coast, including within the PMSR. Red dots indicate area restricted search behavior, where leatherbacks restrict the extent of their movements once prey is encountered, and black dots indicate transit behavior (Benson et al. 2011).

Diversity

The West Pacific DPS exhibits genetic diversity, with six haplotypes identified in 106 samples from Solomon Islands, Papua Barat Indonesia, and Papua New Guinea (Dutton 2006). The population also exhibits temporal nesting diversity, with various proportions of the population nesting during different times of the year (summer versus winter) which helps to increase resilience to environmental impacts (NMFS and USFWS 2020). The foraging strategies are also diverse, with turtles using seven ecoregions of the Pacific Ocean (NMFS and USFWS 2020), which likely provide some resilience against local reductions in prey availability or catastrophic events, such as oil spills or typhoons, by limiting exposure to only a portion of the DPS (NMFS and USFWS 2020). Overall, diversity within the West Pacific DPS likely provides it with some resilience to threats (NMFS and USFWS 2020).

Abundance Estimate

There are no known nesting habitats for the leatherback sea turtle in the action area. There are 28 known nesting sites for the western Pacific Ocean stock ranging across the western tropical Pacific Ocean, from Australia and Melanesia (Papua New Guinea, Solomon Islands, Fiji, and Vanuatu) to Indonesia, Thailand, and China (Chaloupka et al. 2004; Chua 1988; Dutton 2006; Hirth et al. 1993; Suarez et al. 2000). The major nesting populations of the eastern Pacific Ocean stock occur in Mexico, Costa Rica, and Nicaragua (Chaloupka et al. 2004; Dutton et al. 1999; Eckert and Sarti 1997; Márquez 1990; Sarti M. 1996; Spotila et al. 1996), with the largest ones in Mexico and Costa Rica.

Using the best available data for the West Pacific leatherback population (Fitry Pakiding, University of Papua, pers. comm. 2020) and a Bayesian steady-state model, Martin et al. (2020) provided a median estimate of the total number of nesting females (i.e., over one remigration interval) at Jamursba Medi and Wermon beaches of 790 females, with a 95 percent credible interval of 666 to 942 females, as a snapshot of current abundance in 2017. We consider this to be the best available estimate of total adult female abundance at these two nesting beaches in 2017 (based on data from 2014 through 2017). To estimate the total number of nesting females from all nesting beaches in the West Pacific, we need to consider nesting at unmonitored and irregularly monitored beaches. As noted above, an estimated 50 to 75 percent of West Pacific leatherback nesting occurs at Jamursba-Medi and Wermon beaches (Dutton et al. 2007; NMFS and USFWS 2020). Applying the conservative estimate of 75 percent to the Martin et al. (2020) estimate of 790 nesting females at Jamursba Medi and Wermon beaches, the total number of nesting females in the West Pacific population would be 1,054 females with an overall 95 percent credible interval of 888 to 1,256 females. It should be noted that this estimate (i.e., 1,054) of nesting females for the West Pacific population based on more recent available information is an update of the NMFS and USFWS (2020) estimate (i.e., 1,277) which was based on a simple calculation that did not provide confidence or credible intervals.

Based on the estimates presented in Jones et al. (2012) for all Pacific populations, NMFS inferred an estimated West Pacific leatherback total population size (i.e., juveniles and adults) of 250,000 (95 percent confidence interval 97,000 to 535,000) for 2004. Based on the relative change in the estimates derived from Jones et al. (2012) and the more recent Martin et al. (2020), we estimate the current juvenile and adult population size of the West Pacific leatherback population is around 100,000 sea turtles (95 percent confidence interval 47,000 to 195,000 individuals).

Status and Trends

Leatherback sea turtles are endangered by several human activities, including fisheries interactions, entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris (Chaloupka et al. 2004; Eckert and Sarti 1997; Sarti M. 1996). The primary threat to the West Pacific DPS is the legal and illegal harvest of leatherback turtles and their eggs (NMFS and USFWS 2020).

The relatively low index of nesting female abundance of the West Pacific DPS places it at elevated risk for environmental variation, genetic complications, demographic stochasticity, negative ecological feedback, and catastrophes (NMFS and USFWS 2020). These processes, working alone or in concert, place small populations at a greater extinction risk than large populations, which are better able to absorb impacts to habitat or losses in individuals (NMFS and USFWS 2020). Low site fidelity and dispersal of nests among various beaches may help to reduce population level impacts from threats which may disproportionately affect one area over another. However, due to its small size, the DPS has restricted capacity to buffer such losses (NMFS and USFWS 2020). The median trend in annual nest counts estimated for Jamursba Medi (data collected from 2001 to 2017) was −5.7 percent annually (NMFS and USFWS 2020). For Wermon (data collected from 2006 to 2017, excluding 2013–2015 due to low or insufficient effort), the median trend was −2.3 percent annually (NMFS and USFWS 2020).

With low abundance estimates in all four countries where the species nests in the Western Pacific, and the two countries in the Eastern Pacific, leatherback sea turtles are at an extremely high risk of being extirpated from the Pacific Ocean. While leatherback abundance estimates are higher for other portions of its global range (e.g., Northwest Atlantic), all seven leatherback populations are currently at a high risk of extinction (NMFS and USFWS 2020). Extirpation of Pacific leatherbacks would significantly contract the species' range, thus increasing the already high risk of extinction for the globally-listed entity.

Critical Habitat

See Section 6.1.12.

Recovery Goals

See the U.S. Pacific Recovery Plan (NMFS and USFWS 1998a) for leatherback sea turtles for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan (NOAA 2016):

- Reduce fisheries interactions
- Improve nesting beach protection and increase reproductive output
- International cooperation
- Monitoring and research

- Public engagement

7 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02; 84 FR 44976 published August 27, 2019). The following information summarizes the principal natural and human-caused phenomena in the PMSR action area believed to affect the survival and recovery of ESA-listed species (from Section 6.2 above) in the action area.

7.1 Global Climate Change

There is a large and growing body of literature on past, present, and anticipated future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur in the action area as the result of climate change. We address climate change as it has affected ESA-listed species and continues to affect species, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited to our cumulative effects analysis (Section 9), it is discussed here to provide a comprehensive analysis of the effects of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats both within and outside of the action area.

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered. A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP4.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7°C under RCP2.6, 1.1 to 2.6°C under RCP 4.5, 1.4 to 3.1°C under RCP6.0, and 2.6 to 4.8°C under RCP8.5 with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014). The Paris Agreement aims to limit the future rise in global average temperature to 2°C, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018). As there remains a fair amount of uncertainty regarding the implementation of mitigation measures with the goal of curbing pollutants contributing to global climate change, our ESA analyses are conducted under the status quo conditions outlined in RCP8.5.

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al. 2018). The IPCC Special Report on the Impacts of Global Warming (2018) (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (Allen et al. 2018). Average global warming up to 1.5°C as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (Allen et al. 2018).

Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of 11 to 16 percent per decade (Jay et al. 2018). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014).

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Evans and Bjørge 2013; IPCC 2014; Kintisch 2006; Learmonth et al. 2006; MacLeod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Becker et al. 2018; Silber et al. 2017; Simmonds and Isaac 2007), recent research has indicated a range of consequences already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007a; NMFS and USFWS 2007c; NMFS and USFWS 2013a; NMFS and USFWS 2013b; NMFS and USFWS 2015). These impacts will be exacerbated by sea level rise. The loss of leatherback nesting habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. According to Holsman et al. (2019), in the North Pacific, some fish and crab species in the Bering Sea may move into northern Bering Sea waters where fishing is more limited. As a result, small boat fisheries and shore-based subsistence and recreational fishers in this region are likely vulnerable to climate change. Modeling conducted by Woodworth-Jefcoats et al. (2017) showed that increasing temperatures under RCP8.5 may alter the spatial distribution of tuna and billfish species richness across the North Pacific. The models also projected that zooplankton densities would decline across this region. Such declines would be amplified relative to declines in phytoplankton densities. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. McMahon and Hays (2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. MacLeod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction).

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990). Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

Hazen et al. (2012) predicted up to 35 percent change in core habitat for some key Pacific species based on climate change scenarios predicated on the rise in average sea surface temperature by 2100. Climate-mediated changes in the distribution and abundance of keystone prey species like krill and in cephalopod populations worldwide will likely affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1990); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales. Sperm whales, whose diets can be dominated by cephalopods, would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well.

7.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events and the Pacific decadal oscillation, and the North Atlantic oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action area (Beamish 1993; Benson and Trites 2002; Hare and Mantua 2001; Mantua et al. 1997; Mundy 2005; Mundy and Cooney 2005; Stabeno et al. 2004).

In the Northeast Pacific (including the entire action area) a record-breaking marine heatwave known as the "blob" occurred from 2013 to 2015. This warm water region was located along the west coast of North America and spread as far south as the Baja California Peninsula, where water temperatures were as much as four degrees C higher than normal at depths from zero to 300 m. This warm water region was accompanied by a strong El Niño event from 2015 to 2016. Data collected from scat and lanugo samples from 2013 to 2016 suggested that Guadalupe fur seals shifted their foraging areas further north and/or offshore during this timeframe, possibly as far north as northern California (Amador-Capitanachi et al. 2020). This northward shift may have resulted from decreased prey availability in more southern latitudes where increases in water temperature were more pronounced (Amador-Capitanachi et al. 2020). Gálvez et al. (2020) examined the effect of the 2013-2015 warm water anomaly in the northeast Pacific Ocean on weight gain in neonate Guadalupe fur seals off the coast of the Baja California Peninsula, Mexico. Lowest birth weights and slowest weight gains were observed in 2014 while low weights and lowest survival rate were observed in 2015, all of which were likely due to the warm water anomaly (Gálvez et al. 2020). More recent heatwaves in the Northeast Pacific in 2019 and 2020 have raised concerns that an event similar to the "blob" will reappear (Laufkötter et al. 2020).

Studies suggest that periods of what was once considered "anomalous" warm water conditions are occurring more frequently. The current rate of increase in oceanic and atmospheric heat content has increased the frequency and duration of marine heatwaves, or "prolonged discrete anomalously warm water events" (Hobday et al. 2016); a trend that is expected to continue (Oliver et al. 2018) in conjunction with changes in the strength, direction, and variability of major ocean currents (Hoegh-Guldberg and Bruno 2010). On a global scale, the occurrence probabilities of the duration, intensity, and cumulative intensity of most documented, large, and impactful marine heatwaves have increased more than 20-fold as a result of anthropogenic climate change (Laufkötter et al. 2020).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Childers et al. 2005; Hare et al. 1999). Sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. Cartwright et al. (2019) observed a 73 percent decrease in sightings of mother-calf pairs of humpback whales belonging to the Hawaii DPS between 2013 and 2018 during a positive shift in the Pacific decadal oscillation. This coincided with a buildup of warm water in the central, north, and eastern Pacific, which may have suppressed coastal upwelling and productivity, and therefore the availability of humpback whale prey, in these regions. However, more research needs to be done to determine what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder or warmer decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

The California Current Large Marine Ecosystem (CCLME) is a productive coastal upwelling ecosystem, where wind-driven upwelling brings enriched cool water to the surface that supports a diverse array of species and sustains important fisheries (Santora et al. 2020). During 2014–2016, a marine heatwave occurred in the North Pacific that resulted in an unprecedented multi-year warming event. The impacts of the marine heatwave were wide ranging, but notably caused a sustained bloom of toxic *Pseudo-nitzschia* diatoms that led to the persistence of domoic acid (a neurotoxin impacting marine wildlife; e.g., shellfish poisoning, record changes in biodiversity of pelagic species, and an unprecedented delay in the opening of the commercial Dungeness crab (*Metacarcinus magister*) fishery in California (a fixed-gear trap fishery with vertical lines; (Santora et al. 2020). The marine heatwave resulted not only in significant economic loss to fishing communities as a result of closures of shellfish and some finfish fisheries, but also coincided with an alarming rise in whale entanglements, mainly humpback whales (see Section 7.4.1 *Fishing Gear Interactions* below). An evaluation of the regional distribution and spatial intensity of krill (measured by acoustics) and midwater trawl catches of anchovy indicates changes in the availability of prey used by humpback whales preceding and during the marine heatwave (Santora et al. 2020). Humpback whales are flexible foragers that perform rapid distribution changes in response to prey abundance and aggregation intensity, and switch from feeding on krill to schooling fish (Santora et al. 2020). Findings by Santora et al. (2020) suggest that changes in humpback whale distribution and movements (shifts from onshore to offshore feeding), triggered by changes in prey type and availability caused by the marine heatwave, resulted in an increased vulnerability of humpbacks to fishing gear entanglement. The authors conclude that ecosystem shifts and forage availability are a plausible, although unconfirmed, explanation for the increased entanglements during the Pacific marine heatwave, in conjunction with the delayed fishing season.

7.3 Whaling

Population numbers of large whales in the action area have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the IWC's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the ESA of 1966. For example, from 1900 to 1965, nearly 30,000 humpback whales were captured and killed in the Pacific Ocean with an unknown number of additional animals captured and killed before 1900 (Perry et al. 1999). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910 and 1965 (Ohsumi and Wada. 1972); 46,000 fin whales between 1947 and 1987 (Rice 1984); and 25,800 sperm whales (Barlow et al. 1997).

7.4 Unusual Mortality Events

Under the MMPA, a UME is defined as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." In the past, an UME was declared for fin and humpback whales in the Pacific Ocean and Gulf of Alaska, from April 23, 2015 to April 16, 2016, where a total of 46 fin and humpback whales were found dead (NMFS 2019a). A primary cause for the UME was not identified but ecological factors, including El Niño (see Section 7.2), were likely contributors (NMFS 2019a).

Between 1989 and 2011, a total of 118 dead stranded animals were found along the Washington and Oregon coastline (Northwest Region Stranding Database; Wilkinson 2013). Between June 20 and November 1, 2007, 19 Guadalupe fur seals stranded on the Washington and Oregon outer coasts, prompting NOAA to declare an UME on October 19, 2007 (Lambourn et al. 2012). The UME was officially closed on December 11, 2009. In 2012, approximately 58 Guadalupe fur seals stranded on the outer coasts of Washington and Oregon (Lambourn 2013 pers. comm.). This is three times the number of strandings that prompted the UME in 2007. Of all the strandings reported off Washington and Oregon (1989 to 2012), most occurred from mid-May through August with occasional reports between October and December (Northwest Region Stranding Database; Lambourn et al. 2012; Wilkinson 2013).

An UME was declared for Guadalupe fur seals beginning in January 2015, and continuing to 2021 (NMFS 2021a). The UME was declared due to the increased stranding of Guadalupe fur seals in California, and was expanded to include Oregon and Washington due to the elevated number of strandings there. Strandings began in California in January 2015, were eight times higher than the historical average, and continued to remain well above average through 2019 (Figure 33; (NMFS 2021a)). Strandings in Oregon and Washington have been well above typical numbers since 2015 (Figure 34); strandings in these two states were five times higher than the historical average in 2019 (NMFS 2021a). Guadalupe fur seal strandings generally peak in April through June each year. Stranded individuals were mostly weaned pups and juveniles, aged one to two years old. Most stranded individuals showed signs of malnutrition and had secondary bacterial and parasitic infections. As this UME is currently on-going, we expect Guadalupe fur seals to continue to be impacted.

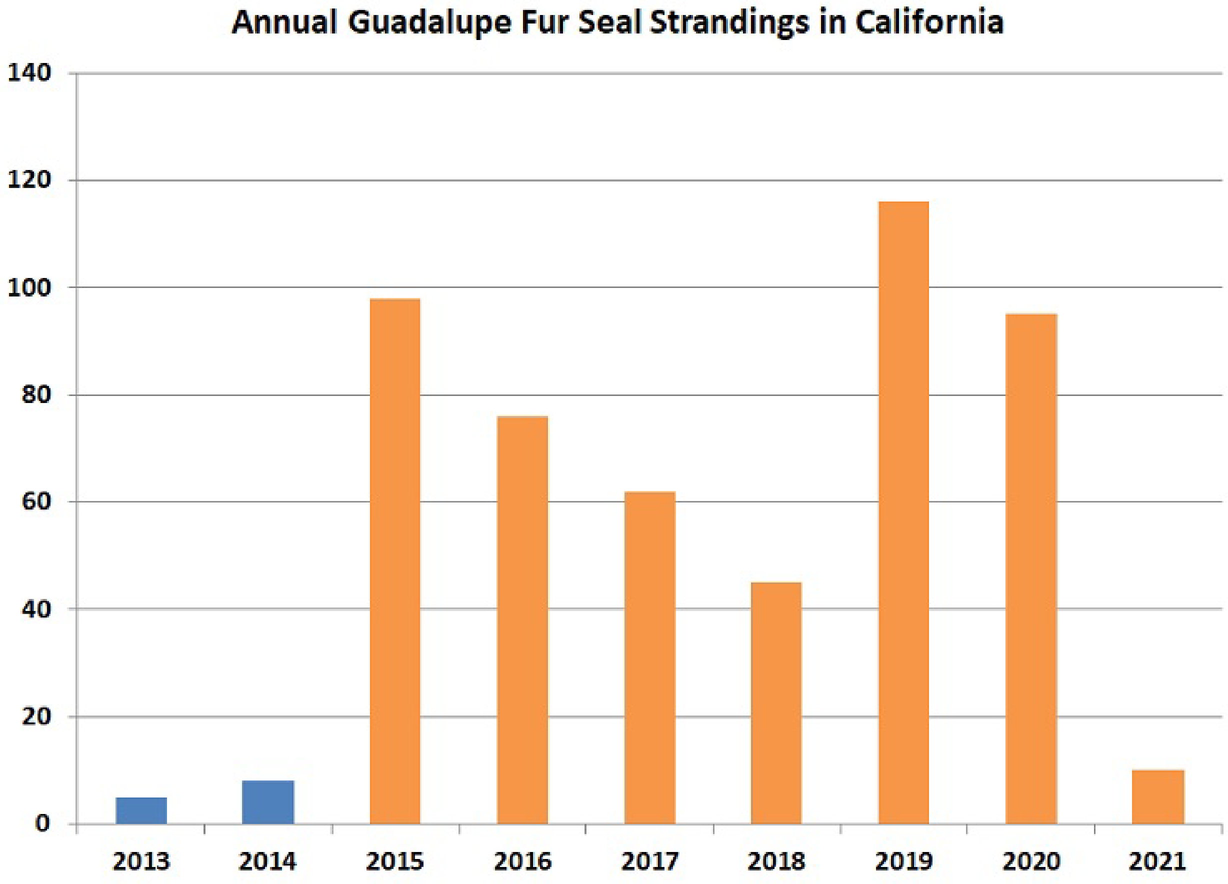

Figure 33. Guadalupe fur seal annual strandings in California, 2013 to present. Orange bars indicate unusual mortality event years (NMFS 2021a).

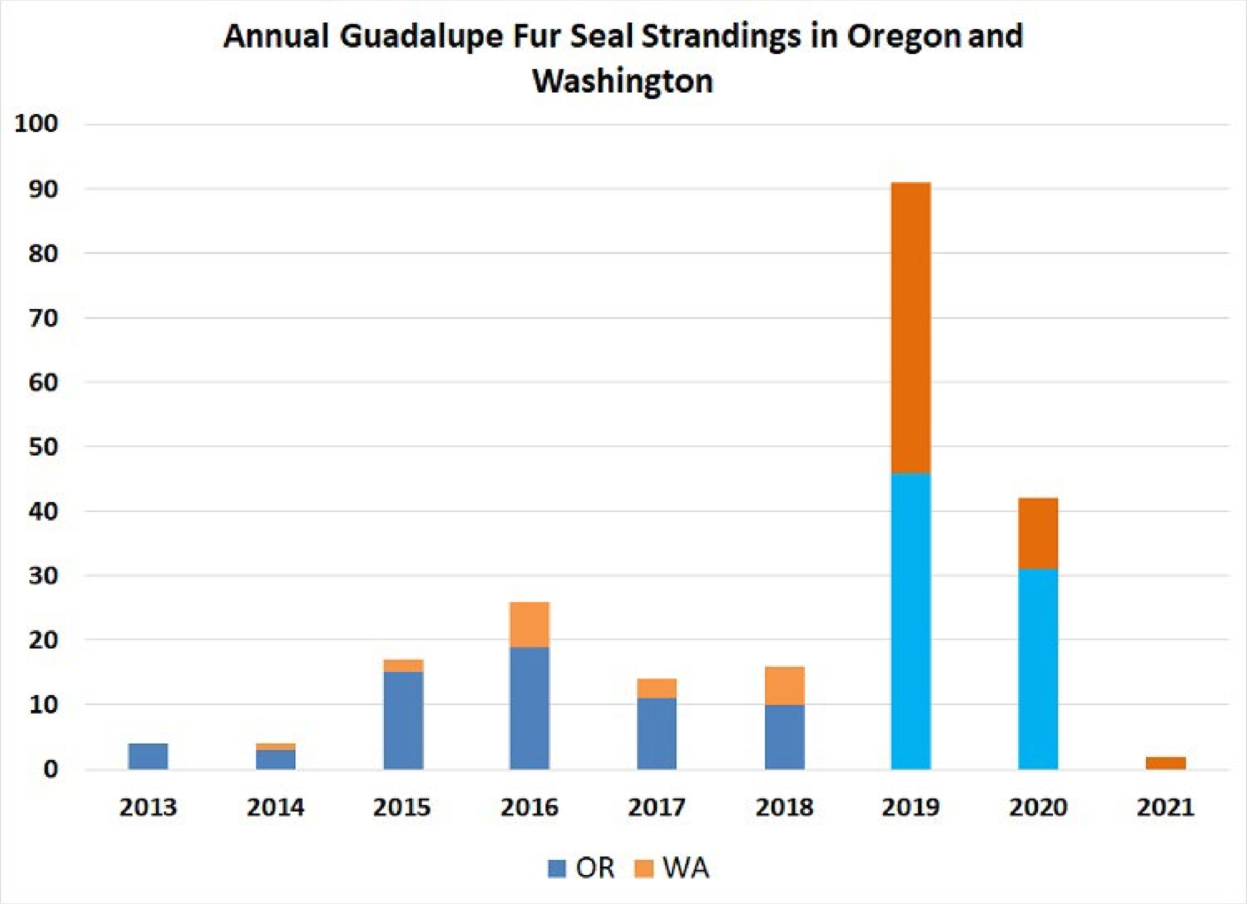

Figure 34. Guadalupe fur seal annual strandings in Oregon and Washington, 2013 to present. Blue/light blue – Oregon; Beige/orange – Washington (NMFS 2021a).

7.5 Fisheries Bycatch and Gear Interactions

In this section we address the impacts to ESA-listed sea turtles and marine mammals in the action area from fisheries bycatch and interactions with commercial fishing gear.

7.5.1 Fisheries Bycatch and Entanglement of Sea Turtles

Fisheries bycatch mortality represents a primary threat to sea turtles. Spotila et al. (1996) and Eckert et al. (2007) noted that adult mortality rates increased significantly as a result of driftnet and longline fisheries. Spotila (2004) concluded that a conservative estimate of annual leatherback fishery-related mortalities (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s is 1,500 animals. He estimated that this represented about a 23 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). In the Pacific Ocean, between 1,000 and 1,300 leatherback sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004).

From 1990 to 2009, there were 24 observed leatherback turtle interactions in the California drift gillnet fishery based on 15.6 percent per year observer coverage (Martin et al. 2015 as cited in NMFS and USFWS 2020). In 2001, NMFS implemented regulations (i.e., a large time/area closure in Central California) that reduced interactions by approximately 80 to 90 percent, with only two leatherback turtle interactions (both alive) observed based on 20 to 30 percent observer coverage since regulations were implemented (NMFS and USFWS 2020). Drift gillnet fishing is prohibited annually from August 15 to November 15 within the California leatherback turtle conservation area. Currently, NMFS anticipates up to 10 interactions (or 7 mortalities) over a 5-year period (NMFS and USFWS 2020). All Pacific U.S. commercial fishing vessels are required to have specific equipment on board to release incidentally captured sea turtles, and fishermen and observers are trained on safe handling and release procedures.

Leatherback sea turtles have been documented historically entangled in large mesh drift gillnet fishery gear targeting swordfish and thresher sharks from central Oregon to central California, although the number of entanglements decreased significantly when a large time/area closure was put in place on the fishery in 2001 (Eguchi et al. 2017). Leatherbacks have also been documented entangled in pot and trap fisheries gear. One leatherback sea turtle was confirmed entangled in California fixed fishing gear in 2019.

7.5.2 Entanglement of Marine Mammals in Fishing Gear

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007); in an extensive analysis of global risks to marine mammals, incidental catch was identified as the most common threat category (Avila 2018). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of cetaceans that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities. Figure 35 shows the number of confirmed whale entanglements per year detected off the U.S. west coast from 1982 to 2017 (Saez et al. 2021). Most west coast entanglements were reported off the coast of California. The number of confirmed whale entanglements, most notably humpback whales, increased markedly throughout the 2014-2016 Pacific marine heat wave event (see Section 7.2 for discussion of Pacific marine heatwave). Dungeness crab fishing gear is the most common source of entanglements in recent years (of those that could be identified to a specific fishery). A total of 26 whales were confirmed entangled off the coasts of Washington, Oregon, and California in 2019, 17 of which were humpbacks (NOAA 2020). By comparison, there were 34 confirmed humpback whale entanglements in 2018 and 19 in 2017 (NOAA 2020).

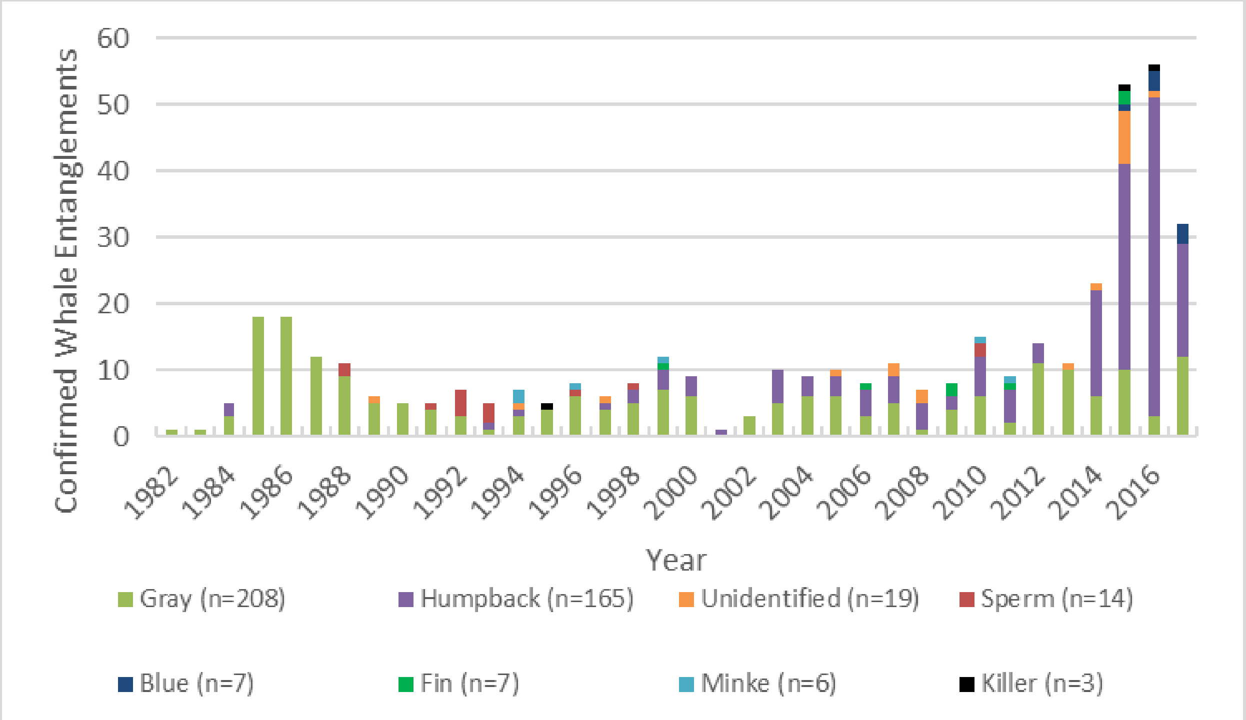

Figure 35. Confirmed whale entanglement reports by year, by whale species; 1982-2017 (n=429). Each bar represents the reporting year, color coded sections on the bar represent the number of reports by whale species for that year (Saez et al. 2021).

