NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on U.S. Navy Hawaii-Southern California Training and Testing and the National Marine Fisheries Service's Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the Navy to "Take" Marine Mammals Incidental to Hawaii-Southern California Training and Testing

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Action Agency: United States Department of the Navy

Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 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 National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed) or designated critical habitat that may be affected by the 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)).

The Federal action agency shall confer with the NMFS under ESA Section 7(a)(4) for species under NMFS jurisdiction on any action which is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat (50 C.F.R. §402.10). If requested by the Federal agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in §402.14.

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 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 expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. NMFS, by regulation, has determined that an ITS must be prepared when take is "reasonably certain to occur" as a result of the proposed action. 50 C.F.R. 402.14(g)(7).

The action agencies for this consultation are the United States (U.S.) Navy (Navy) and NMFS' Permits and Conservation Division (Permits Division). The Navy proposes to conduct Hawaii-Southern California Training and Testing (HSTT) activities 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 HSTT 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, biological opinion, and ITS, were 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. Part 402), and agency policy and guidance by NMFS Office of Protected Resources ESA Interagency Cooperation Division (hereafter referred to as "we"). This biological opinion (opinion) and ITS were prepared by NMFS Office of Protected Resources ESA Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402 and specifically 50 C.F.R. §402.14.

This document represents NMFS' opinion on the effects of the proposed HSTT activities and the Permits Division's promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to HSTT activities on endangered and threatened species and critical habitat that has been designated for those species. 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 training and testing activities within the HSTT Study Area (hereafter referred to as the "action area"; see Section 3.1 of this opinion for a description of the action area) starting in December 2018 and continuing into the reasonably foreseeable future. These activities are hereafter referred to as "Phase III" activities. Navy training and testing activities have been ongoing in this same general geographic area for several decades and as indicated below, many of these activities have been considered in previous ESA section 7 consultations (i.e., as detailed below, in consultations that considered Phase I and Phase II Navy actions).

Between 2007 and 2013, NMFS issued a series of biological opinions on Navy training and testing activities proposed off the coast of Southern California and around Hawaii. The activities considered in these consulations were similar to those proposed for Phase III that are the subject of this consultation and included the use of active sonar, explosives, and vessels. Where incidental take of marine mammals was anticipated, these consultations also considered NMFS Permits Division's promulgation of regulations and issuance of letters of authorization pursuant to the MMPA for the Navy to "take" marine mammals incidental to their activities. Each of these opinions concluded that the Navy and NMFS Permits Division's proposed actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat. Collectively, NMFS and the Navy referred to the activities that were the subject of these consulations as Phase I.[1]

On December 13, 2013, NMFS issued a biological opinion on proposed Phase II HSTT activities starting in December 2013 and the associated MMPA authorization of incidental take of marine mammals by the NMFS Permits Division from December 2013 to December 2018. For the consultation on Phase II activities, the Navy grouped many of the same training and testing activities considered in previous stand-alone consultations, including activities conducted off the coast of Southern California and Hawaii, into a single proposed action. The opinion concluded that the Navy and NMFS' Permits Division's proposed actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat.

After issuance of the December 13, 2013 biological opinion, NMFS identified several inadvertent factual errors and omissions regarding amount of incidental take of species from vessel strike and omission of potential sea turtle injury or mortality from the ITS. These errors and omissions were the result of oversights during the drafting process, and the biological opinion (primarily the ITS) was corrected. On April 23, 2014, NMFS issued a corrected final biological opinion and ITS that superceded the December 13, 2013 biological opinion.

On July 3, 2014, NMFS issued a final determination to list the Central and Southwest Atlantic Distinct Population Segment (DPS) and the Indo-West Pacific DPS of scalloped hammerhead shark (*Sphyrna lewini*) as threatened species, and to list the Eastern Atlantic DPS and Eastern Pacific DPS of scalloped hammerhead sharks as endangered species under the ESA.