Cetaceans are also known to ingest fishing gear, likely mistaking it for prey, which can lead to fitness consequences and mortality. Necropsies of stranded whales, including two sperm whales that stranded in northern California in 2008, have found that ingestion of net pieces, ropes, and other fishing debris has resulted in gastric impaction and ultimately death (Jacobsen et al. 2010).

7.6 Aquaculture

Aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic and noise, impacts to habitat and benthic organisms, and water quality (Clement 2013; Lloyd 2003; Price et al. 2017; Price and Morris 2013). Current data suggest that interactions and entanglements of ESA-listed marine mammals with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk of ESA-listed marine mammals. Nonetheless, given that in some aquaculture gear, such as that used in longline mussel farming, is similar to gear used in commercial fisheries, aquaculture may have impacts similar to fisheries and bycatch. There are very few reports of marine mammal interactions with aquaculture gear, although it is not always possible to determine if the gear animals become entangled in are from aquaculture or commercial fisheries (Price et al. 2017). Also, some aquaculture gear has the potential for behavioral effects on marine mammals based on a study of bottlenose dolphins around fish cages in Italy (reviewed in Callier et al. 2018). Aquaculture gear may also block migration routes (MPI 2013) or at least cause animals to have to circumnavigate the aquaculture gear, as is the case with bottlenose and Dusky dolphins (*Lagenorhynchus obscurus*) avoiding areas with mussel culture longlines (reviewed in Callier et al. 2018; MPI 2013).

An Aquaculture Opportunity Area, defined as a geographic area that has been evaluated for its potential for sustainable commercial aquaculture, is being considered in waters off southern California under the May 2020 Executive Order on Promoting American Seafood Competitiveness and Economic Growth (85 FR 28471). Such an area would be expected to support multiple aquaculture farm sites, including finfish, shellfish, and/or seaweed (NMFS 2020d). The first commercial-scale offshore aquaculture project in U.S. federal waters has been proposed 7.2 kilometers (4.5 statute miles) west of Mission Bay in San Diego, California. Submersible sea cages would be deployed and the project could have potential impacts on marine biological resources and water quality. Mitigation would include the use of proper mesh size netting and the construction of the facilities away from known seal and sea lion haulout areas to minimize marine mammal interactions (U.S. Navy 2022).

7.7 Vessel Strike

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. Allen et al. (2012) recorded the noises from 24 ships ranging in length from 10.4 m to 294.1 m at hydrophone depths of 5, 15, and 25 m and calculated source levels to characterize the three-dimensional acoustic environment a mysticete would encounter during a whale/ship approach. Results indicated that mysticetes near the sea surface may experience greater difficulty localizing oncoming ships than in deeper waters as a combined result of lower source levels at the surface in shallow locations, bow null effect acoustic shadow zones, and masking from ambient noise. As a consequence, the range of detection for a ship may be too close for a mysticete to execute a successful avoidance maneuver.

Commercial vessel strikes to whales is a concern in the waters off Southern California (Calambokidis et al. 2019; Carretta et al. 2019a; Keen et al. 2019a; Keen et al. 2019b; Moore et al. 2018; National Marine Fisheries Service 2019c; Redfern et al. 2017; Rockwood et al. 2017). Reviews of the literature on vessel strikes mainly involve collisions between commercial vessels and whales (Cascadia Research 2017; Currie et al. 2017; Douglas et al. 2008; Jensen and Silber 2004; Laist et al. 2001; Lammers et al. 2013; Monnahan et al. 2015; Nichol et al. 2017; Redfern et al. 2019; Rockwood et al. 2017). While some risk of a vessel strike exists for all the U.S. West Coast waters, 74 percent of blue whale, 82 percent of humpback whale, and 65 percent of fin whale known vessel strike mortalities occur in the shipping lanes associated with the ports of San Francisco and Los Angeles/Long Beach, according to modeling estimates (Rockwood et al. 2017).

Because some marine mammals within the PMSR may seasonally migrate, threats to the population in those other waters are relevant. Within Alaska waters, there were 28 reported marine mammal vessel strikes between 2013 and 2017 (Helker et al. 2019), and for the U.S. West Coast in the same period there were 65 reported vessel strikes to marine mammals

(Carretta et al. 2019b), which is an approximate average consistent with previous reporting periods (Carretta et al. 2018; Carretta et al. 2017a; Carretta et al. 2016a; Helker et al. 2015; Helker et al. 2017). Strandings in Washington between 1980 and 2006 included 19 stranded large whales with signs of blunt force trauma or propeller wounds indicative of a vessel strike and involving fin, grey, blue, humpback, sei, and Baird's beaked whales (Douglas et al. 2008). Since 2002, 10 out of the 12 stranded fin whales in Washington showed evidence attributed to a large ship strike (Cascadia Research 2017). There were 14 known vessel strikes in 2018 off California and 11 strikes (as of June 2) in 2019 (National Marine Fisheries Service 2019a). A total of 151 vessel strikes have been recorded off the U.S. West Coast from 1986 to 2020 (P. Ruvelas, NMFS WCR, pers. comm., NMHS HQ, July, 9, 2021).

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow 1997). More recently, Berman-Kowalewski et al. (2010) reported that between 1988 and 2007, 21 blue whale deaths were reported along the California coast, typically one or two cases annually. In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987).

From the Marine Mammal Health and Stranding Response Program database, the number of confirmed vessel collisions with ESA-listed species in Oregon and Washington from 2000-2018 are: three sperm whale, three humpback whales, and ten fin whales. The number of confirmed vessel collisions with ESA-listed species in California from 1986-2020 is shown in Figure 36. Since only a portion of southern California is included in the PMSR action area, not all of the vessel collisions shown in Figure 36 occurred within the action area.

Many strikes may occur and go unnoticed, while others may occur and subsequently not get reported. Carcass recovery rates have been estimated for various cetacean species including a rate of 3.4 percent for sperm whales. In modelling ship strike mortality for three baleen whales species off the coast of California, Rockwood et al. (2017) used a high recovery rate of 17 percent based on right whales to produce minimum strike estimates and a five percent recovery (the mean of grey, killer and sperm whales) as a best estimate. The higher rate for right whales is based on them being a more buoyant species (Rockwood et al. 2017).

Regarding non-commercial vessel strikes, two confirmed fin whale strikes from an Australian naval vessel resulting in mortality occurred off southern California in May 2021. The two carcasses had become lodged on the hull of the vessel and were dislodged when the vessel pulled into a pier in San Diego, California (Associated Press 2021). Two additional large whale strikes from U.S. Navy vessels occurred off southern California in June and July 2021.

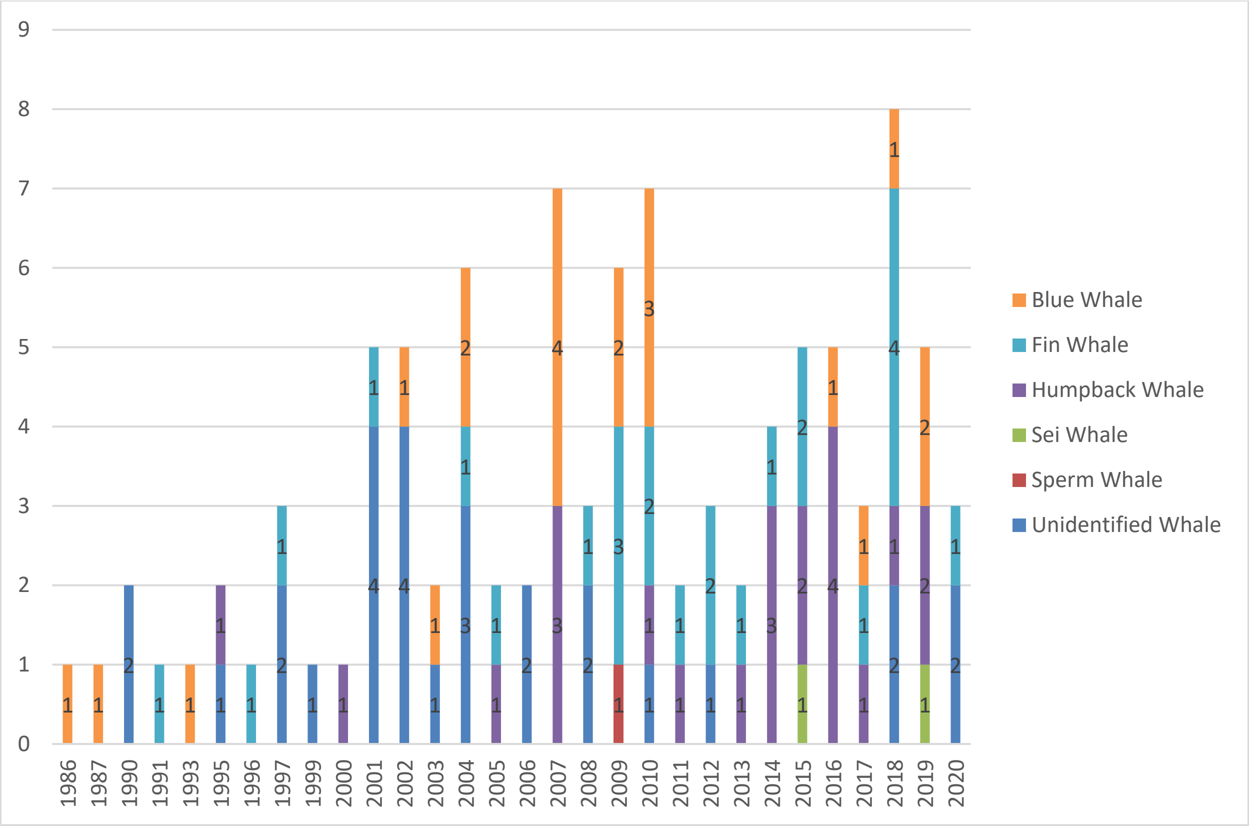

Figure 36. Number of confirmed vessel collisions with ESA-listed species in California from 1986-2020.

7.8 Water Quality Degradation

Within the PMSR, water quality in the nearshore areas is strongly affected by human activities in heavily developed Central and Southern California. Urban runoff is the largest source of contaminants along this portion of the California coast and can transport bacteria, inorganic nutrients, various organic compounds, metals, and debris into downstream or adjacent water bodies. Nonpoint source runoff is substantial in Southern California, because most rivers are highly modified stormwater conveyance systems that are not connected to sewage treatment systems. When storm events occur, runoff plumes can become large oceanographic features that extend for many miles (Center for Ocean Solutions 2009). Along the Southern California coast, land-based chemical pollution, in particular PCBs and DDT, affects water quality. Another potential source of water pollution offshore comes from the oil and gas development industry and natural crude seeps. As activity increases from offshore oil and gas development, the potential for discharge into the action area also increases (U.S. Department of the Navy, 2016). In recent years, the increased frequency and extent of regional beach and shellfish-bed closures, coupled with decreases in local fishing catches, are taken as signs of declining water quality (U.S. Department of Commerce et al., 2008).

Commercial, recreational, and research vessels also discharge water pollutants along the Southern California coast. Shipboard waste-handling procedures, the Uniform National

Discharge Standards, governing the discharge of nonhazardous waste streams have been established for commercial and Navy vessels. The U.S. Navy's Environmental Readiness Program Manual (Chief of Naval Operations Instruction M-5090.1) applies to U.S. Navy ships and floating drydocks worldwide and, as appropriate, to the boats and other craft carried by these ships (U.S. Department of the Navy, 2007). This manual provides the Navy policy for environmental stewardship and compliance for its vessels operating both within U.S. waters and abroad. The discharge of waste, including blackwater (sewage), graywater (water from deck drains, showers, dishwashers, laundries, etc.), hazardous and medical wastes, plastics and other trash, as well as procedures for oil spill response and ballast water control are described.

7.9 Oil Spills

Exposure to petroleum hydrocarbons released into the marine environment via oil spills and other discharge sources represents a serious potential health risk for ESA-listed species. Figure 37 shows the locations of the multiple sources and vectors through which crude oil can accidentally enter the marine and estuarine environment along the Pacific Coast. Figure 38 shows the locations of reported marine oil spill incidents on the coast of California from 2004 to 2020. Polycyclic aromatic hydrocarbons, a component of oil (crude and refined) and motor exhaust, are a group of compounds known to be carcinogenic and mutagenic (Pashin and Bakhitova 1979). Exposure can occur through five known pathways: contact, adhesion, inhalation, dermal contact, direct ingestion, and ingestion through contaminated prey (Rosenberger et al. 2017). Cetaceans have a thickened epidermis that reduces the likelihood of petroleum toxicity from skin contact with oiled waters (Geraci 1990; O'Shea and Aguilar 2001). Inhalation of vapors at the water's surface and ingestion of hydrocarbons during feeding are more likely pathways of exposure. While marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, acute or chronic exposure poses greater toxicological risks (Grant and Ross 2002).

In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Geraci and St. Aubin 1990). Some of these impacts can result in population-level consequences that may take decades to recover from (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016).

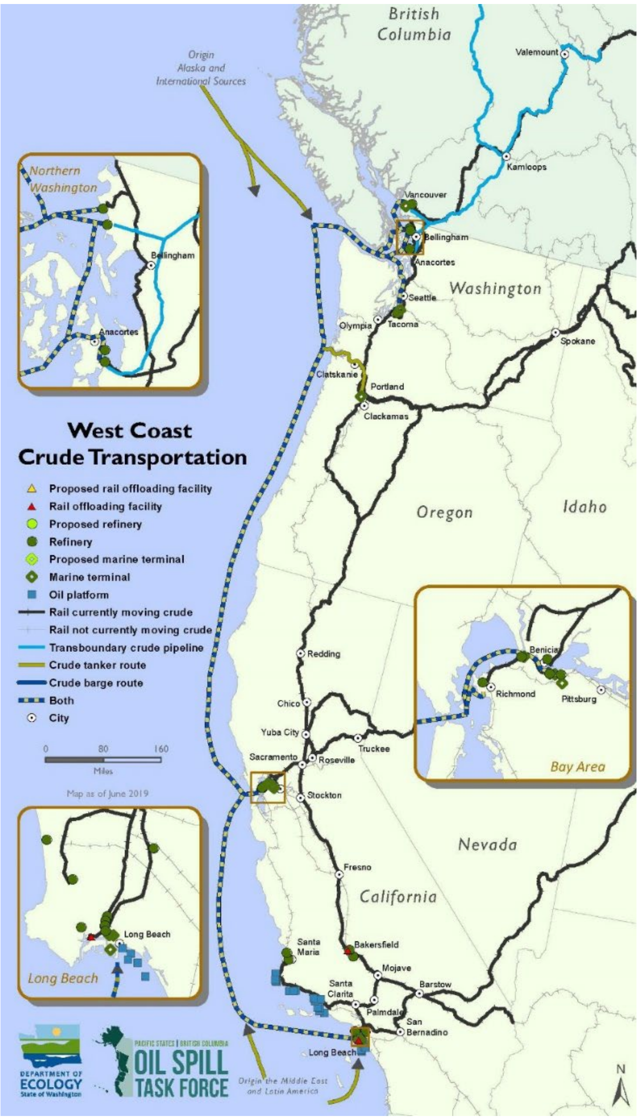

Figure 37. Map of current rail routes, interstate pipelines, and barges transporting crude oil across the West Coast (from: http://oilspilltaskforce.org/wp-content/uploads/2019/07/BCStates_crude_oil_movement_2019_rev4.pdf. Accessed 6 January 2020).

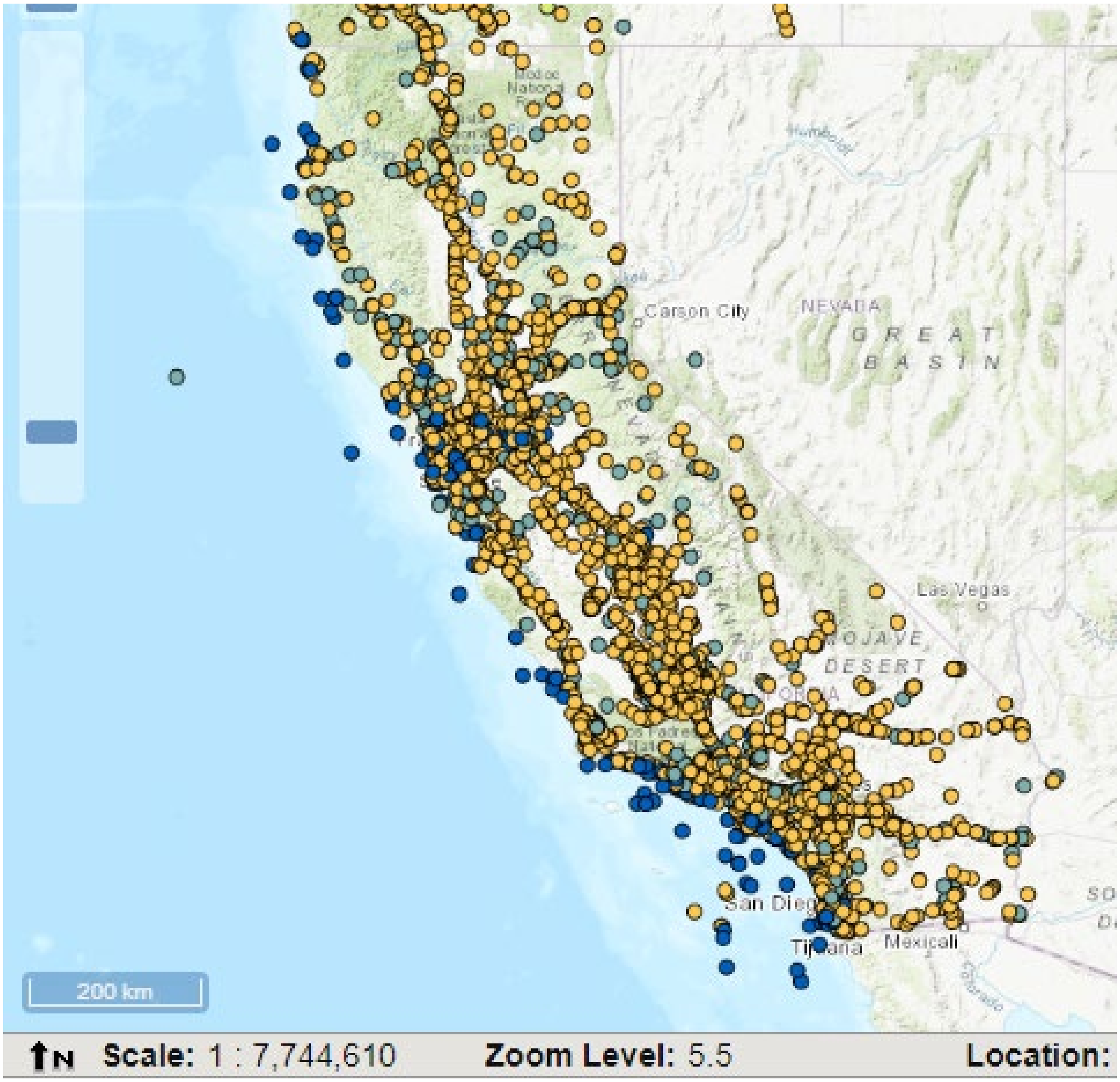

Figure 38. Oil spill incidents on the coast of California from 2004 to 2020 (NOAA Office of Response and Restoration 2021). Marine oil spills locations are indicated by the dark blue circles.

In addition to marine mammals, oil spills can have significant impacts on sea turtles in the action area. For example, leatherback sea turtles are known to ingest and attempt to ingest tar balls (Atlantic Leatherback Turtle Recovery Team 2006), which can block their digestive systems, impairing foraging or digestion and potentially causing death (NOAA 2010), ultimately reducing growth, reproductive success, as well as increasing mortality and predation risk (Fraser 2014). Oil exposure can also cause acute damage on direct exposure to oil, including skin, eye, and respiratory irritation, reduced respiration, burns to mucous membranes such as the mouth and eyes, diarrhea, gastrointestinal ulcers and bleeding, poor digestion, anemia, reduced immune response, damage to kidneys or liver, cessation of salt gland function, reproductive failure, and death (NOAA 2010; Vargo et al. 1986). Further, nearshore spills or large offshore spills can release oil on beaches where leatherback sea turtles lay their eggs (outside of the action area), causing birth defects or mortality in the nests (NOAA 2010).

7.10 Marine Debris

Marine debris has become a widespread threat for a wide range of marine species that are increasingly exposed to it on a global scale. Plastic is the most abundant material type worldwide, accounting for more than 80 percent of all marine debris (Poeta et al. 2017). The most common impacts of marine debris are associated with ingestion or entanglement. Both types of interactions can result in injury or death of many different marine species taxa. Ingestion occurs when debris items are intentionally or accidentally eaten (e.g. through predation on already contaminated organisms or by filter feeding activity, in the case of large filter feeding marine organisms, such as whales) and enter in the digestive tract. Ingested debris can damage digestive systems and plastic ingestion can also facilitate the transfer of lipophilic chemicals (especially persistent organic pollutants) into the animal's bodies. Entanglement in fishing gear also represents a major, on-going threat to many marine species. An estimated 640,000 tons of fishing gear is lost, abandoned, or discarded at sea each year throughout the world's oceans (Macfadyen et al. 2009). These "ghost nets" drift in the ocean and can fish unattended for decades (ghost fishing), killing, injuring or impairing large numbers of marine animals through entanglement.

Marine debris is a significant concern for ESA-listed species, particularly sea turtles and marine mammals. The initial developmental stages of all turtle species are spent in the open sea. During this time both juvenile turtles and their buoyant food are drawn by advection into fronts (convergences, rips, and driftlines). The same process accumulates large volumes of marine debris, such as plastics and lost fishing gear, in ocean gyres (Carr 1987). An estimated four to twelve million metric tons of plastic enter the oceans annually (Jambeck et al. 2015). It is thought that leatherback sea turtles eat plastic because it closely resembles jellyfish, a common natural prey item (Schuyler 2014). Ingestion of plastic debris can block the digestive tract which can cause turtle mortality as well as sub-lethal effects including dietary dilution, reduced fitness, and absorption of toxic compounds (Laist et al. 1999; Lutcavage et al. 1997). Schuyler et al. (2016) synthesized the factors influencing debris ingestion by turtles into a global risk model, taking into account the area where turtles are likely to live, their life history stage, the distribution of debris, the time scale, and the distance from stranding location. They found that up to 52 percent of sea turtles globally have ingested plastic debris and oceanic life stage turtles are at the highest risk of debris ingestion. This study also found the North Pacific gyre to be a regional hotspot for sea turtle debris ingestion. The North Pacific Subtropical gyre is a clockwise circular pattern of four prevailing ocean currents (North Pacific, California, North Equatorial, and Kuroshio currents) where debris from around the North Pacific Rim gathers and circulates (PISC 2016). In addition to ingestion risks, sea turtles can also become entangled in marine debris such as fishing nets, monofilament line, and fish-aggregating devices (Laist et al. 1999; Lutcavage et al. 1997; NRC 1990). Turtles are particularly vulnerable to ghost nets due to their tendency to use floating objects for shelter and as foraging stations (Dagorn et al. 2013; Kiessling 2003).

Marine mammals are also highly susceptible to the threats associated with marine debris and many cases of ingestion and entanglement have been reported around the world (Poeta et al. 2017). Baulch and Perry (2014) found that the proportion of cetacean species ingesting debris or becoming entangled in debris is increasing. Based on stranding data, they found that recorded rates of ingestion have increased by a factor of 1.9 and rates of entanglement have increased by a factor of 6.5 over the last forty years (1970-2010). Ingestion of marine debris can also have fatal consequences for large whales. In 2008, two male sperm whales stranded along the northern California coast with large amounts of fishing net scraps, rope, and other plastic debris in their stomachs. One animal had a ruptured stomach, the other was emaciated, and gastric impaction was suspected as the cause of both deaths (Jacobsen et al. 2010).

While macro-marine debris (debris greater than 5 mm in diameter) found on the seafloor of the Southern California Bight has been quantified in past studies of the Bight, Moore et al. (2016) sampled, for the first time, micro-marine debris (particles 5 mm or less in diameter) imbedded in seafloor sediments. The study analyzed 164 benthic trawl samples and found that one-third of the seafloor in the Bight contained anthropogenic macro-debris with plastics being the most widespread type of debris. Debris consisted of plastic, cans, glass bottles, metal, lumber, and other debris (e.g., cloth, tape, fiberglass, and caulk). Of the six different habitat areas surveyed, the greatest extent of seafloor containing debris was in Marine Protected Areas. This may be a result of intensive fishing that took place in these areas prior to their designation as marine protected areas, which did not occur until after 2011. The extent of seafloor macro-debris nearly doubled from 1994 to 2013, and the extent of plastic increased threefold. Plastic macro-debris was found throughout the Bight.

The extent and abundance of micro-debris (< 5 mm in diameter) in the Bight was assessed by collecting 358 sediment samples across 12 different habitats. Benthic microplastics were found in 38 percent of sediments (Moore et al. 2016). Embayments were the habitat with the greatest relative extent and abundance of microplastics, with the vast majority of the seafloor in ports, marinas, and bays containing microplastics. Continental shelf habitats had the lowest extent and abundance of benthic microplastic. Nylon and high-density polyethylene were the most common polymer types.

A visual survey of the seafloor that included the PMSR area as part of a 15-year quantitative assessment of marine debris on the seafloor off the California coast was conducted (Watters et al. 2010). Plastics were the most abundant material and, along with recreational monofilament fishing line, dominated the debris encountered on the seafloor. Throughout the duration of the survey, only a single object that was potentially "military" in origin (it appeared to be a shell casing) was encountered. U.S. Navy vessels have a zero-plastic discharge policy and return all plastic waste to appropriate disposal or recycling sites on shore.

In 2007–2008, Groundfish Bottom Trawl Surveys were used to study marine debris along the U.S. West Coast. This study characterized the composition and abundance of man-made marine debris at 1,347 randomly selected stations (Keller et al. 2010). The sample sites included locations within the PMSR Study Area. A subset of the sites sampled included historically used post-World War II dump sites. Recovered items identifying the sites as post-World War II-era dump sites included equipment described as helmets, gas masks, uniforms, and other miscellaneous and diverse items such as plastic, file cabinets, and buckets. Since approximately the 1970s, items such as these are no longer disposed of at sea.

Also in 2008, the Ocean Protection Council (OPC) and the National Oceanic and Atmospheric Administration's Marine Debris Program released *An Implementation Strategy to Reduce and Prevent Ocean Litter.* This strategy was successful at promoting actions such as the ratification of the single-use plastic carryout bag ban and the adoption of the State Water Resources Control Board‘s Trash Amendments (California Ocean Protection Council and National Oceanic and Atmospheric Administration Marine Debris Program 2018). The OPC and the National Oceanic and Atmospheric Administration's Marine Debris Program partnered to update the 2008 Strategy; the 2018 California Ocean Litter Prevention Strategy (Strategy) was adopted by the OPC in April 2018. The 2018 update expands the previous Strategy to include projects of a variety of scales and scopes so that entities including government agencies, industry, academia, nonprofits, and tribes can collaborate on meaningful contributions to reducing ocean litter in California. The Strategy includes OPC Priorities to address ocean litter and stakeholder-identified Goals, Objectives, and Action Items to address ocean litter in three broad categories: land-based ocean litter, microplastics and microfibers, and fishing and aquaculture gear. In addition to these efforts, the *Southern California Bight 2018 Regional Monitoring Program*, which is a continuation of the cooperative regional-scale monitoring in Southern California, is planning an Epibenthic Debris Survey as part of the larger SCB Regional Survey. This effort will look at the extent and magnitude of debris as well as debris trends over all SCB surveys (Southern California Coastal Water Research Project 2018). States and local governments can use the Clean Water Act, which provides regulatory tools to address aquatic trash, in conjunction with other non-regulatory measures, to reduce trash loadings into water. Total Maximum Daily Loads for trash have been established for multiple California localities, which identifies the source of the pollutant, and each source is assigned a maximum amount of the pollutant is allowed to release. In Los Angeles, for example, there are more than ten trash Total Maximum Daily Loads in the region (U.S. Environmental Protection Agency 2017).

7.11 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. A wide variety of anthropogenic and natural sources contribute to ocean noise throughout the world's oceans. Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil, gas and mineral exploration, underwater construction, geophysical (seismic) surveys, Naval and other sources of sonar, and underwater explosions (Hatch and Wright 2007b; Richardson et al. 1995c).

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. As described in greater detail later in this opinion (Sections 8.1.1.1), noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress. Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury and, in some cases, may result in behaviors that ultimately lead to death. The severity of these impacts can vary greatly from minor impacts that have no real cost to the animal, to more severe impacts that may have lasting consequences. A comprehensive discussion of the potential impacts of anthropogenic noise on listed species is included in the *Effects of the Action* (Section 8) of this opinion.

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Any potential for cumulative impact should be put into the context of recent changes to ambient sound levels in the world's oceans as a result of anthropogenic activities. There is a large and variable natural component to the ambient noise level as a result of events such as earthquakes, rainfall, waves breaking, and lightning hitting the ocean as well as biological noises such as those from snapping shrimp, other crustaceans, fishes, and the vocalizations of marine mammals (Crawford and Huang 1999; Hildebrand 2004b; Patek 2002). However, several studies have shown that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994; NRC 2000; NRC 2003; NRC 2005; Richardson et al. 1995c). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound (e.g., sonar) to test the systems of Navy vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003).

Fisheries can also introduce explosive sounds into the marine environment. In Southern California, several fisheries including purse seine and set gillnet fisheries use seal bombs as deterrents (Baumann-Pickering et al. 2013; Bland 2017; Wiggins et al. 2019; Wiggins et al. 2018). Based on the number of explosions recorded over the past several years in Southern California, Washington, and Alaska, the use of seal bombs is much more prevalent than might be expected. For example, in the seven months from May to November 2013, over 24,000 explosions identified as seal bombs were recorded at a passive acoustic monitoring site (Site "M") off Long Beach, CA (Debich et al. 2015a). Since this passive acoustic monitoring device only recorded a sample of the total time, it is reasonable to assume there were more than 24,000 seal bomb explosions in that seven-month period. In the most recently reported period of monitoring in the area (2016–2017), the number of explosions attributed to seal bombs decreased, although this was suggested to reflect a shift northward for the squid fishery and a shift to other species for the remainder of the fisheries as a result of the El Niño warming (Wiggins et al., 2018).

Andrew et al. (2002) compared ocean ambient sound from the 1960s to the 1990s from a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 dB in the frequency ranges of 20 to 80 Hz and 200 to 300 Hz, and about 3 dB at 100 Hz over a 33-year period. Each 3 dB increase is noticeable to the human ear as a doubling in sound level. A possible explanation for the rise in ambient noise is the increase in shipping noise. There are approximately 11,000 supertankers worldwide, each operating approximately 300 days per year, each producing constant broadband noise at typical source levels of 198 dB (Hildebrand 2004b). Generally the most energetic regularly operated sound sources are seismic airgun arrays from approximately 90 vessels with typically 12 to 48 individual guns per array, firing about every 10 seconds (Hildebrand 2004b).

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995c). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Sections 7.11.1, 7.11.2, 7.11.3, and 7.11.4 discuss these sound sources in more detail.

7.11.1 Seismic Surveys

NMFS issues permits for seismic activity that may expose marine mammals and ESA-listed sea turtles to acoustic stressors. MMPA authorizations and ESA consultations specify the conditions under which researchers can operate seismic sound sources, such as airguns, including mitigation measure to avoid and minimize adverse effects to protected species. One such mitigation measure is the suspension of seismic activities whenever marine mammals and/or sea turtles are observed within the designated safety zone, which differs by species and sound source, as specified in the permit.

Seismic surveys are typically conducted by towing a sound source behind a research vessel, such as an airgun array that emits acoustic energy in timed intervals. The transmitted acoustic energy is reflected and received by an array of hydrophones. This acoustic information is processed to provide information about geological structure below the seafloor. Research geologists conduct seismic surveys to study plate tectonics as well as other topics in marine geology. The underwater sound produced by seismic surveys could affect marine life, including ESA-listed species.

There are two major categories of seismic surveys: (1) deep seismic surveys which include ocean bottom, vertical seismic profile or borehole, 2-dimensional, 3-dimensional, 4-dimensional and wide azimuth surveys, and (2) high resolution surveys. Deep seismic survey acoustic sources consist of airgun arrays while receiver arrays consist of hydrophones or geophones encased in plastic tubing called streamers. High-resolution surveys collect data on surface and near-surface geology used to identify archaeological sites, potential shallow geologic and manmade hazards for engineering, and site planning for bottom-founded structures. High-resolution surveys may use airguns but also use other sound sources such as sub-bottom profilers (at 2.5-7 kilohertz), echosounders (single-beam at 12-240 kilohertz; multibeam at 50-400 kilohertz), boomers (at

300-3,000 Hz), sparkers (at 50-4,000 Hz), compressed high intensity radar pulse sub-bottom profiler (at 4-24 kilohertz), pingers (at 2 kilohertz), and side-scan sonars (16-1,500 kilohertz).

Exposure of cetaceans to very loud impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges (reviewed in Finneran 2015b). A TTS results in a temporary change to hearing sensitivity, and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. At higher received levels, particularly in frequency ranges where animals are more sensitive, a PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from exposure to a single pulse or from the accumulation of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. Since there is frequency overlap between airgun array sounds and vocalizations of ESA-listed cetaceans, particularly baleen whales and to some extent sperm whales, seismic surveys could mask these calls at some of the lower frequencies for these species.

ESA-listed cetaceans are expected to exhibit a wide range of behavioral responses as a consequence of being exposed to seismic airgun sound fields and echosounders. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Sperm whales are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including vocalizations. These responses are expected to be temporary with behavior returning to a baseline state shortly after the seismic source becomes inactive or leaves the area. Individual whales exposed to sound fields generated by seismic airguns could also exhibit responses not readily observable, such as stress (Romano et al. 2002), that may have adverse effects. Other possible responses to impulsive sound sources like seismic airguns include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007b; Tal et al. 2015; Zimmer and Tyack 2007), but similar to stress, these effects are not readily observable.

As with cetaceans, ESA-listed sea turtles may exhibit a variety of different responses to sound fields associated with seismic airguns and echosounders. Avoidance behavior and physiological responses from airgun exposure may affect the natural behaviors of sea turtles (Mccauley et al. 2000a). Mccauley et al. (2000a) conducted trials with caged sea turtles and an approaching-departing single air gun to gauge behavioral responses of green and loggerhead sea turtles. Their findings showed behavioral responses to an approaching airgun array at 166 dB re: one micro Pascal rms and avoidance around 175 dB re: 1 micro Pascal rms. From measurements of a seismic vessel operating 3-dimensional airgun arrays in 100 to 120 meters water depth this corresponds to behavioral changes at around two kilometers and avoidance around one kilometer.

Offshore seismic surveys involve the use of high energy sound sources operated in the water column to probe below the seafloor. Numerous seismic surveys have been conducted off the west coast over the past several decades. 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). There are already 43 leases in producing status in the Southern California Planning area, which could increase activity and also impact ocean noise levels. Currently, in the nearshore waters of the Santa Barbara Channel in the central portion of the PMSR, there are 15 existing offshore oil and gas production facilities and another seven farther to the south off the Long Beach area (Bureau of Ocean Energy Management 2012; Bureau of Ocean Energy Management 2017; Bureau of Ocean Energy Management 2019). There are four oil production platforms within the Point Conception/Arguello blue whale BIA (Figure 24), with those platforms resulting in noise with the potential to disturb feeding blue whales.

7.11.2 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low frequency for one kilohertz and less, mid frequency for one to 10 kilohertz; high frequency for 10 to 100 kilohertz; and very high frequency for greater than 100 kilohertz (Hildebrand 2004a). Low frequency systems are designed for long-range detection (Popper et al. 2014a). The effective source level of an low-frequency active array, when viewed in the horizontal direction, can be 235 dB re 1μPa-m or higher (Hildebrand 2004a). Signal transmissions are emitted in patterned sequences that may last for days or weeks. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonars include those incorporated into weapons (torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as side-scan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounding, and sub-bottom profiling. They typically generate sound at frequencies of 3 to 200 kilohertz, with source levels ranging from 150-235 dB re 1μPa-m (Hildebrand 2004a). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments, however, fish finders are operated in both deep and shallow areas.

High-frequency sonars are used in the PMSR action area by the Coast Guard and active mid-frequency sonar has been used by the Navy in the HSTT study area in the waters off Hawaii and southern California. This study area overlaps a portion of PMSR to the south. Between 2013 and 2018, 57,940 hours of hull-mounted mid-frequency sonar were anticipated throughout all of HSTT, but the actual number of sonar hours used was significantly lower.

7.11.3 Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of ten to 50 Hz and range from 195 dB re: μPa^2-s at 1 meter for fast-moving (greater than 20 knots) supertankers to 140 dB re: µPa^2-s at 1 meter for smaller vessels (NRC 2003). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kilohertz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013).

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009; Mckenna et al. 2012; NRC 2003). Shipping constitutes a major source of low-frequency (five to 500 Hz) sound in the ocean (Hildebrand 2004a), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. While commercial shipping contributes a large portion of oceanic anthropogenic noise, other sources of maritime traffic can also impact the marine environment. These include recreational boats, whale-watching boats, research vessels, and ships associated with oil and gas activities.

Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans and other mechanical power sources. Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 14 to 962 feet at speeds of 10 knots and at a distance of 500 yards (457.2 meters) from the hydrophone. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 µPa-m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower. Mckenna et al. (2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from Automatic Identification System (AIS). On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 µPa^2, 20 to 1000 Hz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 Hz while container ship and tanker noise was predominantly below 40 Hz. The tanker had less acoustic energy in frequencies above 300 Hz, unlike the container and bulk carrier.

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Anderwald et al. 2013; Erbe et al. 2014; Foote et al. 2004; Guerra et al. 2014; Hatch and Wright 2007a; Hildebrand 2005; Holt et al. 2008; Kerosky et al. 2013; May-Collado and Quinones-Lebron 2014; Melcon et al. 2012; Richardson et al. 1995b; Williams et al. 2014). Given the presence of the ports of Los Angeles/Long Beach and the vessel Traffic Separation Scheme's lanes running through the PMSR, 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 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).

Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate. Significant changes in odontocete behavior attributed to vessel noise have been documented up to at least 5.2 km away from the vessel (Pirotta et al. 2012).

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (NRC 2003; Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (1976) estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB; based on his estimates, Ross predicted a continuously increasing trend in ocean ambient noise of 0.55 dB per year. Average ship traffic noise levels between 1994 and 2007 off southeastern California had increased by as much as 11.7 dB in the 32 Hz frequency band since the 1960s (Andrew et al. 2011). Chapman and Price (2011) recorded low frequency deep ocean ambient noise in the Northeast Pacific Ocean from 1976 to 1986 and reported that the trend of 0.55 dB per year predicted by Ross (1976) persisted until at least around 1980; afterward, the increase per year was significantly less, about 0.2 dB per year.

Urick (1983a) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The ambient noise frequency spectrum and level can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983a). For frequencies between 100 and 500 Hz, Urick (1983a) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

Increasing oceanic noise may impair blue whale behavior. The general trend in increasing ambient low-frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006). Blue whales off California altered call levels and rates in association with changes in local vessel traffic (McKenna 2011).

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick 1983a). At any given time and place, the ambient noise level is a mixture of these noise types. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sound levels tend to be higher than when the bottom is absorptive.

7.11.4 Aircraft Noise

In the vicinity of Naval Base Ventura County (NBVC) Point Mugu, there is civilian and commercial aircraft activity, under the control of the Los Angeles Air Route Traffic Control Center, that normally flies on formal airway route structures at both low and high altitudes. These airways run along the coastline and to various points east. The airways running parallel along the coast are among the most heavily used in the area. The majority of commercial and general aviation aircraft noise are generated from flights going in and out of the regional airports in the area (Santa Barbara Airport, Oxnard Airport, and Camarillo Airport).

7.12 Commercial and Private Marine Mammal Watching

Vessels (both commercial and private) engaged in marine mammal watching also have the potential to impact whales in the action area. A study of whale watch activities worldwide has found that the business of viewing whales and dolphins in their natural habitat has grown rapidly over the past decade into a billion dollar ($US) industry involving over 80 countries and territories and over 9 million participants (Hoyt 2001). In 1988, the Center for Marine Conservation and the NMFS sponsored a workshop to review and evaluate whale watching programs and management needs (CMC and NMFS 1988). That workshop produced several recommendations for addressing potential harassment of marine mammals during wildlife viewing activities that include developing regulations to restrict operating thrill craft near cetaceans, swimming and diving with the animals, and feeding cetaceans in the wild.

Since then, NMFS has promulgated regulations at 50 CFR §224.103 that specifically prohibit: (1) the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; (2) feeding or attempting to feed a marine mammal in the wild; and (3) approaching humpback whales in Hawaii and Alaska waters closer than 100 yd (91.4 m). In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines which in part state that viewers should: (1) remain at least 50 yd (46 m) from dolphins, porpoise, seals, sea lions and sea turtles and 100 yd (91 m) from large whales; (2) limit observation time to 30 min; (3) never encircle, chase or entrap animals with boats; (4) place boat engine in neutral if approached by a wild marine mammal; (5) leave the water if approached while swimming; and (6) never feed wild marine mammals. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states that: "NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals or sea lions in the wild. This includes attempting to swim with, pet, touch or elicit a reaction from the animals."

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic. Another concern is that preferred habitats may be abandoned if disturbance levels are too high.

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Amrein et al. 2020; Au and Green 2000; Christiansen et al. 2013; Christiansen et al. 2011; Corkeron 1995; Currie et al. 2021; Erbe 2002; Felix 2001; Magalhaes et al. 2002; May-Collado and Quinones-Lebron 2014; Richter et al. 2006; Santos-Carvallo et al. 2021; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. Responses changed with these different variables and, in some circumstances, the whales or dolphins did not respond to the vessels, but in other circumstances, whales changed their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions.

Whale watching is popular around the Channel Islands primarily from March through May (during the annual gray whale northward migration) but marine mammal observation is popular year-round. In Santa Barbara and Ventura Counties, whale watching trips are offered year round with the southern migration of gray whales between late December and February and the northern migration between February and mid-May (O'Connor et al. 2009). The peak of activity is between January and March and particularly during the northern migration, as the whales travel much closer to the shore and often more slowly as the mothers are travelling with calves. Blue and humpback whale watching occurs between June and November, although the highest concentration of whales usually occurs between June and September. The Santa Barbara Channel has very reliable sightings of blue whales during this time (O'Connor et al. 2009).

7.13 Ongoing Military Training and Testing Activities

The Navy has conducted training and testing activities and other military readiness activities in the Point Mugu Sea Range since its establishment in 1946. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them. The majority of the training and testing activities the Navy conducts in the action area are similar, if not identical, to activities that have been occurring in the same locations for decades.

The Navy categorizes training exercises and testing activities into functional warfare areas called primary mission areas. PMSR activities fall into the following three primary mission areas: Electronic warfare; Air warfare; and Surface warfare. Details regarding each warfare area can be found above in the *Description of the Proposed Action* (Section 3).

Navy activities produce sound and visual disturbances to marine mammals and sea turtles throughout the action area. Impacts from harassment due to Navy activities include changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Sound produced during Navy training and testing activities also results in instances of TTS and PTS to marine mammals and sea turtles. The Navy training and testing activities constitute a federal action and take of ESA-listed marine mammals and sea turtles considered for Navy activities outside PMSR have previously undergone section 7 consultations (e.g., (NMFS 2020b)). Through these consultations with NMFS, the Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from military training and testing activities on ESA- protected resources in these action areas. Conservation measures include employing visual observers and implementing mitigation zones when training and testing using active sonar or explosives. Active sonar is not part of the PMSR proposed action, but such conservation measures are and will continue to be followed in PMSR for explosives.

7.14 Invasive Species

Introduction of invasive species is considered one of primary threats to ESA-listed species (Anttila et al. 1998; Pimentel et al. 2004; Wilcove and Chen 1998). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the IUCN database for which an extinction cause could be determined (for 75 percent of extinct species a specific cause could not be determined); invasive species were the only cited cause in 20 percent of those cases. Invasive species consistently rank as one of the top threats to the world's oceans (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). A variety of vectors are thought to be responsible for introducing aquatic non-native species including, but not limited to, aquarium and pet trades, recreation, ballast water discharges from ocean-going ships, and hull fouling. Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010).

Caulerpa taxifolia and *Codium fragile tomentosoide* are invasive green algal species found in some areas of Southern California (Dobroski et al. 2015; Gagnon et al. 2015). In addition, *Sargassum muticum* (Japanese wireweed) and *Sargassum horneri* (devil weed) are invasive brown algal species found in Southern California (Dobroski et al. 2015; Marks et al. 2015). *Sargassum muticum* was introduced from the Sea of Japan and now occupies portions of the California coast (Dobroski et al. 2015; Monterey Bay Aquarium Research Institute 2009). *Sargassum horneri* is native to western Japan and Korea. Since *Sargassum horneri* was first discovered in Long Beach Harbor in 2003, the species continues to increase its spatial extent and can now be found near harbors and anchorages from Santa Barbara, California, to Isla Natividad in Baja California (Mexico; (Marks et al. 2015)). Specifically, *Sargassum horneri* was detected in Southern California in 2003. It has spread rapidly throughout California and has been documented at several of the Channel Islands (U.S. Department of the Navy 2015b). Both species of *Sargassum* have been documented in intertidal areas on SNI (Graham et al. 2016b).

Other invasive algae in the action area includes *Undaria pinnatifida* (or wakame), which is an edible seaweed native to Japan and found along the California coast (Dobroski et al. 2015; Global Invasive Species Database 2005). This species was recorded on docks and hulls of docked vessels in Port Hueneme Harbor in May 2008 (Merkel & Associates Inc. 2008). The species primarily occurs in harbors but has also been found in open coast sites. The rapid and uncontrolled spread of this species has ecological and economic consequences that will require further research (Kaplanis et al. 2016).

The invasive alga, *Caulerpa taxifolia*, was discovered in San Diego County's Agua Hedionda Lagoon in 2000, and subsequently in Huntington Harbor (Los Angeles Regional Water Quality Control Board 2018). *Caulerpa* surveys of Port Hueneme were conducted in 2006 and 2008, with no recorded occurrence of *Caulerpa* in the harbor (Merkel & Associates Inc. 2008). *C. prolifera* was discovered in Newport Bay, California in March 2021. An eradication plan has been developed and efforts to map and confirm the infestation location are currently underway (California Department of Fish and Wildlife 2021).

7.15 Parasites and/or Disease

Cetaceans have evolved with a group of parasites belonging to the genus *Crassicauda* (order Spirurida) (Lambertsen 1992a). Infections with these nematodes are endemic in both the toothed and baleen whales. Such infections are a major cause of disease of the urinary, respiratory and digestive systems. Of several known crassicaudid infections, those caused by *Crassicauda boopis* are especially pathogenic. This giant worm infects blue whales, humpback whales, and fin whales (Lambertsen 1992a). Jauniaux et al. (2000) reported evidence for morbillivirus infection in the two fin whales stranded on the Belgian and French coastlines.

A comprehensive study in Alaska that sampled over 900 marine mammals across 13 species, including several mysticetes, odontocetes, pinnipeds, and mustelids, found detectable concentrations of domoic acid in all 13 species and saxitoxin, a toxin absorbed from ingesting dinoflagellates, in 10 of the 13 species (Lefebvre et al. 2016). Algal toxins may have contributed to the stranding and mortality of 30 whales (fin whales and humpback whale) found around the islands in the western Gulf of Alaska and the southern shoreline of the Alaska Peninsula starting in May 2015 (National Oceanic and Atmospheric Administration 2016; Rosen 2015; Savage et al. 2017; Summers 2016). These findings from studies in Alaska are relevant to the PMSR action area given that some fin whales and humpback whales from stocks in the PMSR Study Area migrate to Alaska to feed.

Fibropapillomatosis (FP) is a neoplastic disease that can negatively impact ESA-listed sea turtle populations. FP has long been present in sea turtle populations with the earliest recorded mention from the late 1800s in the Florida Keys (Hargrove et al. 2016). FP has been reported in every species of marine turtle but is of greatest concern in green turtles, the only known species where this disease has reached a panzootic status (Williams Jr et al. 1994). Historical data indicate that the disease rose in prevalence most noticeably in the 1980s. Prevalence rates as high as 45 to 50 percent have been reported within some local green turtle populations (Hargrove et al. 2016; Jones et al. 2015). FP primarily affects medium-sized immature turtles in coastal foraging pastures.

7.16 Scientific Research and Permits

Many of the ESA-listed species in this opinion are the subject of scientific research and monitoring activities. The impacts of these research activities pose both benefits and risks. In the short term, adverse effects to ESA-listed marine mammals and sea turtles may occur in the course of scientific research. However, these activities have a great potential to benefit ESA-listed species in the long-term. Most importantly, the information gained during research and monitoring activities can assist in planning for the recovery of listed species. Information obtained from scientific research is essential for understanding the status of ESA-listed species, obtaining specified critical biological information, and achieving species recovery goals.

Research on the ESA-listed species considered in this opinion is granted an exemption to the ESA take prohibitions of section 9 through the issuance of section 10(a)(1)(A) permits. Research activities authorized through scientific research permits can produce various stressors on wild and captive animals resulting from capture, handling, and research procedures. The ESA requires that research conducted under a section 10(a)(1)(A) research permit cannot operate to the disadvantage of the species. Scientific research permits issued by NMFS are conditioned with mitigation measures to ensure that the impacts of research activities on target and non-target ESA-listed species are as minimal as possible.

Over time, NMFS has issued dozens of permits on an annual basis for various effects to marine mammals, sea turtles, and ESA-listed fish species in the action area from a variety of research activities. Authorized research on ESA-listed marine mammals includes close vessel and aerial approaches, photographic identification, photogrammetry, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, breath sampling, behavioral observations, passive acoustic recording, and underwater observation. Only non-lethal effects to marine mammals are authorized for research activities.

In 2019, NMFS concluded ESA section 7 consultation on a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Cetaceans pursuant to

Section 10(a) of the ESA and Section 104 of the MMPA (NMFS 2019b). According to this programmatic, 466 cetacean (all species) takes due to biopsies and tagging were reported within the research program from 2009 to 2017. In addition, 6,192 takes were reported for all cetacean species due to harassment from vessel surveys. The number of researchers and their proposed research and enhancement activities remain relatively consistent over time; and thus, the frequency of these research and enhancement activities are not expected to significantly change in the foreseeable future (NMFS 2019b). Between 2009 and 2020, 26 takes of Guadalupe fur seals were reported to the Permits Division. These included takes from vessel survey disturbance, sample collection, capture, morphometrics, and tagging. There are currently 13 active permits authorizing research using the aforementioned methods on all or a subset of the ESA-listed marine mammals in the PMSR action area.

ESA-listed sea turtle research includes approach, capture, handling, restraint, tagging, biopsy, blood or tissue sampling, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, laparoscopy, captive experiments, and mortality. Most directed take for which ESA section 7 consultations have been completed is sub-lethal as mortality is rarely authorized by NMFS in sea turtle research permits. On average, from 2007 to 2017, approximately 988 sea turtle (all species) takes were reported within the NMFS research program throughout the U.S. in any given year. In 2017, NMFS concluded ESA section 7 consultation on a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Sea Turtles Pursuant to Section 10(a) of the ESA. This programmatic consultation allows for the authorization of up to two leatherback sea turtle mortalities within the Pacific Ocean basin every ten years (NMFS 2017a).

7.17 Impact of the Baseline on ESA-listed Resources

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on blue whales, fin whales, the Central America and Mexico humpback whale DPSs, sperm whales, Guadalupe fur seals, and leatherback sea turtles. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, whaling, entanglement in fishing gear), whereas others result in more indirect (e.g., a fishery that impacts prey availability) or non-lethal impacts (e.g., whale watching).

We consider the best indicator of the environmental baseline on ESA-listed resources to be the status and trends of those species. As noted in Section 6.2, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the environmental baseline is affecting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the environmental baseline. Therefore, while the environmental baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the environmental baseline is limiting their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historic commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in *Status of Species Likely Affected by the Proposed Action* (Section 6.2) of this Opinion.

8 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as all consequences to ESA-listed species or designated critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur (50 C.F.R. §402.02). Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.17).

In Section 5, we identified the potential stressors created by the Navy's testing and training activities. This section begins with a summary table of our effects determinations by stressor category for each ESA-listed species considered during this consultation (Table 25). This serves as a cross reference for the sections to follow that provide the analyses supporting these effects determinations. This table also lists the overall effects determination for each species. Recall that at the start of Section 6, we provided a complete list of ESA-listed species and designated critical habitat that may be affected by the proposed action. Further, in Section 6.1 we explained that some ESA-listed species and designated critical habitat were not likely to be adversely affected by any of the stressors associated with the proposed action (i.e., overall determination labeled as "NLAA" in Table 25). This is because any effects on these species were extremely unlikely to occur such that they were discountable, or the size or severity of the impact was so low as to be insignificant, including those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. The ESA-listed species and designated critical habitat addressed in Section 6.1 are included in the summary table below because this table reflects all species and critical habitat considered in this opinion.

In this section, we focus on those species that are likely to be adversely affected by one or more stressors created by the proposed action. This section is organized by taxa (i.e., marine mammals and sea turtles) since the species within each taxa often respond to stressors in similar ways. In Section 8.1, we discuss the stressors associated with the proposed action that we determined are not likely to adversely affect all species from a particular taxa (i.e., stressors labeled as "NLAA" in Table 25). We do not carry these stressors forward in our effects analysis since there is no meaningful potential for these stressors to affect the survival or recovery of species within the particular taxa. Finally, in Section 8.2, we summarize the analysis for the stressor and taxa (i.e., marine mammals and sea turtles) combinations that are likely to result in adverse effects to species within the taxa (labeled as "LAA" in Table 25). Cells marked as 'NE' in Table 25 indicate that we anticipate the stressor would have "no effect" on the species; these stressors are not included in our effects analysis for those particular species as there is no meaningful potential for these stressors to affect the survival or recovery of any species in the action area.

Table 25. NMFS ESA effects determinations by stressor and overall effects determination for each ESA-listed species (LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect).