On September 9, 2014, NMFS received a request from the Navy to reinitiate formal consultation pursuant to the ESA on the Navy's HSTT activities and effects on the newly listed Eastern Pacific DPS of scalloped hammerhead shark (*Sphyrna lewini*). In the Biological Evaluation accompanying the Navy's request for reinitiation, the Navy determined Phase II HSTT training and testing activities were likely to adversely affect the newly listed Eastern Pacific DPS of scalloped hammerhead shark.

On November 21, 2014, NMFS determined that there was sufficient information to reinitiate formal consultation as the Navy requested. NMFS also expanded the scope of the reinitiated consultation to include a re-examination of NMFS' analysis of effects to listed cetaceans, pinnipeds, and sea turtles.

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[1] Note: Since this was the first set of MMPA incidental take regulations, ESA biological opinions, and National Environmental Policy Act Environmental Impact Statements for Navy At-Sea training and testing activities, these activities were referred to as Phase I activities. Subsequent phases are referred to as Phase II, Phase III, etc.

On March 31, 2015, the United States District Court for the District of Hawaii ruled that NMFS' biological opinion for the Navy's Phase II activities in the HSTT action area included an arbitrary and capricious "no jeopardy" finding for whales and sea turtles and an invalid ITS for sea turtles (Conservation Council for Hawaii v. NMFS; Natural Resources Defense Council v. NMFS). The court identified three primary issues with the biological opinion and ITS. First, it found that NMFS did not adequately support its conclusion that authorized mortalities of large whales will not appreciably reduce the likelihood of both the survival and recovery of affected large whale species in the wild. Second, the court determined that NMFS failed to support its no jeopardy finding for sea turtles with adequate analysis. Third, the court found the ITS for sea turtles deficient because it failed to provide either a numerical cap on sea turtle take by vessel strike or a surrogate to trigger reinitiation of consultation.

On April 2, 2015, NMFS issued a biological opinion which addressed the issue identified by the court. The reinitiated opinion concluded that the Navy and NMFS' Permits Division's proposed actions would not jeopardize the continued existence of threatened or endangered species or destroy or adversely modify designated critical habitat.

1.2 Consultation History

Our communication with the Navy and NMFS' Permits Division regarding this consultation is summarized below. Note that some communication that is pertinent to the consultation on Phase III HSTT activities occurred concurrent with communication on the consultation on proposed Phase III Atlantic Fleet Training and Testing activities. This is due to the similar nature of the activities proposed in Phase III Atlantic Fleet Training and Testing when compared with Phase III HSTT, the corresponding similar potential effects of these actions on ESA-protected resources (i.e., listed species and designated critical habitat) under NMFS jurisdiction, as well as the similar approaches taken to analyze potential effects of these actions on ESA-protected resources.

- On December 2, 2016, NMFS provided technical assistance, commenting on the Navy's HSTT Phase III Draft Environmental Impact Statement (DEIS), Version 2.
- In May 2017, NMFS provided technical assistance, commenting on the Navy's HSTT Phase III DEIS, Version 3.
- On December 5, 2017, the Navy requested continued technical assistance from NMFS to review a draft Biological Assessment (BA) for Phase III HSTT activities.
- On December 15, 2017, NMFS provided comments on the draft BA to the Navy.
- On January 5, 2018, the Navy requested initiation of formal consultation for Phase III HSTT activities and submitted an initiation package to NMFS, including a BA.
- On April 11, 2018, NMFS sent the Navy a description of additional mitigation measures to further reduce potential adverse impacts of the proposed action on ESA-listed marine

mammals, and requested the Navy incorporate these additional mitigation measures into their proposed action. Many of these additional mitigation measures were proposed to minimize potential adverse effects to specific species found in the Phase III Atlantic Fleet Training and Testing action area. However, some of the mitigation measures, including measures to improve range clearance procedures during explosive exercises and post-activity monitoring of the mitigation zone for more explosive exercises, are relevant to Phase III HSTT activities as well.

- On April 12, 2018, NMFS and Navy met to discuss the additional mitigation measures proposed by NMFS.
- On May 14, 2018, Navy provided a written response to NMFS' request that additional mitigation measures be incorporated in the proposed action in order to reduce potential adverse impacts on ESA-listed marine mammals.
- On June 26, 2018, NMFS' Permits Division issued a proposed rule to authorize the take of marine mammals incidental to Phase III HSTT activities. On June 27, 2018, NMFS Permits Division requested initiation of formal consultation with NMFS' ESA Interagency Cooperation Division on the proposed rule.
- On June 27, 2018, NMFS ESA Interagency Cooperation Division determined that Navy and NMFS Permits Division had provided sufficient information to initiate formal consultation.
- On July 6, 2018, NMFS proposed additional mitigation measures for the Navy to consider implementing to minimize potential adverse impacts on ESA-listed marine mammals. These proposed mitigation measures were specific to activities proposed in the HSTT action area (e.g., geographic mitigations).
- On July 13, 2018, NMFS requested additional information from the Navy to assist with understanding the potential effects of Phase III HSTT activities on black and white abalone.
- On July 16, 2018, NMFS and the Navy met via teleconference to discuss NMFS proposed mitigation measures to minimize potential adverse impacts on ESA-listed marine mammals in the HSTT action area.
- On July 31, 2018, NMFS and Navy met via teleconference to discuss potential effects of Phase III HSTT activities on black and white abalone. Also on July 31, Navy provided supplemental materials to NMFS to assist in understanding potential effects of Phase III HSTT activities on these species.
- On August 8, 2018, the Navy provided a written response to NMFS' request that additional mitigation measures be incorporated in the proposed action in order to reduce potential adverse impacts on ESA-listed marine mammals in the action area.
- On August 15, 2018, NMFS provided a draft biological opinion to the Navy.

- On August 27, 2018, the Navy provided comments to NMFS on the draft biological opinion.
- On September 25, 2018, the Navy requested technical assistance from NMFS to review a draft informal consultation package addressing the effects of training and testing proposed in the Hawaii portion of the action area on designated critical habitat for Hawaiian monk seals and Main Hawaiian Islands Insular DPS false killer whales (MHI IFKW).
- On October 10, 2018 NMFS and the Navy met via teleconference to discuss the marine mammal ship strike analysis in the draft biological opinion and the MMPA rulemaking.
- On October 11, 2018, NMFS provided comments to the Navy on the above referenced informal consultation package for MHI IFKW designated critical habitat.
- On October 26, 2018, Navy provided a final consulation package addressing the effects of training and testing proposed in the Hawaii portion of the action area on designated critical habitat for Hawaiian monk seals and MHI IFKWs.
- On October 29, 2018, the Navy sent NMFS a Memorandum for the Record (MFR) documenting Navy agreement and concurrence with NMFS' proposed species allocation for marine mammal vessel strike.
- On November 8, 2018, the Navy and NMFS met via teleconference to discuss the Navy's final consultation package addressing the effects of training and testing proposed in the Hawaii portion of the action area on designated critical habitat for MHI IFKWs.
- On November 16, 2018, NMFS provided the Navy a draft analysis addressing effects to designated critical habitat for MHI IFKWs.

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 designated critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02).

An ESA section 7 assessment involves the following steps:

1) We describe the proposed action (Section 3) the action area (Section 4), and any interrelated or interdependent actions (Section 5) related to the proposed action.

2) We deconstruct the action into the activities such that we can identify those aspects of the proposed action that are likely to create pathways for adverse impacts to ESA-listed species or designated critical habitat. These pathways or "stressors" may have direct or indirect effects on the physical, chemical, and biotic environment within the action area. We also consider the spatial and temporal extent of those stressors (Section 6).

3) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time (Section 7). During consultation, we determined that some ESA-listed species that occur in the action area were not likely to be adversely affected by the proposed action. We summarize our findings and do not carry those species forward in this opinion (Section 7.1). We describe the status of species that are likely to be adversely affected (Section 7.2).