		Acoustic Stressors				*Energy*	*Physical Disturbance and Strike*			*Entanglement*	*Ingestion*	
ESA-Listed Species	***Overall Determination***	***Vessel Noise***	***Aircraft Noise***	***Weapons Noise***	***Explosions***	***Directed Energy (High-Energy Lasers)***	***Vessel Disturbance***	***Vessel Strike***	***Military Expended Material / In-Water Devices***	***Decelerators/Parachutes***	***Military Expended Material***	***Indirect Effects***
Invertebrates												
Black abalone	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
White abalone	NLAA	NLAA	NLAA	NLAA	NLAA	NE	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Marine Mammals												
Blue whale	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fin whale	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback whale – Central America DPS	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback whale – Mexico DPS	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

		Acoustic Stressors				*Energy*	*Physical Disturbance and Strike*			*Entanglement*	*Ingestion*	
ESA-Listed Species	***Overall Determination***	***Vessel Noise***	***Aircraft Noise***	***Weapons Noise***	***Explosions***	***Directed Energy (High-Energy Lasers)***	***Vessel Disturbance***	***Vessel Strike***	***Military Expended Material / In-Water Devices***	***Decelerators/Parachutes***	***Military Expended Material***	***Indirect Effects***
North Pacific right whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sperm whale	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Western North Pacific gray whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Guadalupe fur seal	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Marine Reptiles												
Green sea turtle – Central North Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green sea turtle – East Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	*Overall Determination*	*Acoustic Stressors*				*Energy*	*Physical Disturbance and Strike*			*Entanglement*	*Ingestion*	*Indirect Effects*
		Vessel Noise	*Aircraft Noise*	*Weapons Noise*	*Explosions*	*Directed Energy (High-Energy Lasers)*	*Vessel Disturbance*	*Vessel Strike*	*Military Expended Material / In-Water Devices*	*Decelerators/Parachutes*	*Military Expended Material*	
Leatherback sea turtle	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Loggerhead sea turtle – North Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fish												
Steelhead – Southern California DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Giant manta ray	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Scalloped hammerhead shark – East Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

8.1 Stressors Not Likely to Adversely Affect ESA-listed Species

The following section discusses stressors we determined may affect, but are not likely to adversely affect some or all ESA-listed species considered in this opinion because the effect of the stressors would be insignificant or discountable. For analysis of the effects to ESA-listed species, note that discussion in this section is organized by taxa (i.e., marine mammals, sea turtles) because the pathways for effects for these stressors is generally the same by taxa and, in most cases, we would not expect different effects at the species level. While there is variation among species within each taxa, the species within each taxa share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors caused by the proposed action.

8.1.1 Marine Mammals

We determined that several of the acoustic stressors, all of the energy stressors, physical disturbance and strike stressors, entanglement stressors, ingestion stressors, and potential secondary stressors may affect, but are not likely to adversely affect ESA-listed blue whales, fin whales, Central America DPS humpback whales, Mexico DPS humpback whales, sperm whales, or Guadalupe fur seals. Our analysis for these stressors and these marine mammals is summarized below.

8.1.1.1 Acoustic Stressors – Marine Mammals

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. Additional discussion of the acoustic stressors associated with the proposed action is included in Section 5.1 above. The effects of additional acoustic stressors (i.e., exlosives), which we determined are likely to adversely affect marine mammals, are discussed in Section 8.2.1.

8.1.1.1.1 Effects of Vessel Noise on Marine Mammals

Additional information on vessel noise as a potential stressor associated with the proposed action can be found in Section 5.1.2.

Marine mammals could be exposed to a range of vessel noises within their hearing abilities. The Navy vessels will produce low-frequency, broadband underwater sound below one kHz for larger vessels, and higher-frequency sound between one kHz to 50 kHz for smaller vessels, although the exact level of sound produced varies by vessel type. Depending on the context of exposure, responses of marine mammals in the action area to vessel noise disturbance would include startle responses, avoidance, or other behavioral reactions, physiological stress responses, or no measurable response.

Blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals are either not likely to respond to Navy vessel noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Additionally, the effects of any temporary masking specifically from Navy vessels are expected to be of a short duration and not result in meaningful changes to an animal's ability to communicate or detect biologically relevant cues given the background noise levels in the action area independent of Navy vessels and the small percentage of vessel traffic Navy vessels represent in the action area (as discussed in Section 5.1.2 above). Therefore, the effects of vessel noise on blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals from Navy vessels are considered insignificant. Thus we conclude that the effects of vessel noise resulting from the proposed action may affect, but are not likely to adversely affect these speceis.

8.1.1.1.2 Effects of Aircraft Noise on Marine Mammals

Additional information on aircraft as a potential stressor associated with the proposed action can be found in Section 5.1.3.

In most instances, exposure of a marine mammal to fixed-wing aircraft, helicopters, and unmanned aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead during training and testing activities as part of the proposed action. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the action area. Takeoffs and landings from Navy vessels could startle marine mammals. However, these events only produce in-water noise at any given location for a brief period as the aircraft climbs to cruising altitude. Given their amphibious life history, Guadalupe fur seals would likely be exposed to aircraft noise for longer periods of time than blue whales, fin whales, humpback whales, and sperm whales. However, Guadalupe fur seals would only be expected to exhibit minor behavioral responses, if any, to aircraft overflights. Some sonic booms from aircraft could also startle marine mammals, but these events are transient and happen infrequently at any given location within the action area. Repeated exposure to most individuals over short periods (days) is extremely unlikely, since blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals have wide ranging life histories. Additionally, aircraft would pass quickly overhead, typically at altitudes above 3,000 feet, which would make marine mammals unlikely to respond.

Kuehne et al. (2020) measured underwater noise levels produced by Growler aircraft (EA-18G) at Naval Air Station (NAS) Whidbey Island, WA. The average of the underwater received levels detected across all 10 overflights in the strongest 1-s window was 134 ± 3dB re 1μPa at 30 m below the sea surface. The frequency of the sound from these overflights ranged from 20 Hz to 30 kHz, with a peak between 200 Hz and 1 kHz. While sound levels between the hydrophone and the surface may have been stronger than those measured at 30 m (Kuehne et al. 2020), this study only examined received levels from one focal point in the water column and did not model sound propagation to determine how noise from Growler overflights spreads throughout the action area. Given the extremely short duration of this stressor (seconds), it is extremely unlikely that ESA-listed marine mammals would co-occur in time and space with Growler aircraft sound at levels that could result in adverse effects. Any exposures of marine mammals to aircraft noise that may occur this close to the surface would likely be short term and infrequent, resulting in either no measurable response or a brief, inconsequential behavioral response.

In summary, blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals are either not likely to respond to Navy aircraft noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Due to the short term and infrequent nature of any exposures, and the brief and inconsequential behavioral responses of animals that could follow such exposure, the effects of aircraft overflight noise from Navy activities on Blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals is considered insignificant. Therefore, we conclude that aircraft overflight noise resulting from the proposed action may affect, but is not likely to adversely affect these species.

8.1.1.1.3 Effects of Weapons Firing, Launch, and Impact Noise on Marine Mammals

Activities using weapons would be conducted as described in Section 3 of this opinion. Additional discussion on weapons noise as a potential stressor is included in Section 5.1.4. The use of weapons during training could occur almost anywhere within the action area. Noise associated with large caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would typically occur at locations greater than 12 NM from shore for safety reasons. Small- and medium-caliber weapons firing could occur throughout the action area.

Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Additionally, due to the short-duration, transient nature of launch noise, marine mammals are unlikely to be exposed multiple times within a short period.

Although missiles are launched from aircraft, they are expected to produce minimal noise in the water due to the altitude of the aircraft at launch. Missiles and targets launched by ships or near the water's surface may expose marine mammals to levels of sound that could produce brief startle reactions, avoidance, or diving. Some objects, such as hyperkinetic projectiles and non-explosive practice munitions, could impact the water with great force and produce a relatively large impulse. Marine mammals within the area may hear the impact of non-explosive ordnance on the surface of the water and would likely alert, startle, dive, or avoid the immediate area.

In summary, blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals are either not likely to respond to Navy weapons noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. If they do occur, behavioral reactions would likely be short-term (seconds to minutes) and multiple exposures of the same animal over a short duration are not anticipated. For these reasons, the effects of weapons noise from Navy activities on ESA-listed marine mammals are considered insignificant. Therefore, we conclude that weapons noise resulting from the proposed action may affect, but is not likely to adversely affect these species.

8.1.1.1.4 Effects of Explosions in Air on Marine Mammals

Explosions that occur during air warfare would typically be at sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude and would not reach the water's surface where blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals could occur. There may also be sound that is audible near the surface, although sound transmission would also be limited by reflection at the air-water boundary, depending on the angle of incidence. Marine mammals within the audible range of sound from explosions in air may exhibit a behavioral startle response but are expected to quickly return to normal behavior. Due to the short duration and sporadic nature of explosions in the air, and the extremely low likelihood of blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals being within close enough proximity to detect sounds from such explosions, we do not expect any temporary behavioral responses to result in a significant disruption of breeding, feeding, or sheltering of individual animals. Therefore, the effects of sound from explosions in air during Navy activities on blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals are considered insignificant. Thus, we conclude that sound from explosions in air during Navy activities that are part of the proposed action may affect, but are not likely to adversely affect these species.

8.1.1.2 Effects of Lasers on Marine Mammals

This section summarizes the effects of high-energy laser weapons used during Navy training and testing activities on blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals within the action area. Additional discussion on energy stressors is included in Section 5.2.

High-energy laser weapons activities involve evaluating the effectiveness of an approximately 30-kilowatt high-energy lasers deployed from a surface ship or a helicopter to create small but critical failures in potential targets from short ranges. A marine mammal could be exposed to the laser beam at or near the water's surface, which could result in injury or death. However, marine mammals could only be exposed if the laser beam missed the target (i.e., if the laser hit the target, it would not be expected to penetrate the water and potentially impact an animal underwater), which is not a common occurrence. The following safeguards are in place to reduce the probability of a high-energy laser weapon striking the water: 1) The high energy laser platform has provisions that prevent misfiring (i.e., firing when not intended) that all but eliminate the possibility of that event; 2) The high-energy laser platforms have built-in constraints that only permit firing when it is locked onto a target. It also automatically interrupts firing if the target track on a target is lost; 3) Operators are trained to stop firing when the laser aim point moves off of the selected target; and 4) SNI will be used as a backstop for some events to prevent any chance of a laser beam traveling farther than the test requires and into an uncontrolled/uncleared area. Additionally, ESA-listed marine mammal densities in the action area are relatively low, which further reduces the likelihood of a laser strike.

Given that: (1) high-energy lasers are precision targeted and firing over relatively short ranges, (2) marine mammal species spend most of their time under the water, (3) marine species are unlikely to remain stationary within the very small diameter of the laser beam, and (4) marine species may avoid the target area during set-up activity prior to and during the testing activity, we consider it extremely unlikely that blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals would be exposed to high energy lasers. Therefore, potential effects from lasers on blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals during Navy activities are considered to be discountable. Thus, we conclude that lasers used during Navy activities considered in this opinion may affect, but are unlikely to adversely affect these species.

8.1.1.3 Physical Disturbance and Strike Stressors – Marine Mammals

This section summarizes the analyses of the potential effects of physical disturbance and strike of blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals during PMSR activities resulting from vessels and military expended materials (including non-explosive practice munitions and fragments from high-explosive munitions).

8.1.1.3.1 Effects of Vessel Disturbance and Strike on Marine Mammals

With regard to marine mammals, the Navy and NMFS have previously determined that these species are either not likely to respond to physical disturbance as a result of Navy vessel noise (83 FR 66937), or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns (NMFS 2018c). Therefore, we consider the effects to ESA-listed marine mammals from physical disturbance from vessels to be insignificant.

As mentioned in Section 7.7, Naval vessels struck two fin whales and two additional unidentifed large whales in the Southern California portion of the HSTT study area outside of the PMSR action area during three separate events in 2021. The fin whale strikes were confirmed mortalities from a 147.5-m (483.9-ft) Royal Australian Navy warship, while the other two strikes were confirmed injuries (and potentially mortalities) from 567-ft U.S. Navy cruisers. Vessel speed was unknown at the time of the fin whale strikes but the other two strikes occurred at vessel speeds of 16 and 25 knots, respectively.

In the 24 years of reporting by the Navy, there have been no known Navy vessel strikes to marine mammals in the PMSR action area, up to and including January 2022. Activities involving Navy vessel movement are variable in duration (i.e., hours to days), would be widely dispersed throughout the action area, and occur intermittently. Predominantly aircraft are used in the PMSR action area rather than water vessels. Many of these vessels are not berthed in the PMSR and would be transiting into the PMSR from San Diego, although the possibility for vessel strikes is still possible during transit. Average military vessel speed for the PMSR acion area is approximately 10.6 knots for the types of vessels typically involved in PMSR activities (Mintz 2016). As indicated in Table 21, the proposed action includes 333 events and 2,805 hours of annual vessel usage in the PMSR. In comparison to the southern California portion of the HSTT area, the estimated number of annual at-sea days in the PMSR action area is less than three percent of what occurs in the southern California portion of the HSTT area annually. For additional details on Navy vessel activity in the action area see Section 5.3.1.

The Navy employs several actions as part of standard operating procedure or mitigation measures (see Sections 3.4, 3.5, and 3.6) to minimize collisions between surface vessels and ESA-listed animals that might occur in the action area.

While it is possible for a Navy vessel to strike a blue whale, fin whale, humpback whale, sperm whale, or Guadalupe fur seal, during the course of training and testing activities in the PMSR, we do not believe this is likely to occur. As stated previously, the Navy has been training in the action area for years and no such incident has occurred in the PMSR. Additionally, significantly fewer vessel hours and activities are proposed for the PMSR than in other training and testing areas (e.g., HSTT) and the Navy employs mitigation measures to reduce the likelihood of a vessel striking a large whale. For the reasons discussed above, while it is possible, we consider it extremely unlikely that a blue whale, fin whale, humpback whale, sperm whale, or Guadalupe fur seal would be struck by a vessel during Navy training and testing activities in the action area.

Given the relatively sparse distribution of blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals throughout the action area and the Navy's mitigation measures for vessel movement (see Section 3.5.1.6), we consider the likelihood of vessel strikes to blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals to be extremely unlikely and thus discountable. Therefore, we conclude that vessel strikes resulting from the proposed action may affect, but are not likely to adversely affect these species.

8.1.1.3.2 Effects of Military Expended Materials on Marine Mammals

While no strike of blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals from military expended materials has ever been reported or recorded, the possibility of a strike still exists. We considered the potential for ESA-listed marine mammal strike resulting from PMSR activities involving the following types of military expended materials: 1) all sizes of non-explosive practice munitions, 2) fragments from high-explosive munitions, 3) expendable targets and target fragments; and 4) expended materials other than munitions, such as sonobuoys, expended bathythermographs, and torpedo accessories.

Given the large geographic area involved and the relatively low densities of blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals in the action area, we do not believe such interactions are likely. Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is extremely unlikely because the objects will slow in velocity as they sink toward the bottom. Heavier items, such as non-explosive munitions, would likely sink faster but would still be slowed as they sink to the bottom, and can be avoided by highly mobile cetacean and pinniped species. In addition, the Navy has proposed procedural mitigation for vessel movement to limit the potential for strikes of blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals where military expended materials are used in offshore environments (see Section 3.5.1 for details).

In summary, NMFS considers it extremely unlikely for blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals to be struck by military expended materials. Any individuals encountering military expended materials as they fall through the water column are likely to move to avoid them. Given the effort expended by individuals to avoid them will be minimal (i.e., a few meters distance) and temporary, behavioral avoidance of military expended materials sinking through the water column is considered minor with no lasting or meaningful effects expected for an individual animal. For these reasons, potential effects on blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals from physical disturbance and strike with military expended materials are discountable (in the case of strikes), or insignificant (in the case of behavioral response). Therefore, we conclude that physical disturbance and strike by military expended materials as a result of the proposed action may affect, but are not likely to adversely affect these species.

8.1.1.3.3 Effects of In-Water Devices on Marine Mammals

Additional information on in-water devices as a potential stressor associated with the proposed action can be found in Section 5.3.3.

Despite thousands of Navy exercises in which in-water devices have been used, there have been no recorded instances of marine species strikes from these devices. Most devices do not have a realistic potential to strike marine mammals because they either move slowly through the water column or are closely monitored by observers manning the towing platform who ensure the towed in-water device does not run into objects in the water. The Navy will implement mitigation to avoid potential impacts from in-water device strikes on marine mammals throughout the action area. Mitigation includes training Lookouts and watch personnel to identify marine mammals and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified distance from marine mammals. For these reasons, NMFS considers it extremely unlikely for any ESA-listed marine mammal to be struck by an in-water device. It is possible that marine mammals that occur in areas that overlap with in-water device use may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be minor and temporary for the animal. In addition, the Navy has proposed standard operating procedures for towed-in water devices to limit the potential for strikes of marine mammals (see Sections 3.4.5 for details). Therefore, the potential effects on blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals from an in-water device strike are extremely unlikely to occur and are considered discountable. Thus, we conclude that physical disturbance caused by in-water devices associated with the proposed action may affect, but is unlikely to adversely affect these species.

8.1.1.4 Entanglement Stressors – Marine Mammals

Expended materials from Navy activities that may pose an entanglement risk for blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals include decelerators and parachutes. Interactions with these materials could occur at the sea surface, in the water column, or on the seafloor. Additional discussion of entanglement stressors, in general, is included in Section 5.3.3.

8.1.1.4.1 Effects of Entanglement from Decelerators and Parachutes on Marine Mammals

Parachutes and decelerators used by the Navy as part of the proposed action could potentially be encountered by blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals at the sea surface, in the water column, or on the seafloor.

The vast majority of large whale (e.g, blue, fin, humpback, and sperm whales) and Guadalupe fur seal entanglements have been associated with fishing gear. In contrast, there has never been a documented instance where a large whale or Guadalupe fur seal was observed entangled in military expended material, including decelerators and parachutes. There are a number of key differences between decelerators/parachutes and fishing gear that result in the likelihood of entanglement in these materials being significantly lower than the likelihood of entanglement in fishing gear. First, except for a small number of large decelerators/parachutes, most decelerators/parachutes used by the Navy sink quickly to the seafloor and do not remain suspended in the water column for extended periods of time. This is in contrast to fishing gear which can remain in the water column for days or weeks at a time. Additionally, parachutes would be highly visible in the water column, likely alerting a nearby animal to the presence of the obstacle. By contrast, fishing gear may consist of some buoys and traps that are visible, but often contains hundreds of feet of rope or line in between these items that is often not visible by design. Finally, the cords associated with parachutes are, at most, 82 ft long. In contrast, typical gear associated with some fisheries has hundreds of feet of rope suspended in the water column.

During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. This standard operating procedure could further reduce the potential entanglement of marine mammals in large decelerators/parachutes. There is the potential for a bottom feeding cetacean (e.g., sperm whale) to become entangled when they are foraging in areas where parachutes have settled onto the seafloor. For example, if bottom currents are present, the canopy may temporarily billow and pose a greater entanglement threat. However, the likelihood of bottom currents causing a billowing of a parachute and being encountered by an ESA-listed marine mammal is considered extremely unlikely.

Overall, given the low density of blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals in the action area, the small number (i.e., less than ten annually) of parachutes/decelerators that would not be recovered, and the vast area over which any one of these decelerators and parachutes would be deployed, the chances of a marine mammal encountering one and becoming entangled is extremely low. Therefore, the potential effects to blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals from entanglement in decelerators and parachutes are considered extremely unlikely and thus discountable. Thus, we conclude that entanglement in decelerators and parachutes due to the proposed action may affect, but is extremely unlikely to affect these species.

8.1.1.5 Ingestion Stressors – Marine Mammals

Additional discussion on ingestion stressors is included in Section 5.5. The munitions and other materials small enough to be ingested by ESA-listed blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals are small- and medium-caliber projectiles, broken pieces of firing targets, chaff, flare caps, and shrapnel fragments from explosive ordnance. Other military expended materials (e.g., non-explosive bombs or surface targets) are considered too large for ESA-listed marine mammals to consume and are made of metal a marine mammal would not be able to break-apart to ingest.

Most expendable materials would be used over deep water portions of the action area and most items are expected to sink quickly and settle onto the seafloor, with the exception of chaff and some firing target materials. Given the limited time most items will spend in the water column, it is not likely that these items would be accidentally ingested by ESA-listed marine mammals that do not typically forage on the sea floor. Of the marine mammals in the action area, the only species potentially exposed to expended munitions and shrapnel fragments while foraging on the sea floor in deep water is sperm whales. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003b). However, the relatively low density of both sperm whales and expended materials along the vast sea floor suggests ingestion would be rare. Humpback whales also feed at the seafloor but do so in relatively shallow water and soft sediment areas where ingestion stressors are less likely to be present (fewer activities take place in shallow water and expended materials are more likely to bury in soft sediment and be less accessible). If a large whale or Guadalupe fur seal were to accidentally ingest expended materials small enough to be eaten, it is likely the item will pass through the digestive tract and neither result in an injury (e.g., Wells et al. 2008) nor an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering.

ESA-listed marine mammals may also encounter military expended material that remains suspended in the water column for extended periods of time. Because baleen whales feed by filtering large amounts of water, they could encounter and consume debris at higher rates than other marine animals (NOAA 2014). For example, baleen whales are believed to routinely encounter microplastics (from numerous anthropogenic sources) within the marine environment based on concentrations of these items and baleen whale feeding behaviors (Andrady 2011). Laist (1997) reported on two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag. Bergmann et al. (2015) documented records of marine debris ingestion in seven mysticetes, including right whales, pygmy right whales, gray whales, and four rorqual species. Information compiled by Williams et al. (2011) listed humpback whale, fin whale, and minke whale as three species of mysticetes known to have ingested debris including items the authors characterized as fishing gear, polyethylene bag, plastic sheeting, plastic bags, rope, and general debris. Military expended materials were not documented as having been consumed in any of these studies.

Some Styrofoam, plastic endcaps, and other small military expended materials (e.g., chaff, flare pads, pistons) may float for some time before sinking. However, these items are likely too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it. Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to its light weight and small size this floating material can be carried great distances in both air and water currents. Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military training (Arfsten et al. 2002; Force 1997; Hullar et al. 1999). Similar to chaff, flare pads and pistons are also relatively small and float in sea water. Given the small size, low densities, and low toxicity of chaff or flare expended materials, any accidental ingestion by ESA-listed marine mammals feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering. Chaff cartridge plastic end caps and pistons and flare pads would also be released into the marine environment during Navy activities, where they may persist for long periods, and therefore could be ingested by marine mammals while initially floating on the surface and sinking through the water column. However, these materials would eventually sink to the seafloor where they would be less likely to be ingested by blue whales, fin whales, humpback whales, and Guadalupe fur seals. As previously mentioned, sperm whale ingestion of these materials on the seafloor would likely be rare. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

In conclusion, because we expect smaller military expended materials would likely pass through blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals with no adverse effects, the effects of this stressor (i.e., ingestion of small expended materials) are insignificant. Since ingestion of military expended material of sufficient size to result in adverse effects on blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals is extremely unlikely, the effects of this stressor (i.e., ingestion of large expended materials) are discountable. While baleen whales could accidentally ingest chaff or flare remains, if this occurs the effects of these stressors on those individuals exposed are expected to be so minor as to be insignificant. Therefore, we conclude the ingestion of expended materials from activities associated with the proposed action may affect, but is not likely to adversely affect blue whales, fin whales, Central America and Mexico humpback whale DPSs, sperm whales, and Guadalupe fur seals.

8.1.1.6 Stressors Resulting in Effects to Marine Mammal Habitat or Prey

This section analyzes potential impacts to ESA-listed marine mammals exposed to stressors through impacts to their habitat or prey. The stressors evaluated in this section include: 1) explosives, 2) explosive byproducts and unexploded munitions, 3) metals, and 4) chemicals.

8.1.1.6.1 Explosives

In this section, we discuss the anticipated effects of PMSR explosives on the prey of blue whales, fin whales, sperm whales, and Guadalupe fur seals. Anticipated effects of explosives on the prey of Central America DPS and Mexico DPS humpback whales are discussed in Section 6.1.11.

Explosions could impact other species in the food web, including prey species that marine mammals feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996; Mather 2004). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected. No underwater explosions are proposed in PMSR, therefore we do not expect marine mammal prey species to be directly injured or killed by explosions above the water surface. For these reasons, the effects of PMSR explosives on blue whales, fin whales, humpback whales, and Guadalupe fur seals through impacts to their prey are insignificant. Therefore, we conclude that impacts to prey species from the use of explosives associated with the proposed action may affect, but are not likely to adversely affect blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals.

8.1.1.6.2 Explosive Byproducts and Unexploded Munitions

High-order explosions (i.e., a successful explosion or an explosion that produces the intended result) consume almost all of the explosive material in the ordnance, leaving little to no material in the environment that could affect marine mammal species or their habitats. By contrast, low order detonations and unexploded munitions leave more explosive material in the environment. Lotufo et al. (2010) studied the potential toxicity of Royal Demolition Explosive byproducts to sheepshead minnows. The median lethal residue was measured as 9.6 mg per kg. The authors concluded that degradation products of these explosives are not toxic at realistic exposure levels and that these products have a low bioaccumulation potential. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6 to 12 in away from degrading munitions, the concentrations of these compounds were not statistically distinguishable from baseline levels beyond 3 to 6 ft from the degrading munitions. Based on these results, while it is possible that ESA-listed marine mammals could be exposed to degrading explosives, such exposure would likely only occur within a very small radius of the explosive, and exposure to degrading explosives at toxic levels is extremely unlikely.

The concentration of munitions, explosives, expended material, or devices in any one location in the action area is expected to be a small fraction of that from the sites described in Section 5.3.2. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects (i.e., no measureable effects are anticipated) on water quality or blue whale, fin whale, humpback whale, sperm whale, or Guadalupe fur seal prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals through impacts on prey and water quality are considered insignificant. Therefore, we conclude that impacts to prey and water quality from explosive byproducts and unexploded munitions associated with the proposed action may affect, but are not likely to adversely affect these species.

8.1.1.6.3 Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group, 2005). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Evidence from a number of studies (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013b) indicate metal contamination is highly localized and that bioaccumulation resulting from munitions cannot be demonstrated. Specifically, in sampled marine life living on or around munitions on the seafloor, metal concentrations could not be definitively linked to the munitions because comparison of metals in sediment next to munitions show relatively little difference in comparison to other baseline marine sediments used as a control (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016), but this would not have an effect on the availability of marine mammal prey. The research cited above indicates that metals introduced into the action area are unlikely to have measureable impacts on ESA-listed marine mammal prey or habitat. Thus, the effects of metals introduced into seawater and sediments as a result of PMSR activities on blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals through impacts to their prey or habitat are insignificant and thus may affect, but are not likely to adversely affect these species.

8.1.1.6.4 Chemicals

Several Navy training and testing activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed marine mammals or their prey. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares and missiles combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment. Flares and missiles that operationally fail may release perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals if in sufficient concentration. However, such concentrations would be localized and are not likely to persist in the ocean. Research has demonstrated that perchlorate did not bioconcentrate or bioaccumulate, which was consistent with the expectations for a water-soluble compound (Furin et al. 2013). Given the dynamic nature of the environment (currents, tides, etc.), long-term impacts from perchlorate in the environment near the expended item are not expected. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on ESA-listed marine mammal prey or habitat. In summary, the effects of chemicals used during Navy training and testing on blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals in the PMSR action area via water quality and prey are considered discountable.

In summary, we find it extremely unlikely that blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals would be exposed to toxic levels of explosives, explosive byproducts, metals, or other chemicals resulting from PMSR activities. This is based on the information provided above regarding the potential for explosives and byproducts, metals, and chemicals to affect blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals through habitat and prey availability impacts. Therefore, the effects of secondary stressors from PMSR activities on blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sperm whales, and Guadalupe fur seals are considered discountable. Thus, we conclude that habitat and prey availability impacts due to exposure to explosives, explosive byproducts, metals, or other chemicals resulting from the proposed action may affect, but are not likely to adversely affect these species.

8.1.2 Sea Turtles

Our analysis of the effects of acoustic stressors, energy stressors, entanglement stressors, ingestion stressors, physical disturbance and strike stressors, and potential secondary stressors on sea turtles is summarized below.

8.1.2.1 Acoustic Stressors – Sea turtles

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action that we determined are not likely to adversely affect sea turtles. The effects of acoustic stressors which we determined are likely to adversely affect leatherback sea turtles (i.e., explosives) are discussed in Section 8.2.2.

8.1.2.1.1 Effects of Vessel Noise on Sea Turtles

Additional information on vessel noise as a potential stressor associated with the proposed action can be found in Section 5.1.2.

Sea turtles could be exposed to a range of vessel noises within their hearing abilities. The Navy vessels will produce low-frequency, broadband underwater sound below one kilohertz for larger vessels, and higher-frequency sound between one kilohertz to 50 kilohertz for smaller vessels, although the exact level of sound produced varies by vessel type. Depending on the context of exposure, responses of sea turtles in the action area to vessel noise disturbance would include startle responses, avoidance, or other behavioral reactions, physiological stress responses, or no measurable response.

Limited information is available on how or if sea turtles may respond to noise from Navy vessels during PMSR activities. As discussed previously, Hazel et al. (2007) suggested that sea turtles may rely more on visual than auditory cues when reacting to approaching vessels. Additionally, there is evidence that reptiles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013) and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). This suggests that if sea turtles were to respond to a Navy vessel, the animal might not respond to the vessel based on noise alone. Popper et al. (2014a) noted that available information on the effects of vessel noise or other continuous sounds on sea turtles is lacking. The only potential effect Popper et al. (2014a) suggested could occur from vessel noise was a behavioral response or masking, with a higher likelihood of a behavioral response occurring the closer the sea turtle is to the vessel.

Compared to marine mammals that are highly adapted to use sound in the marine environment, sea turtles are less dependent on sound and their hearing is more limited in range to very low frequencies. Any masking of biologically important sounds for sea turtles would be temporary, occurring only when a vessel and sea turtle are in close proximity to one another. The short, temporary exposure, would not have any measurable effects on an animal's fitness.

If a sea turtle responded behaviorally to noise from a Navy vessel, most responses would consist of slow movements away from vessels the animals perceive are on an approaching course, perhaps accompanied by slightly longer dives. Changes in behavior would likely consist of a temporary shift from behavioral states that have low energy requirements (resting or milling) to behavioral states with higher energy requirements (foraging, active swimming or traveling) and then returning to the resting or milling behavior shortly thereafter. Any behavioral responses to vessel noise are expected to be temporary (e.g., a startle response, brief avoidance behavior). We expect individual sea turtles that exhibit a temporary behavioral response will return to baseline behavior immediately following exposure to the vessel noise.

For these reasons, vessel noise is expected to cause minimal disturbance to sea turtles. If a sea turtle detects a vessel and avoids it, or has a temporary stress response from the noise disturbance, these responses are expected to be temporary and only endured while the vessel transits through the area where the sea turtle encountered it. Sea turtle responses to vessel noise disturbance are extremely minor, and a sea turtle would be expected to return to normal behaviors and baseline stress levels shortly after the vessel passes. As a result, we find that the likely effects from exposure to vessel noise resulting from the proposed action on ESA-listed sea turtles are insignificant and thus vessel noise may affect, but is not likely to adversely affect leatherback sea turtles.

8.1.2.1.2 Effects of Aircraft Noise on Sea Turtles

Additional information on aircraft as a potential stressor associated with the proposed action can be found in Section 5.1.3.

Based on sea turtle sensory biology (Ketten and Bartol 2006; Lenhardt et al. 1994; Ridgway et al. 1969), sound from low flying aircraft could be heard by a sea turtle at or near the surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow. This suggests that sea turtles might not respond to aircraft overflights based on noise alone.

Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead at relatively high speeds. Exposure to helicopter overflights may last longer and would have a higher likelihood of causing a behavioral response from a sea turtle due to the lower flight altitudes and longer duration the helicopter could be in proximity to an animal. The Navy proposes to conduct exercises involving helicopters both during the day and night. These exercises may occur for extended periods of time, up to a couple of hours in some areas. During these activities, helicopters would typically transit throughout an area and may hover over the water. Longer duration activities (such as a couple of hours) and periods of time where helicopters hover may increase the chance that a sea turtle may startle, change swimming patterns, or have a physiological stress response. Exposures to both sorts of aircraft would be infrequent based on the transitory and dispersed nature of the overflights and repeated exposure to individual animals over a short period of time (hours or days) is extremely unlikely. Furthermore, the SEL would be relatively low to sea turtles that spend the majority of their time underwater and may not even detect the aircraft depending on where they are at in the water column at the time of the overflight.

As with vessel disturbance above, little information is available on how sea turtles respond to aircraft. The working group that developed the 2014 ANSI Guidelines for fish and sea turtles Popper et al. (2014a) did not consider this specific acoustic stressor for sea turtles, in part because it is not considered to pose a great risk. For the purposes of this consultation, we assume sea turtles in the action area may exhibit similar short-term behavioral responses (e.g., diving, changes in swimming direction, etc.) consistent with those behaviors observed during aerial research surveys of sea turtles. We are unaware of any data on the physiological responses sea turtles exhibit to aircraft, but we conservatively assume a low-level, short-term stress response is possible. There could also be temporary masking of biologically relevant cues from exercises that generate longer duration of sound exposure with a hovering helicopter. However, in general aircraft overflight is brief, and does not persist in the action area for significant periods of time (not longer than a few hours), nor is the sound expected to be transmitted well into the water column. Thus, the risk of masking any biologically relevant sound to sea turtles is considered very low. A sea turtle could leave the area where noise disturbance persists for a few hours, and thereby avoid continued disturbance. Any startle reactions that occur are expected to be brief, with sea turtles resuming normal behaviors once the aircraft is no longer detectable or leaves the area. Due to the short-term nature of any exposures to aircraft and the brief responses expected to the noise or visual disturbance produced, the effects of aircraft overflight noise on sea turtles is considered temporary and minor. As a result, we find that the likely effects from exposure to aircraft overflight noise resulting from the proposed action on leatherback sea turtles are insignificant and thus may affect, but are not likely to adversely affect these species.

8.1.2.1.3 Effects of Weapons Firing, Launch, and Impact Noise on Sea Turtles

Additional information on weapons noise as a potential stressor associated with the proposed action can be found in Section 5.1.4.

Sea turtles may be exposed to sounds caused by weapons firing (guns, missile, torpedoes), objects dropping in the water, and inert impact of non-explosive munitions on the water's surface. In general, these are impulsive sounds generated in close proximity to or at the water surface (with the exception of items that are launched underwater). Most in-air weapons noise is expected to be reflected at the air-water interface, and as such is not expected to transmit deep into the water column, nor to propagate across a large expanse of surface waters. The resulting noise would be limited and strongest underwater just below the surface and directly under the firing point of the weapon. Sound produced from missile and target launches is typically the highest near the initiation of the booster rocket and rapidly fades as the missile or target travels downrange from the firing point (Navy 2018a).

The highest level of sound expected to transmit to the water would be from large-caliber guns fired at the lowest elevation angle with peak levels of sound directly below the blast. These peak levels are approximately 200 dB (re 1 µPa). These levels are lower than the impulsive sound pressure thresholds that are thought capable of causing hearing impairment or injury to sea turtles, but higher than the rms value (175 dB) that could elicit a behavioral response. Therefore, the potential effects that are more likely to result from weapons noise exposure for sea turtles are temporary behavioral responses, masking, and concurrent stress responses.

Noise produced from firing weapons is expected to last only a few seconds. Most incidents of impulsive sounds produced by weapons firing, launch, or inert object impacts would be single events, with the exception of gunfire activities (Navy 2018a). Gunfire activities could produce multiple shots fired in a brief period of time. Given that these sounds are below injury criteria for sea turtles, and are expected to be very brief and intermittent over the duration of activities in the action area, only brief startle reactions, diving responses or other avoidance behaviors are likely to occur for sea turtles. For the same reasons, masking of biologically relevant sounds is also not expected to occur for sea turtles because weapons noise would not persist for a long enough duration, and sea turtles are more likely to rely on other senses to detect environmental cues such as visually or through orientation to the earth's magnetic field.

For the reasons above, any physiological stress and behavioral reactions from weapons firing noise would likely be brief and are expected to return to normal shortly after the weapons noise ceases. Therefore, the effects on sea turtles from weapons noise exposure are anticipated to be minor, temporary and will not lead to a significant disruption of normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Likely responses to weapons noise would be short-term with sea turtles returning to normal behaviors and baseline stress levels shortly after the weapon is fired. In summary, we find that the likely effects from exposure to weapons noise resulting from the proposed action on leatherback sea turtles are insignificant and thus may affect, but are not likely to adversely affect these species.

8.1.2.2 Effects of Lasers on Sea Turtles

The maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (U.S. Department of the Navy 2010b). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich 2004). An assessment on the use of low-energy lasers by the Navy determined that low-energy lasers, including those involved in the proposed PMSR activities, have an extremely low potential to impact any marine species (U.S. Department of the Navy 2010b).

The primary concern with lasers used during Navy training and testing is the potential for a sea turtle to be struck by a high-energy laser beam. As discussed previously, high-energy laser weapons testing involves the use of up to 30 kilowatts of directed energy as a weapon against small surface vessels and airborne targets. These weapons systems are deployed from surface ships and helicopters to create small but critical failures in potential targets and used at short ranges from the target (Navy 2018a). Traumatic burns from the high-energy beam could result in injury or death of a sea turtle. Sea turtles could only be exposed to the beam if the laser missed the target and inadvertently hit a sea turtle was located near the target. If this were to occur it would likely be for turtles located at or near the surface. The following safeguards are in place to reduce the probability of the a high-energy laser striking the water: 1) the high-energy laser platform has provisions that prevent misfiring (i.e., firing when not intended) that all but eliminate the possibility of that event, 2) the high-energy laser platforms have built-in constraints that only permit firing when it is locked onto a target, and 3) the operators are trained to stop firing when the laser aim point moves off of the selected target. Laser platforms are typically on helicopters and ships, which may cause sea turtles to move away from the area for reasons such as ship or aircraft noise, making a strike from the laser beam less likely.

Based on the characteristics of activities that would use high-energy laser weapons (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely avoidance behavior of stressors, we consider it extremely unlikely that sea turtles would be exposed to high energy lasers. Therefore, potential effects from lasers on ESA-listed sea turtles are discountable. Thus, we conclude that the use of high-energy laser weapons as part of the proposed action may affect, but is not likely to adversely affect leatherback sea turtles.

8.1.2.3 Physical Disturbance and Strike Stressors – Sea Turtles

This section summarizes our analysis of the potential impacts of the various types of physical disturbance, including the potential for strike, during training and testing activities within the action area from vessels, in-water devices, military expended materials (including non-explosive practice munitions and fragments from high-explosive munitions), and seafloor devices.

8.1.2.3.1 Effects of Vessel Strike on Sea Turtles

Additional information on vessel strike as a potential stressor associated with the proposed action can be found in Section 5.3.1.

Although possible, sea turtle vessel strike is unlikely to occur offshore given the anticipated low offshore density of these species and sporadic, widely dispersed Navy vessel traffic throughout the vast offshore area. There has never been a documented case of a sea turtle vessel strike by a Navy vessel in the PMSR action area. In addition, the Navy has proposed procedural mitigation for vessel movement to limit the potential for strikes of sea turtles (see Sections 3.5.1.6 for details). Therefore, we find that the likelihood of an ESA-listed sea turtle vessel strike as a result of the proposed action is extremely unlikely, and thus discountable. We conclude that vessel strike associated with the proposed action may affect, but is not likely to adversely affect leatherback sea turtles.

8.1.2.3.2 Effects of Military Expended Materials on Sea turtles

Additional information on military expended materials as a potential stressor associated with the proposed action can be found in Section 5.3.2.

While no strike of sea turtles from Navy military expended materials has ever been reported or recorded, the possibility of a strike still exists. We considered the potential for sea turtle strike resulting from PMSR activities involving the following types of military expended materials: 1) all sizes of non-explosive practice munitions, 2) fragments from high-explosive munitions, 3) expendable targets and target fragments; and 4) expended materials other than munitions, such as sonobuoys, expended bathythermographs, and torpedo accessories.

Sea turtles are expected to be widely distributed in the offshore portion of the action area. While disturbance or strike from any expended material as it falls through the water column is possible, it is extremely unlikely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.2 meters per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile species such as sea turtles. The anticipated low offshore density of ESA-listed sea turtles in the action area further decreases the likelihood of a strike from military expended materials. In addition, the Navy has proposed procedural mitigation for vessel movement and standard operating procedures for towed-in water devices to limit the potential for strikes of sea turtles where military expended materials are used in offshore environments (see Sections 3.5.1.6 and 3.4.5 for details).

In summary, NMFS considers it extremely unlikely for a sea turtle to be struck by military expended materials. Any individuals encountering military expended materials as they fall through the water column are likely to move to avoid them. The effort expended by individuals to avoid them will be minimal (i.e., a few meters distance) and temporary, behavioral avoidance of military expended materials sinking through the water column is likely inconsequential to an individual sea turtle. For these reasons, we find the potential effects from physical disturbance and strike with military expended materials for leatherback sea turtles are discountable (in the case of strikes) or insignificant (in the case of behavioral response) and thus these stressors may affect, but are not likely to adversely affect these species.

8.1.2.3.3 Effects of In-water Devices on Sea Turtles

Additional information on in-water devices as a potential stressor associated with the proposed action can be found in Section 5.3.3.

Despite thousands of Navy exercises in which in-water devices have been used, there have been no recorded instances of marine species strikes from these devices. Most devices do not have a realistic potential to strike living marine species because they either move slowly through the water column (e.g., most unmanned underwater vehicles) or are closely monitored by observers manning the towing platform who ensure the towed in-water device does not run into objects in the water. The Navy will implement mitigation to avoid potential impacts from in-water device strikes on sea turtles throughout the action area. Mitigation includes training Lookouts and watch personnel to identify sea turtles and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified distance from sea turtles. For these reasons, NMFS considers it extremely unlikely for any ESA-listed sea turtle to be struck by an in-water device. It is possible that sea turtles that occur in areas that overlap with in-water device use may experience some level of physical disturbance, but it is not expected to result in more than a momentary behavioral response. Any avoidance behavior would be of short duration and intensity such that it would be minor and temporary for the animal. In addition, the Navy has proposed standard operating procedures for towed-in water devices to limit the potential for strikes of sea turtles (see Sections 3.4.5 for details). Therefore, the potential effects on sea turtles from an in-water device strike are extremely unlikely to occur and are considered discountable. The potential effects on leatherback sea turtles from physical disturbance caused by in-water devices are insignificant, and thus may affect, but not likely to adversely affect these species.

8.1.2.4 Entanglement Stressors – Sea Turtles

Sea turtles could encounter expended materials used during PMSR activities that may result in entanglement. Turtles could encounter these items at the water's surface, in the water column, or along the seafloor. Many factors influence the degree of entanglement risk for sea turtles such as and life stage and size, sensory capabilities, and foraging methods (i.e. along the seafloor or in the water column). Similar to other marine animals, most entanglements associated with sea turtles are from materials that float or are suspended at the ocean's surface for long periods of time, such as fishing gear. This is particularly true for leatherback turtles which feed almost exclusively on soft-bodied invertebrates (i.e., jellyfish and tunicates) floating in the water column. Entanglement stressors associated with the proposed action (i.e., wires, cables, decelerators, and parachutes) are discussed further in Section 5.3.3.

8.1.2.4.1 Effects of Entanglement in Decelerators and Parachutes on Sea turtles

Parachutes and decelerators used by the Navy as part of the proposed action could potentially be encountered by ESA-listed sea turtles at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with these materials have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a sea turtle encounters them. The primarily large and extra-large decelerators and parachutes proposed for use in the PMSR may pose a higher degree of risk for sea turtles because these parachutes are larger and have long lines (large chutes have 28 cords, approximately 40 to 70 ft long; extra-large parachutes have 64 cords, up to 82 ft long), associated with them. Additionally, large parachutes are not weighted with anything to help them sink rapidly, and could potentially remain suspended in the water column for approximately 20 minutes. By contrast, small and medium sized parachutes and decelerators would not remain suspended in the water column for more than a few minutes. Small and medium decelerators and parachutes with weights are expected to remain at the surface for 5 to 15 seconds before the housing sinks to the seafloor where it becomes flattened (Navy 2019b).

Since leatherbacks are known to forage on jellyfish at or near the surface, exposure would involve either the decelerator or parachute landing directly on the turtle or the turtle swimming into it before it sinks. The likelihood of this occurring is very low. During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. This standard operating procedure could further reduce the potential entanglement of sea turtles in large decelerators/parachutes.

Overall, given the low density of sea turtles in the action area, the small number (i.e., less than ten annually) of parachutes/decelerators that would not be recovered, and the vast area over which any one of these decelerators and parachutes would be deployed, the chances of a sea turtle encountering one and becoming entangled is extremely low. Therefore, the potential effects to leatherback sea turtles from entanglement in decelerators and parachutes are considered extremely unlikely and thus these stressors may affect, but are extremely unlikely to affect these animals.

8.1.2.5 Ingestion Stressors – Sea turtles

Additional information on ingestion stressors associated with the proposed action can be found in Section 5.5.

The munitions and other expended materials that we consider small enough to be ingested by sea turtles are small and medium caliber projectiles (up to 2.25 in), broken pieces of firing targets, chaff, flare casings (caps and pistons), decelerators and parachutes (cloth, nylon and metal weights) and shrapnel fragments from high-explosives ordnance. Types of munitions that can result in fragments small enough to be ingested include demolition charges, projectiles, missiles, and bombs. The size of these fragments would vary depending on the NEW and munitions type. Other munitions and munitions fragments such as large-caliber projectiles or intact training and testing bombs are too large for sea turtles to consume.

Most expendable materials would be used over deep water and are expected to sink quickly and settle on the seafloor, with the exception of chaff and some firing target materials (Navy 2018a). Because they typically forage in the water column either at or near the surface, it is unlikely that sea turtles would be susceptible to ingesting expended materials that sink quickly to the bottom.

Chaff fibers are too small for sea turtles to confuse with prey and forage, but there is the possibility that sea turtles could come in contact or accidentally ingest some of the chaff material. Given the low concentration that would be ingested, the small size of the fibers, and the anticipated low toxicity (Arfsten et al. 2002), any accidental ingestion of chaff by sea turtles feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from a significant disruption of normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Firing target materials, which may also float on the surface, are normally retrieved before sinking so it is unlikely that sea turtles would ingest such materials (Navy 2018a).

Chaff cartridge plastic end caps and pistons and flare pads and pistons would also be released into the marine environment during PMSR activities. These materials may persist in the environment for long periods, and therefore could be ingested by sea turtles while initially floating on the surface or sinking through the water column (Navy 2018a). These materials would eventually sink to the seafloor where they would be less likely to be ingested by leatherback sea turtles that forage at or near the surface.

The chances of a sea turtle ingesting expended materials in the water column increase if it is within close proximity to falling munitions, mistakes a sinking munition for prey, and reacts quickly enough to ingest the sinking material. This is an unlikely scenario given their feeding habits and low density of ESA-listed sea turtles in the action area. The likelihood of this occurring would be further reduced by the Navy's mitigation measures, such as avoiding mats of floating vegetation and having Lookouts posted to detect sea turtle presence in the area prior to discharging weapons (Navy 2018a).

We have no information indicating that military expended materials have been found in sea turtles that have been necropsied, unlike plastics that appear similar to jellyfish or other turtle prey and are found in a large proportion of sea turtles worldwide (Schuyler et al. 2016). Sea turtles may attempt to ingest a projectile fragment and then reject it, after realizing it is not a food item. If material is ingested, most ingestible-sized items would likely be spit out or passed through the digestive tract without significantly impacting the individual. Therefore, negative impacts of fragment ingestion may be limited to the unlikely event of an item that becomes embedded in tissue or is too large to be passed through the digestive system. If the material or fragment is particularly large in proportion to the turtle ingesting it, the item could become permanently encapsulated in the stomach lining and, although rare, could impede the turtle's ability to feed or take in nutrients. However, the likelihood of this occurring would be low. In addition, given the anticipated wide dispersal of expended materials (other than munitions) throughout the action area, and the short duration of time these military expended materials would remain in the water column, the probability of a sea turtle encountering these materials is low. In summary, we believe adverse effects resulting from the ingestion of expended materials are extremely unlikely to occur and thus discountable and conclude that ingestion of expended materials associated with the proposed action may affect, but is extremely unlikely to affect leatherback sea turtles.

8.1.2.6 Stressors Resulting in Effects to Sea Turtle Habitat or Prey

Stressors from training and testing activities that could result in secondary effects on sea turtles via impacts to habitat, prey, and water quality include explosives, metals, chemicals, and other expended materials.

Explosions could impact other species in the food web, including prey species that ESA-listed sea turtles feed upon. Leatherback sea turtles prey mainly on various types of jellyfish. The occurrence and distribution of jellyfish in the action area are dependent on the physical oceanographic conditions in the California Current Ecosystem. The abundance of jellyfish prey near the detonation point could be diminished for a short period of time, before being repopulated by animals from adjacent waters. Any of these scenarios would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. In addition, the impacts of explosions would differ depending on the type of prey species in the area of the blast. For the reason state above, we believe the effects of explosives on sea turtles via impacts to their prey will be insignificant.

Sea turtles could be exposed to metals introduced into the water column as a result of PMSR activities involving targets, munitions, and other military expended materials. Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. A variety of heavy metals have been found in sea turtles tissues in levels that increase with turtle size. These include arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc, (Barbieri 2009; Fujihara et al. 2003; García-Fernández et al. 2009; Godley et al. 1999; Storelli et al. 2008). Cadmium has been found in leatherbacks at the highest concentration compared to any other marine vertebrates (Gordon et al. 1998). However, biomagnification of trace elements via trophic transfer might be limited in leatherbacks due to their lower trophic level diet of cnidarian zooplankton (Harris et al. 2011).

Evidence from a number of studies indicate metal contamination is highly localized and that bioaccumulation resulting from munitions cannot be demonstrated (Briggs et al. 2016; Edwards and coauthors. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013b). Because leatherbacks do not forage at or near the seafloor, contamination from metals accumulated in sediments is extremely unlikely to occur. Due to the extremely low concentrations of metals resulting from the proposed action in the open ocean, it is extremely unlikely that sea turtles or their prey would be impacted by exposure to metals via the water or sediment. Therefore, the effects of metals introduced into seawater and sediments as a result of the proposed action on leatherback sea turtles are extremely unlikely to occur, and thus discountable.

Navy training and testing activities also introduce chemicals into the marine environment that are potentially harmful in higher concentrations. Rapid dilution would be expected and toxic concentrations are unlikely to be encountered by sea turtles or their prey. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment. Flares and missiles that operationally fail may release perchlorate. However, research has demonstrated that perchlorate does not bioconcentrate or bioaccumulate (Furin et al. 2013). Given the dynamic nature of the environment (currents, tides, etc.), long-term impacts from perchlorate in the environment near the expended item are not expected. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on leatherback sea turtle prey or habitat.

In summary, the effects of chemicals used during Navy training and testing on leatherback sea turtles via water quality and prey are extremely unlikely to occur and thus discountable. Therefore, we belive these stressors may affect, but are not likely to adversely affect leatherback sea turtles.

8.2 Stressors Likely to Adversely Affect ESA-listed Species

Of all the potential stressors resulting from the proposed PMSR training and testing activities (see Section 5 *Potential Stressors*), we determined that only stressors associated with the use of explosives would likely result in adverse effects to ESA-listed blue whale, fin whale, humpback whale (Central America and Mexico DPSs), sperm whale, Guadlaupe fur seal, and leatherback sea turtle. In the following sections, we consider the exposures that could cause an effect on ESA-listed species that are likely to co-occur with the effects of explosives on the environment in space and time, and identify the nature of that co-occurrence. We consider the frequency and intensity of exposures that could cause an effect on blue whale, fin whale, humpback whale (Central America and Mexico DPSs), sperm whale, Guadalupe fur seal, and leatherback sea turtle and, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or subpopulation(s) those individuals represent. We also consider the responses of the ESA-listed species to exposure. While NMFS recognizes that Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assume that the training and testing activities proposed by the Navy during the seven-year period of NMFS' proposed LOA under the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed during this consultation.

8.2.1 Marine Mammals

Additional information on explosives as a potential stressor associated with the proposed action can be found in Section 5.1.1. For a discussion of the criteria and thresholds used to predict impacts from explosives on marine mammals, see Section 2.2.2.

Explosives occurring in-air or near the water surface at PMSR include detonations of bombs, missiles, rockets, and naval gun shells. There are no fully underwater explosives proposed for use in the PMSR. All explosives used during testing and training activities at the PMSR would detonate in air, with a subset of those occurring at or near the water's surface (near being defined here as at a height within 10 m above the surface). Explosions near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. Research indicates that an in-air shock wave loses the majority of its energy crossing the air-water interface (Bolghasi et al. 2017; Chapman and Godin 2004; Cheng and Edwards 2003; Moody 2006; Richardson et al. 1995a; Sawyers 1968; Sohn et al. 2000a; Swisdak 1975; Waters and Glass 1970; Woods et al. 2015). Farther from the point of detonation, the peak pressure decays and the explosive waves propagate as an impulsive, broadband sound lacking the high peak pressures nearer to the source (U.S. Navy 2021).

Assessing whether an explosive detonation may disturb or injure a marine mammal involves understanding the characteristics of the explosive sources, the marine mammals that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on marine mammal hearing and behavior. Many other factors besides just the received level or pressure wave of an explosion such as the animal's physical condition and size;

prior experience with the explosive sound; and proximity to the explosion may influence physiological effects and behavioral reactions.

The potential range of effects from explosions include death, physical injury or trauma, observable behavioral response, and stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Permanent or temporary hearing loss may occur as well. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Behavioral responses range from brief distractions to avoidance of a sound source to prolonged flight. The sections below provide additional background on the potential effects of explosives on marine mammals. In our exposure and response analyses below, we use this information to discuss the likely effects of Navy PMSR explosive use on ESA-listed marine mammals.

8.2.1.1.1 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 will vary depending on the frequency of the noise, with frequencies at and above the noise frequency most strongly affected (i.e., higher amount of threshold shift). The amount of hearing loss may range from slight to profound. Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. Hearing threshold shifts in mid-frequency cetaceans exposed to non-impulsive sound (e.g., active sonar tones) has been investigated in multiple studies (e.g., Finneran et al. 2010; Finneran et al. 2005; Finneran and Schlundt 2013; Mooney et al. 2009a; Mooney et al. 2009b).

Hearing loss is typically quantified in terms of threshold shift — the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of threshold shift measured

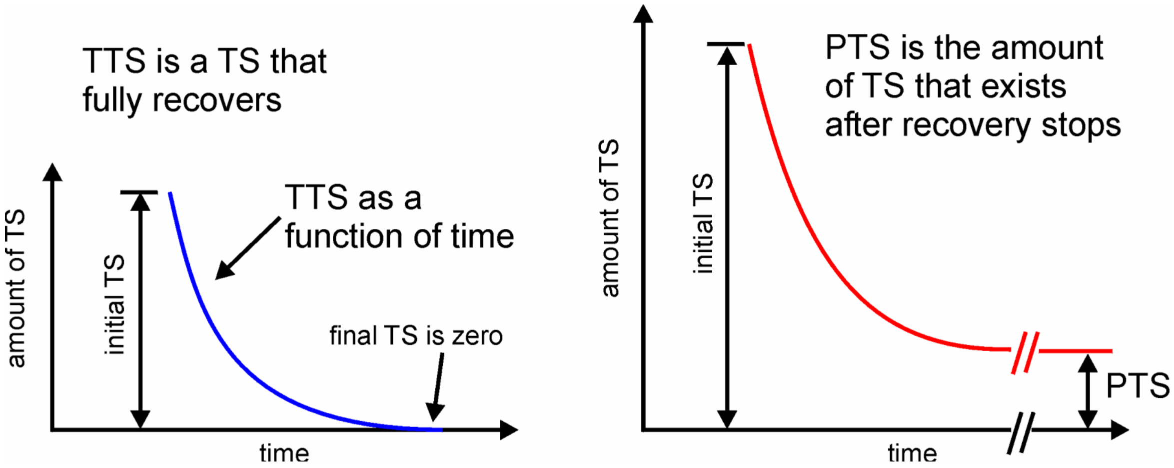

Figure 39. Two hypothetical threshold shifts.

usually decreases with increasing recovery time — the amount of time that has elapsed since a noise exposure. If the threshold shift eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is considered temporary or TTS. If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is determined to be permanent or PTS. Figure 40 shows two hypothetical threshold shifts: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

Studies have revealed that intense noise exposures may also cause auditory system injury that does not result in PTS (i.e., hearing thresholds return to normal after the exposure, but there is injury nonetheless). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure, 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 with a TTS in auditory-evoked potential up to approximately 50 dB, measured 24 hours post-exposure resulting in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury because exposures producing high levels of TTS (40 to 50 dB measured 24 hours after exposure) — but no PTS — may result in auditory injury or impairment.

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). Further, TTS and PTS are mutually exclusive because an exposure that produces TTS cannot also produce PTS within the same frequency band in the same individual (Reichmuth et al. 2019). If an initial threshold shift results in only partial recovery, resulting in some amount of PTS, the difference between the initial threshold shift and the PTS is not called TTS. As TTS increases, the likelihood that additional exposure or duration to sound will result in PTS and/or other injury also increases. An exception to this is that researchers might not be able to observe gradual growth of TTS with increased levels of sound exposure before onset of PTS (Reichmuth et al. 2019). Similarly, PTS can occur without measurable behavioral modifications (Reichmuth et al. 2019). Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS. 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 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al. 1965; Ward 1960). It is reasonable to assume the same relationship would hold for marine mammals because there are many similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran et al. 2005; Finneran et al.

2015; Ketten 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately four minutes after exposure represent the limit of a non-injurious exposure; i.e., higher level exposures have the potential to cause auditory injury. Exposures sufficient to produce a TTS of 40 dB, measured approximately four minutes after exposure therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS, or other auditory injury such as the delayed neural degeneration identified by Kujawa and Liberman (2009) and Lin et al. (2011) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in marine mammals (See Finneran et al. 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 et al. 2015).
- The amount of TTS varies with the hearing test frequency. The higher the SPL, the higher the TTS induced at frequencies higher than the exposure frequency (1-2 kHz down-sweeps); below 148 dB re 1 μPa, the maximum TTS was at 6.5 kHz, whereas above 148 dB re 1 μPa, the maximum TTS was at 9.2 kHz (Kastelein et al. 2014a). For high level exposures to tonal or octave band sounds, 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. 2013; Popov et al. 2011; Reichmuth et al. 2019; 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 usually increases with exposure SPL and duration, and is correlated with SEL, especially if the range of exposure durations is relatively small (Kastak et al. 2007; Kastelein et al. 2014a; Popov et al. 2014). As the exposure duration increases, 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 and Schlundt 2010; 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 cetacean 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 that are well below the frequency level of best sensitivity are less hazardous than those at or near the level of best sensitivity (Finneran and Schlundt 2013). The onset of TTS — defined as a threshold shift of six dB measured approximately four minutes after exposure (i.e., clearly above the typical variation in threshold measurements) — also varies with exposure frequency. At low frequencies TTS onset exposure levels are higher compared to those in the region of best sensitivity. However, gradual increases of TTS may not be directly observable with increasing exposure levels before the onset of PTS, which can occur without measurable behavioral modifications (Reichmuth et al. 2019).
- 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. 2010; Kastelein et al. 2015; Kastelein et al. 2014a; Mooney et al. 2009b). This means that TTS predictions based on the total, cumulative SEL will likely 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., approximately 40 dB) may require several days or longer for recovery. Recovery times are consistent for similar-magnitude shifts, regardless of the type of fatiguing sound exposure (impulsive, continuous noise band, or sinusoidal) (Kastelein et al. 2019). Under many circumstances TTS recovers linearly with the logarithm of time (Dear et al. 2010; Finneran et al. 2010; Finneran and Schlundt 2013; Kastelein et al. 2013a; Kastelein et al. 2012a; Kastelein et al. 2012b; Kastelein et al. 2014a; Kastelein et al. 2014b; Popov et al. 2014; Popov et al. 2013; Popov et al. 2011). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., six dB recovery per doubling of time), although this may not hold for all sound sources and species.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of man-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include sonars, transducers, and impulsive sound sources such as air guns, explosives, and impact pile driving. Of these sources, only explosives detonating at or above the water surface would be used by the Navy in PMSR. Recent studies have begun to show that some cetaceans may learn to reduce their hearing sensitivity (presumably to protect their hearing) when warned of an impending intense sound exposure (Finneran 2018; Nachtigall and Supin 2013; Nachtigall et al. 2016).

Southall et al. (2019) updated scientific information after evaluating Southall et al. (2007a) to propose revised noise exposure criteria to predict onset of auditory effects in marine mammals (i.e., PTS and TTS onset). Southall et al. (2019) note that the quantitative processes described and the resulting exposure criteria (i.e., thresholds and auditory weighting functions) are largely identical to those in Finneran (2015a) and NMFS (2016b); NMFS (2018b). However, they differ in that the Southall et al. (2019) exposure criteria are more broadly applicable as they include all marine mammal species (rather than those only under NMFS jurisdiction) for all noise exposures (both in air and underwater for amphibious species), and that while the hearing group compositions are identical they renamed the hearing groups. The thresholds discussed in the paper (TTS/PTS only) are the same as the Navy's criteria and NMFS’ criteria.

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.

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 AEP-measured TTS of 7 to 20dB in a harbor porpoise exposed to single impulses from a seismic air gun.

In addition to these studies, a number of impulsive noise exposure studies have been conducted without behaviorally measurable TTS of 6 dB or more. The results of these studies are either consistent with the Navy criteria and thresholds (e.g., exposure levels were below those predicted to cause TTS and TTS did not occur) used to support the analysis for the proposed action or suggest that the thresholds used to support the analysis for the proposed action overestimate the potential for impact (e.g., exposure levels were above thresholds used to support the analysis for the proposed action, but TTS did not occur).

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

8.2.1.1.2 Non-Auditory Injury

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

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

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. 1973a; 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.

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. 1973a; Yelverton et al. 1973). Specific physiological observations for each test animal are documented in Richmond et al. (1973a). Gas-containing internal organs, such as lungs and intestines, were the principle damage sites in submerged terrestrial mammals; this is consistent with earlier studies of mammal exposures to underwater explosions in which lungs were consistently the first areas to show damage, with less consistent damage observed in the gastrointestinal tract (Corey et al. 1943; Ward and W. 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

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 cetaceans 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 cetaceans 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. 2014; 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 kilograms) to underwater detonations, Richmond et al. (1973a) reported that no blast injuries were observed when exposures were less than six pounds per square inch per millisecond (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 gastrointestinal tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25-27 psi-ms (170-190 Pa-s). Lung injuries were found to be slightly more prevalent than gastrointestinal tract injuries for the same exposure.

The Lovelace subject animals were exposed near the water surface; therefore, depth effects were not discernible in this data set. In addition, this data set included only small terrestrial animals, whereas marine mammals may be several orders of magnitude larger and have respiratory structures adapted for the high pressures experienced at depth. Goertner (1982) examined how lung cavity size would affect susceptibility to blast injury by considering both cetacean 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 meters for dolphins (Ridgway and 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 meters 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 and 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 cetaceans exhibiting pre-dive exhalation to reduce the lung volume (e.g., phocid seals; (Kooyman et al. 1973).

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

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

8.2.1.1.3 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 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. Efforts are underway to try to improve understanding of, and the ability to predict, how stressors ultimately affect marine mammal populations (e.g., New et al. 2013a; New et al. 2013b; Pirotta et al. 2015). With respect to acoustically-induced stress, this includes not only determining how and to what degree various types of anthropogenic sounds cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the animal'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 and Branstetter 2013; St Aubin and Dierauf 2001). Because there are many unknowns regarding the occurrence of acoustically-induced stress responses in marine mammals, it is a reasonable assumption 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 fishery interactions, pollution, 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 2000). 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. 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.

Rolland et al. (2017) studied glucocorticoid hormones in North Atlantic right whales, evaluating and comparing healthy whales with whales that were chronically entangled in fishing gear. The authors found that stress hormones in the entangled whales were elevated compared to those of healthy whales. The authors also cited several studies to conclude that stress responses over a short period of time (i.e., hours/days) can be beneficial and life-saving. However, chronic elevations of glucocorticoids (i.e., weeks/months) may result in decreased growth, depressed immune system function, and suppression of reproduction (e.g., Romero and Wikelski 2001; Sapolsky et al. 2000). If the magnitude and duration of the stress response is too great, too long, or occurs at a time when the animal is in a vulnerable state, it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

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 (catecholamines) may be different in marine versus terrestrial mammals. 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 role in mitigating stress response (St Aubin and Dierauf 2001; St. Aubin and Geraci 1989).

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al. 1990) 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, it cannot be determined from this study 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. 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 versus 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, researchers observed a rapid but short-lived decrease in heart rates in harbor and gray seals exposed to seismic air guns (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/kilogram/stroke during preferred swim speeds to a maximum expenditure of 6.41 Joules/kilogram/stroke when freely following a boat. Houser et al. (2020) measured cortisol and epinephrine levels in bottlenose dolphins and found no correlation between these stress hormone levels and received sound pressure levels from mid-frequency sonar signals. Houser et al. (2020) and Houser et al. (2013) observed that the severity of bottlenose dolphin behavioral responses scaled with sound pressure level. Therefore, behavioral reactions to sonar signals may not be indicative of a hormonal stress response.

Similarly, a limited amount of work has addressed how chronic exposure to acoustic stressors affect stress hormones in cetaceans, particularly as it relates to survival or reproduction. 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 reduced 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; Noren et al. 2009). 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. 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 measurements 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.

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. 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.

8.2.1.1.4 Masking

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 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. Their method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2016) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, 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 and Parks 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (e.g., Holt 2008; Holt et al. 2011; 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 and Parks 2016). This shift in frequency was modeled, and it was found that it led to increased detection ranges between right whales. The frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 km to over 9 km (Tennessen and 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 and Finneran 2008). Signal characteristics (e.g., whether the signal has harmonics, or is frequency modulated) may further enhance the detectability of a signal in noise (Cunningham et al. 2014).

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators (Allen et al. 2014; Cummings and Thompson 1971a; Cure et al. 2015), 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 (Cure et al. 2015) changed their behavior in response to killer whale vocalization playbacks. These findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking can also result from exposure to sound from Navy explosives. There are no direct observations of masking in marine mammals due to exposure to explosive sources. Due to the short duration of sound from explosives, the potential for explosives to result in masking that would be biologically significant is limited.

8.2.1.1.5 Behavioral Reactions

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

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 cetacean groups, with only a few studies available for mysticetes and odontocetes. 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 cetaceans, it is likely that these responses represent a worst-case scenario as compared to responses to Navy impulsive sources such as explosives. Navy explosive activities typically consist of a single or multiple explosions occurring over a short period of time in a relatively small area whereas seismic surveys input impulsive sound from airguns into the water column over a long period of time and over a large area (e.g., following a transect).

For their quantitative effects analysis, the Navy assumes that significant behavioral responses to solitary explosions are not anticipated due to the short duration of acoustic exposure from such explosions, but this does not preclude the potential for responses within the range to TTS. There has been very little research conducted on this topic. Depending on numerous factors (e.g., proximity, attentional focus, charge weight of blast, and experience of the animal) the responses of individuals may vary and we would assume some animals would exhibit more of a reaction than others. The mitigation measures that would be implemented (such as exclusion zones) are expected to reduce the potential for significant behavioral responses to occur from exposure to solitary explosions.

8.2.1.1.6 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. 2000b; Richardson et al. 1985; Southall et al. 2007a). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin, and bowhead whales. For the purposes of this analysis, due to the limited amount of data available, 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 to impulsive sources, 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; Malme et al. 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5 to 8 km from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et al. 1998) and up to 3 km from a source vessel moving directly across their migratory path (Dunlop et al. 2017), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al. 2015). When comparing received levels and behavioral responses when using ramp-up versus a constant noise level of airguns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decreased their swim speeds (Dunlop 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 airguns so some of the response was likely due to the presence of the vessel and not the received level of the airguns.

When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different air guns and found responses occurred more towards the smaller, closer source than to the larger source at the same received level, demonstrating the importance of proximity. Responses were found to be more likely when the source was within 3 kilometers or above 140 dB re 1 μPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al. 2017). McDonald et al. (1995a) 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 kilometers of seismic vessels (Richardson et al. 1995c), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 μPa. Additionally, Malme et al. (1988) observed clear changes in diving and breathing patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 μPa. Bowhead whales may also avoid the area around seismic surveys, from 6 to 8 km (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^2s (Di Lorio and 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 to 45 km) where 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 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^2s cumulative SEL, and ceased altogether at received levels over 170 dB re 1 μPa^2s cumulative SEL (Blackwell et al. 2015).

Mysticetes seem to be the most sensitive taxonomic group of cetaceans 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 and short term (i.e., instantaneous for explosives) as compared to sources in these studies, and so responses would likely occur in closer proximity or not at all.

8.2.1.1.7 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. Based on the limited available information, 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). The whales showed no horizontal avoidance, however one whale rested at the water's surface for an extended period of time until air guns ceased firing (Miller et al. 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al. 2009). Similarly, Weir (2008) observed that seismic air gun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to air gun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to air gun impulses within approximately 1 km of the source (Weir 2008). The dolphins were observed at greater distances from the vessel when the air gun was in use, and when the air gun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized or were reluctant to return to the test station after exposure to single impulses from a seismic water gun (Finneran et al. 2002). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran 2015b). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, Florida 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 to 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.

8.2.1.1.8 Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995c) and Southall et al. (2007a). 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 (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 five m (Lalas and 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 and 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. Pinnipeds 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. (2007a)). Pinnipeds may even experience TTS before exhibiting a behavioral response Southall et al. (2007a).

8.2.1.1.9 Impact Range to Effects from Explosives

Section 2.2.2 presented information on the criteria and thresholds used to estimate impacts to marine mammals from explosives. Additional information on these criteria is described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). In this section, we present information on calculated range to effects for various explosive sources used by the Navy as part of the proposed action.

The tables below (Table 26 through Table 33) provide range to effects for explosive sources to the criteria and thresholds described in Section 2.2.2 as they were used as inputs into NAEMO.

The range to effects are shown for a range of explosive bins from E1 (up to 0.25 lb NEW) to E10 (up to 500 lb NEW). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause a non-auditory injury, PTS, TTS and significant behavioral disruption. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure based ranges are estimated using the best available science; however, data on peak pressure at far distances from explosions are very limited. For additional information on how ranges to impacts from explosions were estimated, see the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing Ranges* (Navy 2018b).

Ranges to mortality, based on animal mass, in Table 26 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. Ranges to gastrointestinal tract injury typically exceed ranges to slight lung injury; therefore, the maximum range to effect is not mass dependent (Table 27). 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. SEL-based and peak based range to effects (PTS, TTS, and behavioral for SEL only) for low-frequency cetaceans (i.e., blue, fin, and humpback whales) are shown by bin and cluster size in Table 28 and Table 29, respectively. For mid-frequency cetaceans (i.e., sperm whales), SEL-based and peak based range to effects are shown in Table 30 and Table 31, respectively. Similarly for otariids (i.e., Guadalupe fur seals), SEL-based and peak based range to effects are shown in Table 32 and Table 33, respectively.

Table 26. Ranges to Mortality (in meters) for All Marine Mammal Hearing Groups as a Function of Animal Mass.

Bin[2]	***Range to Mortality (meters) for Various Animal Mass Intervals (kg)***[1]					
	10 kg	***250 kg***	***1,000 kg***	***5,000 kg***	***25,000 kg***	***72,000 kg***
E1	3 (3–3)	1 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E3	9 (7–10)	4 (2–8)	2 (1–2)	1 (0–1)	0 (0–0)	0 (0–0)
E5	13 (12–30)	7 (4–25)	3 (2–7)	2 (1–5)	1 (1–2)	1 (0–2)
E6	16 (15–25)	9 (5–23)	4 (3–8)	3 (2–6)	1 (1–2)	1 (1–2)
E7	55 (55–55)	26 (18–40)	13 (11–15)	9 (7–10)	4 (4–4)	3 (2–3)

E8	42 (25–65)	22 (9–50)	11 (6–19)	8 (4–13)	4 (2–6)	3 (1–5)
E9	33 (30–35)	20 (13–30)	10 (9–12)	7 (5–9)	4 (3–4)	3 (2–3)
E10	55 (40–170)	24 (16–35)	13 (11–15)	9 (7–11)	5 (4–5)	4 (3–4)

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

[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E2 (> 0.25 – 0.5), E3 (> 0.5 – 2.5), E4 (> 2.5 - 5), E5 (> 5 - 10), E7 (> 20 - 60), E8 (> 60 - 100), E10 (> 250 - 500)

Note: kg = kilogram

Table 27. Ranges to non-auditory Injury (in meters) for all marine mammal hearing groups.

Bin[2]	*Range to Non-Auditory Injury (meters)* [1]
E1	12 (11–13)
E3	25 (25–25)
E5	40 (40–65)
E6	52 (50–60)
E7	120 (120–120)
E8	98 (90–150)
E9	123 (120–270)
E10	155 (150–430)

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

Notes: All ranges to non-auditory injury within this table are driven by gastrointestinal tract injury thresholds regardless of animal mass.

[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E2 (> 0.25 – 0.5), E3 (> 0.5 – 2.5), E4 (> 2.5 - 5), E5 (> 5 – 10), E7 (> 20 – 60), E8 (> 60 - 100), E10 (> 250 - 500)

Table 28. Sound Exposure Level (SEL)-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans (i.e., blue, fin, and humpback whales).

Ranges to Effects for Explosives: Low-Frequency Cetaceans (meters)[1]				
Bin	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	1	51 (50–55)	231 (200–250)	378 (280–410)
	18	183 (170–190)	691 (450–775)	934 (575–1,275)
E3	1	113 (110–120)	477 (330–525)	689 (440–825)
	12	327 (250–370)	952 (600–1,525)	1,240 (775–4,025)
E5	20	702 (380–1,275)	1,667 (850–11,025)	2,998 (1,025–19,775)
E6	1	250 (190–410)	882 (480–1,775)	1,089 (625–6,525)
E7	1	794 (775–900)	4,892 (2,775–6,275)	9,008 (3,775–12,525)
E8	1	415 (270–725)	1,193 (625–4,275)	1,818 (825–8,525)
	1	952 (900–975)	6,294 (3,025–9,525)	12,263 (4,275–20,025)
E9	1	573 (320–1,025)	1,516 (725–7,275)	2,411 (950–14,275)
E10	1	715 (370–1,525)	2,088 (825–28,275)	4,378 (1,025–32,275)

[1] Average distance (meters; minimum and maximum distances due to varying propagation environments in parentheses) to PTS, TTS, and behavioral thresholds. Values depict the range produced by SEL hearing threshold criteria levels.

Notes: PTS = permanent threshold shift; SEL = sound exposure level; TTS = temporary threshold shift

Table 29. Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Low Frequency Cetaceans (i.e., blue, fin, and humpback whales).

Range to Effects for Explosives: Low-Frequency Cetaceans (meters)[1]		
Bin	**PTS**	**TTS**
E1	135 (130–140)	249 (220–270)

E3	292 (240–310)	499 (330–550)
	310 (310–310)	583 (550–600)
E5	451 (310–525)	740 (410–1,025)
E6	547 (350–700)	842 (460–1,275)
E7	927 (900–950)	1,524 (1,275–1,525)
E8	799 (450–925)	1,030 (575–1,775)
E9	947 (500–1,275)	1,294 (675–3,025)
E10	1,032 (550–1,775)	1,388 (800–4,275)

[1] Average distance (meters; minimum and maximum distances due to varying propagation environments in parentheses) to PTS and TTS are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by peak pressure threshold criteria levels.

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

Table 30. Sound Exposure Level (SEL)-Based Ranges (in meters) to Onset PTS, Onset TTS, and Behavioral Reaction for Mid-Frequency Cetaceans (i.e., sperm whales).

Range to Effects for Explosives: Mid-Frequency Cetaceans (meters)[1]				
Bin	**Cluster Size**	**Range to PTS**	**Range to TTS**	**Range to Behavioral**
E1	1	25 (25–25)	116 (110–120)	199 (190–210)
	18	94 (90–100)	415 (390–440)	646 (525–700)
E3	1	50 (50–50)	233 (220–250)	381 (360–400)
	12	155 (150–160)	642 (525–700)	977 (700–1,025)
E5	20	290 (280–300)	1,001 (750–1,275)	1,613 (925–3,275)
E6	1	98 (95–100)	430 (400–450)	669 (550–725)
E7	1	110 (110–110)	527 (500–575)	1,025 (1,025–1,025)
E8	1	162 (150–170)	665 (550–700)	982 (725–1,025)
E9	1	215 (210–220)	866 (625–1,000)	1,218 (800–1,525)
E10	1	270 (250–280)	985 (700–1,275)	1,506 (875–2,525)

[1] Average distance (meters; minimum and maximum distances due to varying propagation environments in parentheses) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances whichare in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Notes: PTS = permanent threshold shift; SEL = sound exposure level; TTS = temporary threshold shift

Table 31. Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans (i.e., sperm whales).

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]		
Bin	**Range to PTS (meters)**	**Range to TTS (meters)**
E1	43 (40–45)	84 (80–90)
E3	98 (95–100)	183 (170–190)
E5	155 (150–160)	288 (270–300)
E6	197 (190–210)	359 (320–400)
E7	296 (290–300)	525 (525–525)
E8	333 (310–340)	574 (440–625)
E9	442 (370–460)	757 (500–850)
E10	546 (420–700)	939 (550–1,275)

[1] Average distance (meters; minimum and maximum distances due to varying propagation environments in parentheses) to PTS, TTS, and behavioral thresholds. Values depict the range produced by peak pressure threshold criteria levels.

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

Table 32. SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Responses (in meters) for Otariids (i.e., Guadalupe fur seals).

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 to effect is depicted above the minimum and maximum distances, which are in parentheses.

Notes: SEL = Sound Exposure Level, PTS = permanent threshold shift, TTS = temporary threshold shift

Table 33. Peak Pressure-Based Ranges[1] for Explosives to Onset PTS and Onset TTS (in meters) for Otariids (i.e., Guadalupe fur seals).

Bin	PTS	TTS
E1	35 (30–40)	64 (40–95)
E2	45 (35–50)	82 (45–95)

Bin	PTS	TTS
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 to effect is depicted above the minimum and maximum distances, which are in parentheses.

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

8.2.1.1.10 Exposure and Response Analysis – Marine Mammal Exposure to Explosives

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

A detailed explanation of this analysis is provided in the technical report *Quantifying Acoustic Impactson Marine Mammals and Sea Turtles: Methods and Analytical Approach for Activities at the Point Mugu Sea Range* (U.S. Navy 2020).

For detailed information on how the criteria and thresholds used to estimate impacts on marine mammals from explosives were derived, see the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a).

NAEMO exposure estimates represent the total number of exposures, and not necessarily the number of individuals exposed as a single individual may be exposed multiple times over the course of a year. The numbers of potential impacts from the quantitative analysis estimated for individual species of marine mammals from exposure to explosive energy and sound for training activities are presented below for each species. Results are presented for a maximum explosive use year (Table 34) and over the seven-year period of the proposed MMPA rule (Table 35) . Testing and training activities under the proposed action would use explosive ordnance at or near the surface. Under the proposed action, there could be fluctuation in the amount of explosives use that could occur annually, although potential impacts would be similar from year to year.

There is a potential for impacts to occur anywhere within the action area where sound and energy from explosions and the species overlap.

Table 34. Estimated Impacts* for ESA-Listed Marine Mammals per Year from Explosive Activities Within the PMSR.

Common Name	Stock/DPS	Annual		
		Behavioral Response	TTS	PTS
Blue whale	Eastern North Pacific	7	4	0
Fin whale	California, Oregon, and Washington	14	7	1
Humpback whale	California, Oregon, and Washington/Mexico DPS	7	4	0
	California, Oregon, and Washington/Central America DPS	1	0	0
Sperm whale	California, Oregon, and Washington	1	1	0
Guadalupe fur seal	Mexico to California	1	1	0

*The estimated impact numbers shown on this table reflect the total summation of all fractional probabilities of exposure from all explosive activities over the period of a year. For example, the one predicted PTS exposure for a fin whale is the summation of all estimated fractional probabilities for 23 types of explosives occurring in multiple different testing or training events and multiple locations during a 1-year period in the PMSR action area.

Notes: TTS = Temporary Threshold Shift, PTS = Permanent Threshold Shift

Table 35. Estimated Impacts* for ESA-listed Marine Mammals per Seven-year Period from Explosive Activities Within the PMSR.

Common Name	Stock/DPS	Total Take		
		Behavioral Response	TTS	PTS
Blue whale	Eastern North Pacific	52	27	0
Fin whale	California, Oregon, and Washington	101	46	7
Humpback whale	California, Oregon, and Washington/Mexico DPS	52	29	0
	California, Oregon, and Washington/Central America DPS	6	0	0
Sperm whale	California, Oregon, and Washington	7	8	0
Guadalupe fur seal	Mexico to California	5	7	0

*Seven-year total impacts may differ from the annual number of exposures times seven as a result of standard rounding.

Notes: TTS = Temporary Threshold Shift, PTS = Permanent Threshold Shift

Blue Whales

Male and female blue whales across all life stages may be exposed to sound or energy from explosions associated with testing and training activities when they occur in the action area. The quantitative analysis, using the number of explosives per year under the proposed action estimates seven behavioral reactions and four TTS may occur annually, and 52 behavioral reactions and 27 TTS every seven years of the proposed action.

Fin Whales

Male and female fin whales across all life stages may be exposed to sound or energy from explosions associated with testing and training 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 may occur annually, and 101 behavioral responses, 46 TTS, and 7 PTS may occur every seven years of the proposed action.

Humpback Whale – Central America DPS and Mexico DPS

Male and female humpback whales across all life stages may be exposed to sound or energy from explosions associated with testing and training activities during the seasons when they are present in the action area. 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. The analysis estimates 52 behavioral reactions and 29 TTS for every seven years of the proposed action. For the Central America DPS humpback whales in the California, Oregon, and Washington stock, thequantitative analysis estimates one behavioral reaction may occur annually and six behavioral reactions every seven years of the proposed action.

Sperm Whales

Male and female sperm whales across all life stages may be exposed to sound or energy from explosions associated with testing and training activities occurring throughout the year in the action area. The quantitative analysis using the number of explosives per year under the proposed action estimates one behavioral reaction and one TTS may occur annually, and seven behavioral reactions and eight TTS every seven years of the proposed action.

Guadalupe Fur Seals

Male and female Guadalupe fur seals across all life stages may be exposed to sound or energy from explosions associated with training activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates one behavioral reaction and one TTS effect may occur and no PTS effects would occur as a result of testing or training activities. The analysis estimates five behavioral responses and seven TTS every seven years of the proposed action.

Given the above estimated exposures of ESA-listed marine mammals to explosives, in this section, we describe the likely responses of these species to this exposure. This includes behavioral response, sound-induced hearing loss (i.e., TTS or PTS), as well as other possible responses (e.g., stress) that marine mammals may exhibit as a result of exposure to Navy explosives. Our aim with this response analysis is to assess the potential responses to explosives that might reduce the fitness of individual ESA-listed marine mammals. In doing so, we consider and weigh evidence of adverse consequences, as well as evidence suggesting the absence of such consequences.

Hearing Threshold Shifts

Explosives are a broadband source, so if an animal experiences TTS or PTS from explosives, a large frequency band will be affected. Because such a large frequency band will be affected due to explosives, there is an increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. The exposure analysis indicates that the following numbers of exposures to explosives are expected as a result of PMSR activities: four for blue whales, eight for fin whales, four for Mexico DPS humpback whales, one for sperm whales, and one for Guadalupe fur seals. Based on information regarding sound levels and hearing thresholds for these animals, our response analysis indicates one exposure from explosives that would result in PTS for fin whales per year and exposures of four blue whales, seven fin whales, four Mexico DPS humpback whales, one sperm whale, and one Guadalupe fur seal that would result in TTS. No PTS or TTS from exposure to explosives on the part of Central America DPS humpback whales is expected.

Behavioral response

There are no direct observations of behavioral reactions from marine mammals due to exposure to explosive sounds. General research findings regarding potential behavioral reactions from marine mammals due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail earlier in this section. Behavioral reactions from explosive sounds could be similar to reactions studied for other impulsive sounds such as those produced by seismic air guns (e.g., startle reactions, avoidance of the sound source), but there are important differences in how seismic surveys using air guns are conducted compared with explosive use by the Navy. Seismic surveys using air guns are typically conducted over transects and successive air gun blasts occurring over a sustained period of time. In contrast, Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time. The available information on the response of humpback and sei whales to explosives indicates animals may alert to the sound source, may alter foraging behavior, or exhibit avoidance behavior. These responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends. Based on information regarding the behavioral responses to explosive use on the part of marine mammals and our exposure analysis, we believe the following number of exposures to explosives are expected to result in significant behavioral disruptions per year as a result of PMSR activities: seven for blue whales, 14 for fin whales, seven for Mexico DPS humpback whales, one for Central America DPS humpback whales, one for sperm whales, and one for Guadalupe fur seals.

Non-auditory Physical or Physiological responses

The available research on the potential for explosives or other sources of anthropogenic noise to result in physiological responses (e.g., stress) is described earlier in this section. 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). However, increased stress has been documented as a result of both acute (e.g., Romano et al. 2004) and chronic (e.g., Rolland et al. 2012) anthropogenic noise. As described previously, though there are 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.

Masking

Some limited masking could occur due to the Navy's use of explosives when animals are in close enough proximity. That is, if an animal is close enough to the source to experience TTS or a significant behavioral disruption, we anticipate some masking could occur. Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Given that Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time, if masking occurs it would likely be a very short-term effect.

8.2.1.2 Anticipated Consequences of Acoustic Stressors on Individual Marine Mammals Exposed

In the exposure and response analyses above we established that the use of Navy explosives during PMSR activities are likely to result in TTS, PTS, behavioral response, and physiological stress on the part of blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals. We determined that the potential effects of masking from explosives are limited because of the short duration of explosive sound effects. As such, we have concluded that there is little to no risk to marine mammals associated with exposure and response to the effects of masking. Therefore, in this section, we assess the likely consequences of the PTS, TTS, and behavioral responses to the individual blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals that have been exposed.

Efforts have been made to link short-term effects to individuals due to anthropogenic stressors with long-term consequences to marine mammal populations using population models. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. Unfortunately, for explosive impacts on cetacean populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The Population Consequences of Acoustic Disturbance model (NRC 2005) proposes a conceptual framework for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population.

In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al. 2016a; Costa et al. 2016b; Harwood et al. 2014; Hatch et al. 2012; New et al. 2014; New et al. 2013a; New et al. 2013b; Pirotta et al. 2018). However, the Population Consequences of Disturbance model is still in the preliminary stages of development. Costa et al. (2016b) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions.

The long-term consequences due to individual behavioral reactions 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 cetaceans. Of critical importance in discussion on the potential consequences of such effects is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated effects, would be more significant if the affected animal were already in poor condition as such animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. 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 to individuals exposed to the effects of Navy explosives as part of the proposed action.

To consider the potential consequences of PTS, TTS, and behavioral response to affected animals, we also consider the context of the exposure and response scenario including the following: 1) the duration of the exposure and associated response, 2) whether or not repeated exposures would be expected, 3) the behavioral state of the animal at the time of the response, and 4) the health of the animal at the time of the response.

Because marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators), fitness consequences could occur to individual animals from hearing threshold shifts that last for a long time (e.g., PTS), occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold shift of limited duration and occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues would likely have no effect on an animal's fitness.

The NAEMO modeling and classification of modeled effects from acoustic stressors, such as TTS and PTS, are performed in a manner as to conservatively overestimate the impacts of those effects. Acoustic stressors are binned and all stressors within each bin are modeled as the loudest source, necessarily overestimating impacts within each bin. Additionally, the thresholds for PTS and TTS (and therefore the PTS and TTS estimates) are for the onset of such effects, as opposed to a severe case of such effects. Further, the Navy's mitigation measures (i.e., not deploying an explosive when a marine mammal is in the mitigation zone) will minimize the likelihood that large whales will be close to the impact area at the time of detonation. This reduces the potential for more severe instances of PTS.

In most cases, TTS is expected to be of short duration. Longer duration TTS is expected to last hours or at most a few days (Finneran 2015b). Unlike TTS, PTS is permanent, meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of an animal's life functions that do not overlap in time and space with the proposed action. While hearing loss in marine mammals resulting from temporary exposure to PTS-causing sound levels is not expected to deafen the animals, we expect it would have some effect on the hearing ability of the animals in the frequencies of the sound that caused the damage. For the purposes of this assessment, we assume that the frequencies affected overlap with those utilized by animals for acoustic cues. Therefore, PTS from explosives may interfere with the ability of fin whales (the only species expected to experience PTS as a result of the proposed action) to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. The ability to detect anthropogenic sounds may be important to provide information on the location and direction of human activities, and may provide a warning regarding nearby activities that may be hazardous. The ability to detect conspecifics is also important for mating and mother-calf communication.

Our exposure and response analyses indicate that fin whales would experience PTS, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy’s proposed mitigation. With this minor degree of PTS, a few individual fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances.

The duration and magnitude of the proposed activity is important to consider in determining the likely severity, duration, and potential consequences of exposure and associated response to Navy explosives. As noted in Southall et al. (2007a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. However, while Navy activities that are part of the proposed action may occur over subsequent days, with hours of down time, to meet mission objectives, there is no Navy activity that lasting longer than 24 hours. As discussed in Section 3.5.1, mitigation zones for explosive projectiles, missiles, and bombs extend up to 1,000, 2,000, and 2,500 yards respectively from the explosive, depending on the size of the charge. The sizes of these zones are designed such that all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS will be avoided or reduced, depending on the species. Therefore, there is a low likelihood that animals and Navy activities would co-occur for extended periods of time or repetitively over the duration of an activity.

While it is difficult to predict exactly what a marine mammal may be doing at the time of exposure, we can make some predictions based on time of year and the location of the animal at the time of exposure, where such information is available. Blue whales are known to feed in BIAs located towards the inshore portion of the action area (see Sections 6.2.1 and 6.2.3). Anthropogenic noise can have negative impacts on marine mammals if they result in the animals leaving the area, potentially away from a food source.

Also important to consider is an animal’s prior experience with a sound source. The majority of ESA-listed marine mammals exposed to sound from PMSR activities have likely been exposed to such sources previously as these activities have been occurring in the action area for decades. Harris et al. (2017a) suggested that processes such as habituation, sensitization, or learning from past encounters may lead to stronger or weaker reactions than those of a naïve animal. For example, humpback whale reactions from airguns, an impulsive noise, may decrease following the initial exposure and small explosive charges meant to keep pinnipeds away from fishing gear have been shown to have only short-term deterrence effects on these species (Richardson et al. 1995a).

Quantifying the fitness consequences of behavioral responses is exceedingly difficult for marine mammals because of the limitations of studying these species (e.g., due to the costs and logistical challenges of studying animals that spend the majority of time underwater). Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). A key limitation in these models is that we often do not have empirical data to link sub-lethal behavioral responses to effects on animal vital rates.

Behavioral responses may impact health through a variety of different mechanisms, but most Population Consequences of Disturbance models focus on how such responses affect an animal's energy budget (Farmer et al. 2018; King et al. 2015; NAS 2017; New et al. 2014; Villegas-Amtmann et al. 2017). Responses that relate to foraging behavior, such as those that may indicate reduced foraging efficiency or involve the complete cessation of foraging, may result in an energetic loss to animals (Miller et al. 2009). Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (Bejder et al. 2019; NAS 2017). Important in considering whether or not energetic losses, whether due to reduced foraging or increased traveling, will affect an individual's fitness is considering the duration of exposure and associated response. Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts on an animal (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007a; Villegas-Amtmann et al. 2015).

We also recognize that aside from affecting health via an energetic cost, a behavioral response could result in more direct impacts to health and/or fitness. For example, if a marine mammal hears Navy explosions and avoids the area, this may cause it to travel to an area with other threats such as vessel traffic or fishing gear. However, we find such possibilities (i.e., that a behavioral response would lead directly to a ship strike) to be unlikely due to the low densities of the ESA-listed marine mammals in the action area and the size and relative ease of detection of these species by shipboard observers. Therefore, we focus our risk analysis on the energetic costs associated with a behavioral response.

We would expect many of the anticipated exposures and potential responses of ESA-listed marine mammals to explosives (i.e., behavioral responses and TTS) to have little effect on the exposed animals. Based on the controlled exposure experiments and opportunistic research presented above, responses are expected to be short term, with the animal returning to normal behavioral patterns shortly after the exposure is over. However, there is some uncertainty due to the limitations of the controlled exposure experiments and observational studies used to inform our analysis. Additionally, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. Quantifying the fitness consequences of sub-lethal impacts from acoustic stressors is exceedingly difficult for cetaceans and we do not currently have data to conduct a quantitative analysis on the likely consequences of such sub-lethal impacts. While we are unable to conduct a quantitative analysis on how sub-lethal behavioral effects and temporary hearing impacts may impact animal vital rates (and therefore fitness), based on the best available information, we expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

During exposure, affected animals may be engaged in any number of activities including, but not limited to, migration, foraging, nursing, or resting. If marine mammals exhibited a behavioral response to Navy explosives, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, behavioral responses to Navy explosives are anticipated to be short-term and instances of hearing impairment (i.e., TTS) are expected to be mild or moderate. Based on best available information that indicates marine mammals resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013; Melcon et al. 2012), we anticipate that exposed animals will be able to return normal behavioral patterns after this short duration activity ceases. Goldbogen et al. (2013) suggested that if the documented temporary behavioral responses interrupted behavior, this could have impacts on individual fitness and eventually, population health. For this to be true, we would have to assume that an individual animal could not compensate for this lost resting/nursing or feeding opportunity by either moving to another location, by stopping the activity until shortly after cessation of acoustic exposure, or by resting/nursing or feeding at a later time. There is no indication this is the case. There would likely be an energetic cost associated with any temporary disruption of marine mammal resting/nursing or feeding activities to find alternative locations for these to occur. However, unless such disruptions occur over long durations or over subsequent days, we do not anticipate these movements to be consequential to the animal's fitness over the long-term (Southall et al. 2007a). While activities could be conducted for up to ten days, there is no Navy activity in the proposed action that is both long in duration (more than a day) and concentrated in the same location.

Based on the estimated abundance of the ESA-listed marine mammals that are expected to occur in the action area, and the estimated maximum annual number of instances of behavioral disruption (i.e., TTS or significant behavioral response) expected from explosives (i.e., estimates based on Navy modeling using maximum annual activity level), most individual blue whales, fin whales, humpback whales, sperm whales, and Guadalupe fur seals would be exposed, and respond, to Navy explosives, on average, less than once per year (Table 36 and Table 37). ESA-listed marine mammal annual abundance numbers were obtained from the Navy's 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 2020). For those seasonal species exhibiting densities in the action area that vary throughout the year, the species density most representative of each species (covering the greatest area in the density distribution maps provided by U.S. Department of the Navy 2020) for each season was used to calculate the estimated abundance in winter/spring and summer/fall months throughout the entire action area.

Winter/spring months are defined as December through May, while summer/fall months are defined as June through November. The estimated abundances were then used to obtain estimates of the annual number of behavioral disruptions per animal (Table 36 and Table 37). The highest number of behavioral disruptions per animal is anticipated for blue whales during winter/spring months (i.e., 0.25 disruptions per animal). For all other species, less than 0.2 behavioral disruptions are anticipated per animal annually, regardless of the time of year. This indicates that multiple exposures of the same individual within a year would likely be rare, and some (or many, depending on the species or DPS) individuals within the population would not experience a single behavioral disruption per year due to Navy explosives.

Table 36. Estimated average behavioral disruptions (i.e., TTS or significant behavioral response) from Navy explosives per animal of each species/DPS in the action area during summer/fall months. These estimates are based on a year of estimated maximum behavioral disruptions during a year of maximum explosive activity levels.

Species	Number of Individuals or Size of Listing Unit Likely to be Found in Action Area	Annual Behavioral Disruptions from Explosives	Annual Disruptions per Animal
Blue Whale	314	11	0.035
Fin Whale	954	21	0.022
Humpback Whale – Central America and Mexico DPSs	183	12	0.066
Sperm Whale	148	2	0.014
Guadalupe Fur Seal	2,597	2	0.00077

Table 37. Estimated average behavioral disruptions (i.e., TTS or significant behavioral response) from Navy explosives per animal of each species/DPS in the action area during winter/spring months. These estimates are based on a year of estimated maximum behavioral disruptions during a year of maximum explosive activity levels.

Species	Number of Individuals or Size of Listing Unit Likely to be Found in Action Area	Annual Behavioral Disruptions from Explosives	Annual Disruptions per Animal
Blue Whale	44	11	0.25
Fin Whale	126	21	0.17
Humpback Whale – Central America and Mexico DPSs	462	12	0.026
Sperm Whale	148	2	0.014
Guadalupe Fur Seal	5,744	2	0.00035

We recognize that the calculation of the number of disruptions per animal is based on Navy modeling and is a rough approximation of what will occur during Navy training and testing activities in the action area. Therefore, some individuals from each species could experience a few more or less disruptions annually than what is presented. However, due to the limitations on acoustic exposure modeling capabilities, we are unable to identify which individual from each population will be exposed to and affected by a particular training or testing event in the action area. For this reason, we are not able to predict exactly how many times each animal in the action area will be exposed to and affected by Navy explosives annually. The estimates presented in Table 36 and Table 37 are based on conservative assumptions, and are provided to indicate the relative magnitude of likely exposures on an annual basis.

In summary, we anticipate some animals in the action area could experience more than one behavioral disruption per year, but animals would be exposed periodically and based on the available literature that indicates infrequent exposures are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007a; Villegas-Amtmann et al. 2015). We anticipate that any instances of TTS will be of minimum severity and short duration. This conclusion is based on literature indicating that even following relatively prolonged periods of sound exposure resulting in TTS, recovery occurs quickly (Finneran 2015b). The brief amount of time marine mammals are expected to experience TTS is unlikely to significantly impair their ability to communicate, forage, or breed and is not expected to have long-term fitness consequences for the individuals affected. Additionally, we do not anticipate these species will experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history and that Navy activities also occur over large geographic areas (i.e., both the animal and the activity are moving within the action area, most likely not in the same direction). This decreases the likelihood that animals and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity. Although there is an increased chance that TTS resulting from explosives would affect frequencies utilized by animals for acoustic cues, the Navy's quantitative model predicts very few instances of TTS from explosives. Since it is unlikely that an individual marine mammal would experience TTS from Navy explosives on multiple occasions, adverse effects on acoustic cues resulting from such exposures would likely be limited in scope and duration for individual whales.

PTS from explosives may interfere with the ability of fin whales to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. However, this PTS is expected to be minor due to the conservative methods used to calculate impacts, including modeling in air explosives based on in-water calculations, and the Navy's proposed mitigation. With this minor degree of PTS, a few individual fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances. However, these indivduals represent a very small portion of the fin whale population.

For the reasons above, instances of behavioral response or TTS from Navy activities would be short in duration and we do not anticipate that these instances would result in long-term fitness consequences to individual ESA-listed marine mammals in the action area. We anticipate that instances of PTS in fin whales may result in fitness consequences to individual animals of this species, but the Navy's continued implementation of procedural mitigation to avoid or reduce potential impacts on marine mammals from explosives decreases the likelihood of long-term fitness consequences resulting from these activities (see Section 3.5.1 *Procedural Mitigation* for details).

8.2.2 Sea Turtles

Additional information on explosives as a potential stressor associated with the proposed action can be found in Section 5.1.1. For a discussion of the criteria and thresholds used to predict impacts from explosives on sea turtles see Section 2.2.3.

Explosives occurring in-air or near the water surface at PMSR include detonations of bombs, missiles, rockets, and naval gun shells. There are no fully underwater explosives proposed for use in the PMSR. All explosives used during testing and training activities at the PMSR would detonate in air, with a subset of those occurring at or near the water's surface (near being defined here as at a height within 10 m above the surface). Explosions near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. Research indicates that an in-air shock wave loses the majority of its energy crossing the air-water interface (Bolghasi et al. 2017; Chapman and Godin 2004; Cheng and Edwards 2003; Moody 2006; Richardson et al. 1995a; Sawyers 1968; Sohn et al. 2000a; Swisdak 1975; Waters and Glass 1970; Woods et al. 2015). Farther from the point of detonation, the peak pressure decays and the explosive waves propagate as an impulsive, broadband sound lacking the high peak pressures nearer to the source (U.S. Navy 2021).

Sea turtles could be exposed to a range of impacts depending on the explosive source and context of the exposure. In addition to acoustic impacts including temporary or permanent hearing loss, auditory masking, physiological stress, or changes in behavior; potential impacts from an explosive exposure can include non-lethal injury and mortality.

Primary blast injury is injury that results from the compression of a body exposed to a blast wave. This 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. 1973b). Injury from in-water explosives have been documented in sea turtles but we have no information on sea turtle injury resulting from in-air explosives, as proposed for PMSR activities.

Hearing loss is a noise-induced decrease in hearing sensitivity, which can either be temporary or permanent. To date, no studies have been conducted specifically related to sea turtle hearing loss. We evaluated sea turtle susceptibility to hearing loss based upon what is known about sea turtle hearing abilities in combination with impulsive auditory effect data from other species such as marine mammals and fish. Sea turtle hearing is most sensitive around 100–400 Hz in-water, is limited over 1 kHz, and is much less sensitive than that of any marine mammal. The criteria and thresholds used to evaluate the potential for hearing impairment in sea turtles from Navy sonar are described in Section 2.2.3.

Stress caused by acoustic exposure has not been studied for sea turtles. As described for cetaceans, a stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long it can have negative consequences to the animal such as low reproductive rates, decreased immune function, diminished foraging capacity, etc. Physiological stress is typically analyzed by measuring stress hormones (such as cortisol), other biochemical markers, and vital signs. To our knowledge, there is no direct evidence indicating that sea turtles will experience a stress response if exposed to acoustics stressors. However, physiological stress has been measured for sea turtles during nesting, capture and handling (Flower et al. 2015; Gregory and Schmid 2001; Jessop et al. 2003; Lance et al. 2004), and when caught in entanglement nets and trawls (Hoopes et al. 2000; Snoddy et al. 2009). Therefore, based on their response to other anthropogenic stressors, and including what is known about cetacean stress responses, we assume that some sea turtles will experience a stress response if exposed to a detectable sound stressor. Compared to marine animals, such as marine mammals which are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. As such, the range of sounds that may produce a stress response in sea turtles is expected to be more limited compared with other taxa that are more sensitive to acoustic stressors.

Animals often respond to anthropogenic stressors in a manner that resembles a predator response (Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles may experience a stress response if exposed to acoustic stressors, especially loud sounds. We expect breeding adult females may experience a lower stress response, as studies on loggerhead, hawksbill, and green turtles have demonstrated that females appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). However, anthropogenic sound producing activities may have the potential to provide additional stressors beyond those that naturally occur.

Due to the limited information about acoustically induced stress responses in sea turtles, we assume physiological stress responses would occur concurrently with any other response such as hearing impairment or behavioral disruptions. However, we expect such responses to be brief, with animals returning to a baseline state within hours to days. As with cetaceans, such a short, low level stress response may in fact be adaptive and beneficial as it may result in sea turtles exhibiting avoidance behavior, thereby minimizing their exposure duration and risk from more deleterious, high sound levels.

Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options. Because sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment, the potential for masking would be limited to certain sound exposures. Only continuous anthropogenic sounds that have a significant low-frequency component, are not of brief duration, and are of sufficient received level could create a meaningful masking situation (e.g., long-duration vessel noise affecting natural background and ambient sounds). Other intermittent, short-duration sound sources with low-frequency components would have more limited potential for masking, depending on how frequently the sound occurs.

As described previously, there is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013), magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015), and scent (Shine et al. 2004). Thus, any effect of masking on sea turtles could be mediated by their normal reliance on other environmental cues.

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. The response of a sea turtle to an anthropogenic sound would likely depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered. In the ANSI Guidelines (Popper et al. 2014b), qualitative risk factors were developed to assess the potential for sea turtles to respond to various underwater sound sources. To date, very little research has been conducted on sea turtle behavioral responses relative to explosives exposure. McCauley et al. (2000b) experimentally examined behavioral responses of sea turtles in response to seismic air guns. They found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB rms (re: 1 μPa), or slightly less, in a shallow canal. They reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB rms (re: 1 μPa). At 175 dB rms (re: 1 μPa), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000b). Based on these data, NMFS assumes that sea turtles would exhibit a significant behavioral response in a manner that constitutes harassment or other adverse behavioral effects, when exposed to received levels of 175 dB rms (re: 1 μPa). This is the level at which sea turtles are expected to begin to exhibit avoidance behavior based on experimental observations of sea turtles exposed to multiple firings of nearby or approaching air guns.

8.2.2.1 Impact Range to Effects from Explosives

As part of their quantitative analysis, the Navy modeled the distance that noise from an explosion would need to propagate to reach exposure level thresholds that would cause non-auditory injury (Table 38), mortality (Table 39), TTS and PTS (Table 40 and Table 41), and behavioral responses (Table 42) in sea turtles. Criteria and thresholds to predict impacts to sea turtles are described in Section 2.2.3.2. 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. Ranges are provided for a representative source depth and cluster size (the number of rounds fired [or buoys dropped] within a very short duration) for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds.

There are no underwater detonations as part of the proposed action within the PMSR (i.e., all explosives would detonate in the air). The Navy’s modeling conservatively considers detonations that would occur within 10 m above the water’s surface as if the detonation occurred as a point source located 10 cm underwater (U.S. Department of the Navy 2020). The Navy modeling assumes all acoustic energy from the detonation remains underwater with no sound transmitted into the air and that none of the energy from the detonation would be released as a plume of water from the surface. As a result of these conservative modeling assumptions, the modeling will tend to overestimate potential ranges to effects for sea turtles from explosives.

For more details on how range to effects were estimated refer to the Navy’s *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 2018b).

Table 38. Ranges to non-auditory injury[1] (in meters) for sea turtles exposed to explosives as a function of animal mass.

Bin[2]	Ranges to Non-Auditory Injury (m)[1]	
	Animal Mass of 250 kg	Animal Mass of 1000 kg
E1	12 (11–13)	12 (11–13)
E3	25 (25–45)	25 (25–45)
E5	40 (40–40)	40 (40–40)
E7	79 (75–120)	79 (75–120)
E8	93 (90–110)	93 (90–110)
E10	155 (150–160)	155 (150–160)

[1] Average distance (m) to non-auditory injury is depicted above the minimum and maximum distances which are in parentheses. The ranges depicted are the farther of the ranges for gastrointestinal tract injury or slight lung injury for an explosive bin and animal mass combination.

[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E3 (> 0.5 – 1), E5 (> 2.5 – 5), E7 (> 10 – 20), E8 (> 20 – 60), E10 (> 100 – 250).

Table 39. Ranges to mortality (in meters) for sea turtles exposed to explosives as a function of animal mass[1]

Bin[2]	Ranges to Mortality (m)	
	Animal Mass of 250 kg[1]	Animal Mass of 1000 kg[1]
E1	1 (1–1)	0 (0–0)
E3	6 (6–10)	2 (2–5)
E5	8 (7–8)	4 (3–4)
E7	29 (25–35)	16 (14–20)
E8	40 (40–40)	21 (21–21)
E10	27 (25–30)	16 (16–17)

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

[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E3 (> 0.5 – 1), E5 (> 2.5 – 5), E7 (> 10 – 20), E8 (> 20 – 60), E10 (> 100 – 250).

Table 40. Peak pressure based ranges to TTS and PTS (in meters) for sea turtles exposed to explosives

Ranges to Effects for Explosives Bin: Sea turtles[1]			
Bin[2]	Cluster Size	Range to PTS (m)	Range to TTS (m)
E1	1	37 (35–40)	69 (65–70)
	16	37 (35–40)	69 (65–70)
	18	37 (35–40)	69 (65–70)
	5	48 (45–50)	88 (80–90)
E5	1	128 (120–130)	243 (230–250)
	8	128 (120–130)	243 (230–250)
	20	128 (120–130)	243 (230–250)
E10	1	481 (470–490)	863 (850–875)
	2	481 (470–490)	863 (850–875)

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

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[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E5 (> 2.5 – 5), E10 (> 100 – 250).

Table 41. Sound exposure level-based ranges (in meters) to TTS and PTS for sea turtles exposed to explosives

Range to Effects for Explosives Bin: Sea turtles			
Bin[2]	Cluster Size	Range to PTS (m)[1]	Range to TTS (m)[1]
E1	1	0 (0–0)	0 (0–0)
	18	0 (0–0)	2 (2–2)
E5	1	1 (1–1)	7 (7–8)
	20	5 (5–6)	26 (25–190)
E10	1	14 (13–21)	87 (60–440)

[1]Average distance (m) to TTS and PTS are depicted above the minimum and maximum distances which are in parentheses. Values depict ranges to TTS and PTS based on the SEL metric.
[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E5 (> 2.5 – 5), E10 (> 100 – 250).

Table 42. Ranges to behavioral response for sea turtles exposed to multiple explosions within any given event

Bin[2]	Ranges to Behavioral Response (m)[1]
E1	4,265 (4,025–4,775)
E5	7,011 (6,025–8,275)
E10	34,037 (9,525–64,775)

[1]Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2] Bin (net explosive weight, lb.): E1 (0.1 – 0.25), E5 (> 2.5 – 5), E10 (> 100 – 250).

8.2.2.2 Exposure and Response Analysis –Sea Turtles

In this subsection, we summarize the results from the Navy's quantitative acoustics effects model and discuss the anticipated responses (i.e., numbers of individuals taken, types of take anticipated) based on the leatherback exposure levels predicted by the model. The NAEMO model takes into account (1) criteria and thresholds used to predict impacts from explosives, (2) the density and spatial distribution of leatherback sea turtles, and (3) the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation and explosive energy when estimating the received sound level and pressure on the animals. For details on the approach used to evaluate the effects of explosives on leatherback sea turtles and model inputs refer to Section 2.2.3 (criteria and thresholds) and Section 2.3.1 (leatherback densities) of this opinion, and the Navy's technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018b).

Juvenile and adult leatherback sea turtles from the Western North Pacific population are expected to be exposed to explosive stressors associated with the proposed action. Hatchlings from this population emerge from nests in the western tropical and equatorial Pacific and are thought to spend years developing in the central Pacific as they slowly migrate towards the U.S. west coast (Bailey et al. 2012; Gaspar and Lalire 2017). No hatchlings are expected to occur in the action area.

The quantitative analysis, using a maximum year of training and testing activities, estimates that no leatherback sea turtle mortalities or non-auditory injuries would occur as a result of PMSR explosive activities. The mortality threshold is based on the sound exposure level (SEL) expected to result in extensive lung hemorrhage. The data used to derive the threshold equations for onset of mortality are from Richmond et al. (1973a). The injury threshold is based on the exposure level expected to result in onset of a slight lung injury and/or contusions to the gastrointestinal tract. The data and theory used to derive these threshold are from Richmond et al. (1973a) and Goertner (1982).

During a maximum year of training and testing activities, the quantitative analysis also estimated no PTS or TTS responses of leatherback sea turtles. The quantitative analysis using NAEMO predicts that leatherback sea turtles would be exposed to the levels of explosive sound and energy that could result in ten behavioral responses per year during testing and training activities under the proposed action. However, as discussed above (Section 2.3.1), the leatherback density estimate used by the Navy for their NAEMO analysis (i.e., 0.001 turtles per km^2) was likely biased high, potentially by an order of magnitude or greater. Therefore, based on the supplemental density information provided by the Navy (U.S. Department of the Navy 2021a), we anticipate that up to one leatherback sea turtle would be exposed annually to the levels of explosive sound and energy that could result in a behavioral responses.

It is assumed that some portion of these exposures would result in behavioral harassment responses. As discussed previously for marine mammals, significant leatherback sea turtle behavioral responses to solitary explosions (i.e., cluster size equals one) are not anticipated due to the short duration of acoustic exposure from such explosions. NAEMO exposure estimates represent the total number of exposures, and not necessarily the number of individuals exposed as a single individual may be exposed multiple times over the course of a year.

(Hobday et al. 2016; Hoegh-Guldberg and Bruno 2010; Oliver et al. 2018)NAEMO estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation (see Section 3.5.1 for details). Procedural mitigation measures include delaying or ceasing applicable detonations when a sea turtle is observed in a mitigation zone. The impact analysis does not analyze the potential for mitigation to further reduce the risk of PTS, TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects.

There are limited data available regarding the behavioral responses of sea turtles to anthropogenic sound sources. Sea turtle behavioral responses to an explosion could include a startle response, leaving an area, avoiding an area, diving, or a disruption of activity (e.g., feeding or resting). Because sea turtles exhibit avoidance behaviors to air gun exposure at levels above 175 dB rms (re 1 μPa), responses to explosive detonations could be similar. Exposure to multiple detonations over a short period may cause a sea turtle to exhibit behavioral reactions such as interruption of feeding or avoiding the area. However, exposure to a single blast during an event, which is the most probable scenario during Navy activities, would more likely result in a short-term startle response. Sea turtles would presumably return to normal behaviors quickly after exposure to a single blast. Additionally, significant behavioral responses that result in disruption of important life functions are more likely to occur from multiple exposures over a longer period of time. We do not expect this to occur as a result of the Navy's use of explosives during their training and testing exercises. Most explosions occur in more discrete areas and would not likely persist for long enough periods of time to result in a significant, long-term behavioral response with fitness consequences. Therefore, the anticipated impacts are minor and short-term for the small number of leatherback sea turtles that would be exposed at levels that could elicit a behavioral response. Sea turtles that experience a strong behavioral response are also expected to experience a physiological stress response. Whereas stress is an adaptive response that does not normally place an animal at risk, distress involves a chronic stress response resulting in a negative biological consequence to the individual. Stress responses from this stressor are expected to be short-term in nature given that in most cases sea turtles would not experience repeated exposure to explosives. As such, we do not anticipate stress responses would be chronic, involve distress, or have negative long-term impacts on any individual sea turtle's fitness.

In summary, a very small number of leatherback sea turtles (i.e., up to one estimated leatherback exposure per year) would experience behavioral harassment and physiological stress responses from exposure to explosives. While these responses may result in short-term impacts, alone they are not expected to result in long-term fitness consequences for the individual sea turtles exposed.

9 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, we searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area. We conducted electronic searches of business journals, trade journals, and newspapers using First Search, Google, and other electronic search engines. We did not find any information about non-Federal actions other than what has already been described in the *Environmental Baseline* (Section 7), most of which we expect would continue in the future. In particular, we are reasonably certain that threats associated with climate change, marine debris, fisheries bycatch, vessel strike, and anthropogenic ocean noise will continue in the future. An increase in these activities could similarly increase the magnitude of their effects on ESA-listed species and for some stressors, including climate change and anthropogenic ocean noise, an increase in the future is considered likely to occur. For many of the activities and associated threats identified in the environmental baseline, and other unforeseen threats, the magnitude of increase and the significance of any anticipated effects remain unknown. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on populations of ESA-listed species. Thus, this opinion assumes effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the *Species and Designated Critical that May be Affected* (Section 6) and *Environmental Baseline* (Section 7).

10 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action and the effects caused by the action that are reasonably certain to occur. In this section, we add the *Effects of the Action* (Section 8) to the *Environmental Baseline* (Section 7) and the *Cumulative Effects* (Section 9) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce appreciably the value of designated critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species Likely to be Adversely Affected* (Section 6.2).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species . These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the activities considered further in this opinion, specifically the use of explosives.

10.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is to enage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 C.F.R. 402.02). Therefore, the jeopardy analysis considers both the survival and recovery of the species.

Based on our effects analysis, adverse effects to ESA-listed species are reasonably certain to occur from the implementation of the proposed action. The following discussions summarize the probable risks that activities involving the use of explosives pose to threatened and endangered species over the 7-year lifetime of the MMPA authorization and into the reasonably foreseeable future. These summaries integrate our exposure and response analyses from Section 8.2.

10.1.1 Blue Whale

Blue whales may be exposed to explosive stressors associated with training and testing activities throughout the year. The minimum population size for blue whales in the eastern north Pacific is 1,050; the more recent abundance estimate is 1,496 whales (Carretta et al. 2020). Acoustic modeling predicts that blue whales from the Eastern North Pacific stock would be exposed to impulses from explosive sources associated with training and testing activities that would result in seven behavioral reactions and four TTS exposures annually, and 52 behavioral responses and 27 TTS every seven years of the proposed action. Overall, PMSR training and testing activities would result in estimates of 0.035 and 0.25 behavioral disruptions annually per blue whale in the eastern north Pacific during the summer/fall and winter/spring months respectively (see Table 36 and Table 37). The anticipated take of blue whales could lead to a temporary loss of reproduction at an individual level if the animals were to avoid or leave the area, but no mortality is expected. Therefore exposed blue whales would not be removed from the breeding population and take of blue whales would not be expected to have a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of blue whales and no reduction in the distribution of this species is expected as a result of the action. For this reason, we do not expect the take of individuals to result in population-level consequences to blue whales.

The 2020 blue whale recovery plan outlines downlisting and delisting criteria, which include increasing blue whale resiliency and ensuring geographic and ecological representation, minimizing anthropogenic effects, and ensuring anthropogenic activities are not contributing to the species being in danger of extinction within the foreseeable future throughout all or a significant portion of its range. The recovery plan lists several stressors potentially affecting the status of blue whales in the North Pacific Ocean that are relevant to PMSR activities including vessel strike, vessel disturbance, and military operations. Anthropogenic noise associated with PMSR activities is not expected to impact the fitness of any individuals of this species. No reduction in the number of blue whales is expected to occur from PMSR activities.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by training and testing activities the Navy will conduct in the PMSR action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from February 2022 to February 2029, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of blue whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training and testing activities and related incidental take specified in the MMPA Rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of blue whales in the wild. We conclude that the proposed action will not jeopardize the continued existence of blue whales.

10.1.2 Fin Whale

Fin whales may be exposed to explosive stressors associated with training and testing activities throughout the year. The best current abundance estimate for fin whales in California, Oregon, and Washington waters out to 300 nautical miles is 9,029 (CV=0.12) (Carretta et al. 2020; Nadeem et al. 2016); the minimum population estimate is 8,127 individuals (Carretta et al. 2020). Acoustic modeling predicts that fin whales would be exposed to impulses from explosive sources associated with training and testing activities in PMSR that would result 14 behavioral reactions, seven TTS exposures, and one PTS exposure annually. The modeling predicts 101 behavioral reactions, 46 TTS, and 7 PTS every seven years of the proposed action. Overall, PMSR training and testing activities would result in estimates of 0.022 and 0.17 behavioral disruptions annually per fin whale during the summer/fall and winter/spring months respectively (see Table 36 and Table 37).

The one PTS exposure that may occur annually to fin whales is expected to be minor due to the conservative methods used to calculate impacts and the Navy's mitigation. With this minor degree of PTS, even though an individual fin whale is expected to experience a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance), this individual represents a small portion of the fin whale population in California, Oregon, and Washington waters. Therefore, we would not expect such impacts to have meaningful effects at the population level. We do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of fin whales in the Pacific Ocean or rangewide.

The 2010 fin whale recovery plan defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to PMSR activities. Anthropogenic noise associated with PMSR activities will not impact the fitness of any individuals of this species. Downlisting criteria for fin whales includes the maintenance of at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years. To our knowledge a population viability analysis has not been conducted on fin whale recovery populations.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by training and testing activities the Navy will conduct in the PMSR action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from February 2022 to February 2029, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to result in appreciable reductions in overall reproduction, numbers, or distribution of the fin whale population in the Pacific Ocean. Similarly, the effects from ongoing Navy training and testing activities and related incidental take specified in the MMPA Rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of fin whales in the wild. We conclude that the proposed action will not jeopardize the continued existence of fin whales.

10.1.3 Humpback Whale – Central America and Mexico DPSs

Based on surveys from 2004 to 2006, the Central America DPS is estimated to have just below 800 individuals, while the Mexico DPS is estimated to have just below 3,000 individuals (Wade 2017). The abundance estimate of humpback whales occurring off the U.S. West Coast is 4,776 individuals (Calambokidis and Barlow 2020). However, sightings of humpbacks off the U.S. West Coast have been increasing in more recent years, and these DPS numbers are likely underestimates. Population growth rates are currently unavailable for the Central America DPS and Mexico DPS of humpback whales (Calambokidis 2017).

Humpback whales may be exposed to explosives associated with training and testing activities throughout the year. The humpback whales in the action area potentially belong to one of two ESA-listed DPSs: the threatened Mexico DPS or the endangered Central America DPS. Acoustic modeling predicts that humpback whales from the Mexico DPS would be exposed to impulses from explosive sources associated with training and testing activities that would result in seven behavioral reactions and four TTS exposures annually and 52 behavioral reactions and 29 TTS every seven years of the proposed action. The modeling predicts that humpback whales from the Central America DPS would be exposed to impulses from explosive sources associated with training and testing activities that would result in one behavioral reaction annually and six behavioral reactions every seven years of the proposed action. Overall, for humpback whales from the Central America and Mexico DPSs, PMSR training and testing activities would result in estimates of 0.066 and 0.026 behavioral disruptions annually per whale during the summer/fall and winter/spring months respectively (see Table 36 and Table 37). The anticipated take of Central America and Mexico DPSs of humpback whales could lead to a loss of reproduction at an individual level if the animals were to avoid or leave the area, but no mortality is expected. Therefore, exposed Central America and Mexico DPSs of humpback whales would not be removed from the breeding population and take of Central America and Mexico DPSs of humpback whales would not be expected to have a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of Central America and Mexico DPSs of humpback whales and no reduction in the distribution of these DPSs is expected as a result of the action. For this reason, we do not expect the take of individuals to result in population-level consequences to the Central America and Mexico DPSs of humpback whales.

The 1991 humpback whale recovery plan does not outline specific downlisting and delisting criteria. The recovery plan does list several threats known or suspected of impacting humpback whale recovery including subsistence hunting, commercial fishing stressors, habitat degradation, loss of prey species, ship collision, and acoustic disturbance. Of these, ship collision and acoustic disturbance are relevant to PMSR activities. As described previously, anthropogenic noise associated with PMSR activities will not impact the fitness of any individuals of this species. No reduction in the numbers of Central America and Mexico DPSs of humpback whales is expected to occur from PMSR activities.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by training and testing activities the Navy will conduct in the PMSR action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from February 2022 to February 2029, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to result in appreciable reductions in overall reproduction, numbers, or distribution of Central America and Mexico DPSs of humpback whales. Similarly, the effects from ongoing Navy training and testing activities and related incidental take specified in the MMPA Rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of fin whales in the wild. We conclude that the proposed action will not jeopardize the continued existence of the Central America DPS or the Mexico DPS of humpback whale.

10.1.4 Sperm Whale

Sperm whales in California, Oregon, and Washington waters is estimated to consist of 1,997 individuals (N_{min}=1,270) (Carretta et al. 2020). Sperm whales may be exposed to acoustic stressors associated with training and testing activities throughout the year. The acoustic analysis predicts that sperm whales would be exposed to explosives associated with training and testing activities that would result in one behavioral reaction and one TTS exposure annually, and seven behavioral reactions and eight TTS every seven years of the proposed action. Overall, PMSR training and testing activities may result in an estimated 0.014 behavioral disruptions annually per sperm whale from the California/Oregon/Washington stock (see Table 36 and Table 37). The anticipated take of sperm whales could lead to a temporary loss of reproduction at an individual level if the animals were to avoid or leave the area, but no mortality is expected. Therefore, exposed sperm whales would not be removed from the breeding population and non-lethal take of sperm whales would not be expected to have a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of sperm whales and no reduction in the distribution of this species is expected as a result of the action. For this reason, we do not expect the take of individuals to result in population-level consequences to sperm whales.

The 2010 sperm whale recovery plan defines three recovery populations by ocean basin (the Atlantic Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, oil spills, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to PMSR activities. As discussed previously, anthropogenic noise associated with PMSR activities will not impact the fitness of any individuals of this species. No reduction in the number of sperm whales is expected to occur from PMSR activities. Downlisting criteria for sperm whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years. To our knowledge a population viability analysis has not been conducted on sperm whale recovery populations.

PMSR explosive stressors will not affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). We do not anticipate any reductions in survival rate or trajectory of recovery of the species from explosive stressors as listed pursuant to the ESA, or as currently proposed pursuant to the ESA, that would be sufficient to be readily perceived or estimated. Due to a lack of fitness consequences to individuals and the populations they represent, we also do not anticipate any reductions in survival rate or trajectory of recovery of sperm whales as currently proposed from explosive stressors.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by training and testing activities the Navy will conduct in the PMSR action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from February 2022 to February 2029, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of sperm whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training and testing activities and related incidental take specified in the MMPA Rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of sperm whales in the wild. We conclude that the proposed action will not jeopardize the continued existence of sperm whales.

10.1.5 Guadalupe Fur Seal

The current minimum population estimate for Guadalupe fur seals is 31,019 individuals, which is estimated to be growing at approximately 5.9 percent per year (Carretta et al. 2020). Guadalupe fur seals are present within the action area year-round. The acoustic effects analysis predicts that Guadalupe fur seals would be exposed to explosives associated with training and testing activities in the action area that would result in one behavioral reaction and one TTS exposure annually, and five behavioral reactions and seven TTS every seven years of the proposed action. Overall, PMSR training and testing activities would result in estimates of 0.00077 and 0.00035 behavioral disruptions annually per Guadalupe fur seal during the summer/fall and winter/spring months respectively (see Table 36 and Table 37). The anticipated take of Guadelupe fur seals could lead to a temporary loss of reproduction at an individual level if the animals were to avoid or leave the area, but no mortality is expected. Therefore, exposed Guadelupe fur seals would not be removed from the breeding population and take of Guadelupe fur seals would not be expected to have a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of Guadalupe fur seals and no reduction in the distribution of this species is expected as a result of the action. For this reason, we do not expect the take of individuals to result in population-level consequences to Guadalupe fur seals. No reduction in the number of Guadalupe fur seals is expected to occur from PMSR activities.

The Guadalupe fur seal does not have a recovery plan; therefore, specific downlisting and delisting criteria are not established. We concluded no mortality of individuals would occur and that effects from explosive stressors would be temporary and not impact the fitness of individuals or the population. In the absence of fitness consequences on individuals or the population to which those individuals belong, we do not expect an appreciable reduction in the ability of this species to recover.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by training and testing activities the Navy will conduct in the PMSR action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from February 2022 to February 2029, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of Guadelupe fur seals in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training and testing activities and related incidental take specified in the MMPA Rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of Guadalupe fur seals in the wild. We conclude that the proposed action will not jeopardize the continued existence of Guadalupe fur seals.

10.1.6 Leatherback Sea Turtle

The leatherback sea turtle was listed as endangered throughout its entire range on June 2, 1970, under the Endangered Species Conservation Act of 1969, a precursor to the ESA. The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Plastic ingestion is also common in leatherbacks and can block gastrointestinal tracts leading to death.

Pacific leatherbacks are split into western and eastern Pacific subpopulations based on their distribution and biological and genetic characteristics. Only western Pacific leatherbacks are expected to be found within the PMSR action area. Western Pacific leatherbacks nest in the Indo-Pacific, primarily in Indonesia, Papua New Guinea and the Solomon Islands. Spotila et al. (2000) estimated that the Pacific leatherback population declined from an estimated 81,000 adult turtles to 2,955 females (adult and subadult) in the two decades from 1980 to 2000. Martin et al.

(2020) estimated the abundance of western Pacific leatherbacks for the two index beaches in Indonesia, which represent approximately 75 percent of all nesting individuals. Using the median value for imputed nest counts they estimated 790 total nesters (95 percent CI: 666–942). Jones et al. (2018) used model-estimated annual female distributions for 2015 to 2017 to estimate an index of current total reproductive female abundance for the western Pacific leatherback population. This was computed as a 3-year run sum based on an assumed 3-year remigration interval. The estimates for 2015-2017 annual females ranged from 340 to 439 and the summed total reproductive female estimate was 1,180 (95 percent CI: 949–1,479) (Jones et al. 2018). Using this estimate, and assuming a 3:1 ratio of females to males, NMFS (2019c) estimated the current adult portion of the population is 1,851 (1,488-2,320). NMFS (2019c) used the proportion or change in the estimates derived from the information contained in Jones et al. (2018) to estimate the current population size of the West Pacific Ocean leatherback sea turtle. The total West Pacific Ocean population estimate is 175,000 leatherback sea turtles, but may range between 68,000 and 360,000 individuals (NMFS 2019c).

Population growth rates for leatherback sea turtles vary by ocean basin. Leatherbacks have been in decline in all major Pacific basin rookeries (nesting areas/groups) for at least the last two decades (Dutton et al. 2007; Gilman 2008; NMFS and USFWS 2007b; Sarti M. 1996; Spotila et al. 1996; Spotila et al. 2000; Tapilatu et al. 2013; TEWG 2007). Based on counts of leatherbacks at nesting beaches in the western Pacific, Tapilatu et al. (2013) estimated that the subpopulation has been declining at a rate of almost six percent per year since 1984. Based on a recent population assessment, Martin et al. (2020) reported a declining trend for western Pacific leatherback sea turtles of negative 6.1 percent annually. Estimated leatherback densities in the offshore portion of the action area are very low (i.e., 0.000114 per km^2) and nesting sites for the western Pacific subpopulation are far removed from the proposed action.

Based on our *Effects Analysis* (Section 8.2.2.1, we anticipate a very small number of leatherback sea turtles (i.e., about one estimated exposure per year) would experience behavioral and physiological stress responses from exposure to explosives used during PMSR activities. The Navy's quantitative model predicts that no leatherbacks are likely to be exposed to levels of explosive sound and energy that could cause injury, PTS, or TTS. Behavioral responses from explosives are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. In addition, since leatherback nesting does not occur within the action area, behavioral responses to explosives would have no impact on reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance and strike, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

In summary, we anticipate an extremely small number of individual leatherbacks, relative to the population size, would be affected by the proposed action. Those effects would likely be limited to only minor, short-term behavioral responses with no resulting reductions in numbers, reproduction or individual fitness. We do not anticipate any effects from the proposed action would result in the mortality, injury or reduced fitness of individual leatherback sea turtles. The impacts expected to occur and affect leatherback sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. Given these sea turtles generally have large ranges in which they disperse, no reduction in the distribution or current geographic range of leatherback sea turtles is expected as a result of the proposed action.

Based on the evidence available, including the Environmental Baseline, Effects of the Action and Cumulative Effects, effects resulting from stressors caused by training and testing activities the Navy will conduct in the PMSR action area on an annual basis, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the Status of Listed Resources or Environmental Baseline), would not be expected to appreciably reduce the likelihood of the survival of the leatherback sea turtle in the wild by reducing the reproduction, numbers, or distribution of the species. We also conclude that effects from ongoing Navy training and testing activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of the leatherback sea turtle in the wild by reducing the reproduction, numbers, or distribution of this species. Therefore, we do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the leatherback sea turtle.

11 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of: blue whale, fin whale, humpback whale (Central America DPS and Mexico DPS), sperm whale, Guadalupe fur seal, and leatherback sea turtle.

It is also NMFS' biological opinion that the proposed action is not likely to adversely affect the following ESA-listed species: black abalone, white abalone, North Pacific right whale, gray whale Western North Pacific DPS, sei whale, loggerhead sea turtle North Pacific DPS, green sea turtle East Pacific and Central North Pacific DPSs, steelhead Southern California DPS, giant manta ray, and scalloped hammerhead shark East Pacific DPS; and designated critical habitat for humpback whale (Central America DPS and Mexico DPS) and leatherback sea turtle and therefore, the action is not likely to jeopardize any of these species or result in the destruction or adverse modification of designated critical habitat.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. When an action will result in incidental take of ESA-listed marine mammals, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS, including those specified as necessary to comply with the MMPA, Section 101(a)(5). Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA for ESA-listed marine mammals become effective only upon the issuance of MMPA authorization to take the marine mammals identified here.

12.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by the proposed action while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

Table 43 lists the incidental take that is reasonably certain to occur from training and testing activities by species and the issuance of a seven-year regulation and LOAs by NMFS' Permits Division to authorize the incidental take of marine mammals pursuant to the MMPA. The amount of take resulting from PMSR activities was estimated based on the best information available.

Table 43. The estimated total number of takes of threatened and endangered marine mammals and sea turtles reasonably certain to occur annually as a result of the proposed Navy training and testing activities in the PMSR action area.

ESA-Listed Species	Type of Take from Explosive Stressors		
	Harassment (TTS)	Harassment (Behavioral)	Harm (PTS)
Blue Whale	4	7	0

Fin Whale (includes California, Oregon, and Washington and Northeast Pacific stocks)	7	14	1
Humpback Whale (Central America DPS)	0	1	0
Humpback Whale (Mexico DPS)	4	7	0
Sperm Whale	1	1	0
Guadalupe Fur Seal	1	1	0
Leatherback Sea Turtle	0	1	0

Activity Levels as Indicators of Take for Marine Mammals and Sea Turtles

As discussed in this opinion, the estimated take of ESA-listed sea turtles and marine mammals from explosive stressors is based on Navy modeling, which represents the best available means of numerically quantifying take. As the level of modeled explosive use increases, the level of take is likely to increase as well. For take from explosive sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of PMSR activities do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Navy modeling, and the link between explosive use and the level of take, to determine when anticipated take levels have been exceeded. As such, we established a term and condition of this ITS that requires the Navy to report to NMFS any exceedance of activity level specified in this opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level for any activity associated with take of an ESA-listed species will require the Navy to reinitiate consultation.

12.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" (RPMs) are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). The reasonable and prudent measures described below must be undertaken by the Navy and/or NMFS Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, RPMs and Terms and Conditions to implement the measures, must be provided. Only incidental takes resulting from the agency actions and any specified RPMS and Terms and Conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

NMFS has determined the following RPMs described below are necessary and appropriate to minimize the impacts of incidental take on blue whale, fin whale, humpback whale (Central America and Mexico DPSs), sperm whale, and leatherback sea turtle:

1. The Navy and NMFS Permits Division shall minimize effects to ESA-listed marine mammals and sea turtles from the use of explosives during training and testing activities. This includes adherence to the mitigation measures specified in the final MMPA rule and LOA.

2. The Navy and NMFS Permits Division shall monitor and report to NMFS' Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed marine mammals and sea turtles from the use of explosives during PMSR training and testing activities. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOA.

12.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Navy and NMFS Permits Division must comply (or must ensure that any applicant complies) with the following Terms and Conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If the Navy or NMFS Permits Division fail to ensure compliance with these Terms and Conditions to implement the associated RPMs applicable to the authorities of each agency, the protective coverage of section 7(o)(2) may lapse. The Terms and Conditions detailed below for each of the RPMs include monitoring and minimization measures where needed.

1) The following terms and conditions implement RPM 1:
    a) The Navy shall implement all mitigation measures as specified in the final MMPA rule and LOA.
    b) NMFS Permits Division shall ensure that all mitigation measures as prescribed in the final rule and LOA are implemented by the Navy.
    c) The Navy shall continue technical assistance/adaptive management efforts with NMFS to help inform future consultations on Navy training and testing in the action area. Adaptive management discussions should include review of Navy's exercise and monitoring reports, review of ESA section 7 reinitiation triggers (described in Section 14 below), and potential new measures to increase mitigation effectiveness.
2) The following terms and conditions implement RPM 2:

a) The Navy shall monitor training and testing activities and submit reports annually to NMFS Permits Division and NMFS ESA Interagency Cooperation Division including the location and total hours and counts of explosives used, and an assessment if activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs, and any new information regarding the ranges to effects used in our analysis of the effects of explosive stressors on ESA-listed species.

b) The Navy shall report to NMFS any exceedance of activity levels specified in the preceding opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted.

c) NMFS Permits Division shall review the reports submitted by the Navy described above in 2(a). Within two months of receipt of each Navy report, NMFS Permits Division will submit written documentation to NMFS ESA Interagency Cooperation Division assessing if Navy activities conducted in the action area exceeded levels of training and testing analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs.

d) The Navy shall report to the NMFS ESA Interagency Cooperation Division all observed injury or mortality of any ESA-listed species resulting from the proposed training and testing activities within the action area. The Navy shall report when enough data are available to determine if the dead or seriously injured ESA-listed species may be attributable to these activities, including but not limited to, the use of explosives and vessel strike.

e) The Navy shall comply with the stranding Notification and Reporting Plan (NMFS 2021b).

f) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(e) suggest investigation of the associated Navy activities is warranted (see stranding and notification document for example circumstances), and an investigation into the stranding is being pursued, NMFS personnel will submit a written request to the Navy asking that they provide the status of all explosive use in the 48 hours preceding and within 50 km (27 NM) of the discovery/notification of the stranding by NMFS, or estimated time of stranding. Navy will submit this information as soon as possible, but no later than seven business days after the request.

13 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

The following conservation recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the Navy:

1. As practicable, the Navy should develop procedures to aid any individual ESA-listed marine mammal or sea turtle that has been impacted by PMSR activities and is in a condition requiring assistance to increase likelihood of survival.

2. The Navy should continue to model potential impacts to ESA-listed marine mammals and sea turtles using NAEMO and other relevant models. The Navy should validate assumptions used in risk analyses and seek new information and higher quality data for use in such efforts.

3. The Navy should coordinate with NMFS on the collection of information for better understanding the effectiveness of mitigation measures implemented by the Navy during PMSR explosives use. This should include an assessment of the effectiveness of Navy Lookouts for minimizing impacts to ESA-listed species (see Oliveira et al. 2019). Findings should be incorporated into the Navy's approach to quantitatively evaluating the effects of acoustics stressors on ESA-listed species.

4. As practicable, the Navy should supplement the proposed visual monitoring mitigation measures described in Section 3.5.1 with passive and active acoustic monitoring for activities that could cause marine mammal injury or mortality.

5. We recommend the Navy consider using the potential standards for towed array passive acoustic monitoring in the Towed Array Passive Acoustic Operations for Bioacoustic Applications: ASA/JNCC Workshop Summary March 14-18, 2016 Scripps Institution of Oceanography, La Jolla, California, USA (Thode 2017).

6. The Navy should continue to conduct research on thermal detection monitoring systems, as a supplement to visual monitoring, to further minimize the impacts of Navy acoustic stressors on ESA-listed marine mammals.

7. As practicable, we recommend that Navy vessels operate at speeds of 10 knots or less within the PMSR. This recommendation would not apply to any scenario where the vessel's safety is threatened or when impractical based on mission requirements.

8. The Navy should report to NMFS all sea turtle sightings within the PMSR as a feedback mechanism to improve on the effectiveness of the NOAA CoastWatch TOTAL tool for implementing the proposed loggerhead sea turtle awareness notification message (see

Section 3.6). To the extent practicable, sightings reports should include the following: species identification, latitude/longitude coordinates, and date.

In order for NMFS' Office of Protected Resources ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Navy should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 REINITIATION NOTICE

This concludes formal consultation on the Navy's proposed PMSR training and testing activities and NMFS' promulgation of regulations and issuance of an LOA pursuant to the MMPA. Consistent with 50 C.F.R. §402.16(a), reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(1) The amount or extent of taking or the surrogate specified in the ITS is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to the listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed, or critical habitat designated under the ESA that may be affected by the action.

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