4) We describe the environmental baseline in the action area (Section 8) including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, and impacts of state or private actions that are contemporaneous with the consultation in process.

5) We evaluate the direct and indirect effects of an action on ESA-listed species or designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (Section 9).

    a) During our evaluation, we determined that some stressors were not likely to adversely affect some ESA-listed species or categories of ESA-listed species (Section 9.1).

    b) The stressors that are likely to adversely affect ESA-listed species were carried forward for additional analysis (Section 9.2). For these stressors, 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 analyses.

    c) We identify the number, age (or life stage), and gender if possible and if needed, of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. This is our exposure analysis.

d) We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis.

e) The adverse modification analysis considers the impacts of the proposed action on the essential habitat features and conservation value of designated critical habitat using the same exposure, response, and risk framework.

6) We describe any cumulative effects of the proposed action in the action area (Section 10).

7) We integrate and synthesize the above factors (Section 11) by considering the effects of the action to the environmental baseline and the cumulative effects to determine whether the action would reasonably be expected to:

   a) Reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or

   b) Reduce the conservation value of designated or proposed critical habitat.

8) We state our conclusions regarding jeopardy and the destruction or adverse modification of designated critical habitat (Section 12).

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 to the action that would allow the action to proceed in compliance with ESA section 7(a)(2). The reasonable and prudent alternative also must meet other regulatory requirements.

If incidental take of ESA-listed species is expected, section 7(b)(4) requires that we provide an ITS that specifies the amount or extent of take, the impact of the take, reasonable and prudent measures 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); Section 13). ESA section (7)(o)(2) provides that compliance by the action agency with the terms and conditions exempts any incidental take from the prohibitions of take in ESA section 9(b) and regulations issued pursuant to ESA section 4(d).

"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. NMFS has not yet defined "harass" under the ESA in regulation. However, on

December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as an action that "creates 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 2016c). 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. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

We also provide discretionary conservation recommendations that may be implemented by action agency. 50 C.F.R. §402.14(j). 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 these analyses 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 that represent evidence of adverse consequences or the absence of such consequences. We conducted electronic literature searches throughout this consultation, including within NMFS Office of Protected Resource's electronic library. We examined the Navy's BA (Navy 2018d), the Navy's DEIS (Navy 2017b), the literature that was cited in the Navy's BA and DEIS, and any articles we collected through our electronic searches. We also evaluated the Navy's annual and comprehensive monitoring reports required under the existing MMPA rule and LOAs and the previous biological opinion for current training and testing activities occurring in the same geographic area. These resources 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 critical habitat for the conservation of ESA-listed species. In addition, we engage 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 incorporate 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. 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 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.

The sections below discuss NMFS' approach to analyzing the effects of sound produced by Navy training and testing activities in the HSTT action area on ESA-listed marine mammals, sea turtles, and fish. 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 effect from each 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 Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g). NMFS 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.[1] NMFS' analysis of the effects of and potential consequences of such exposures is included in Section 9 of this opinion.

2.2 The Navy's Acoustic Effects Analysis for Marine Mammals and Sea Turtles

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars and air guns), as well as incidental sources of broadband sound produced as a byproduct of vessel movement, aircraft transits, pile driving and removal, 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 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 detailed explanation of this analysis is in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g). NMFS verified the methodology and data used by the Navy in this analysis and unless otherwise specified in Section 9 of this opinion, accepted the modeling conclusions on exposure of marine mammals and sea turtles to sound generated by the proposed action. NMFS 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.

[1] The Navy's acoustic effects analysis did not estimate the number of instances ESA-listed fish or abalone that could be affected by acoustic stressors from the proposed action.

2.2.1 Criteria and Thresholds to Predict Impacts to Marine Mammals and Sea Turtles

The Navy's quantitative acoustic effects analysis for marine mammals and 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 each species and sound source associated with Navy training and testing activities.

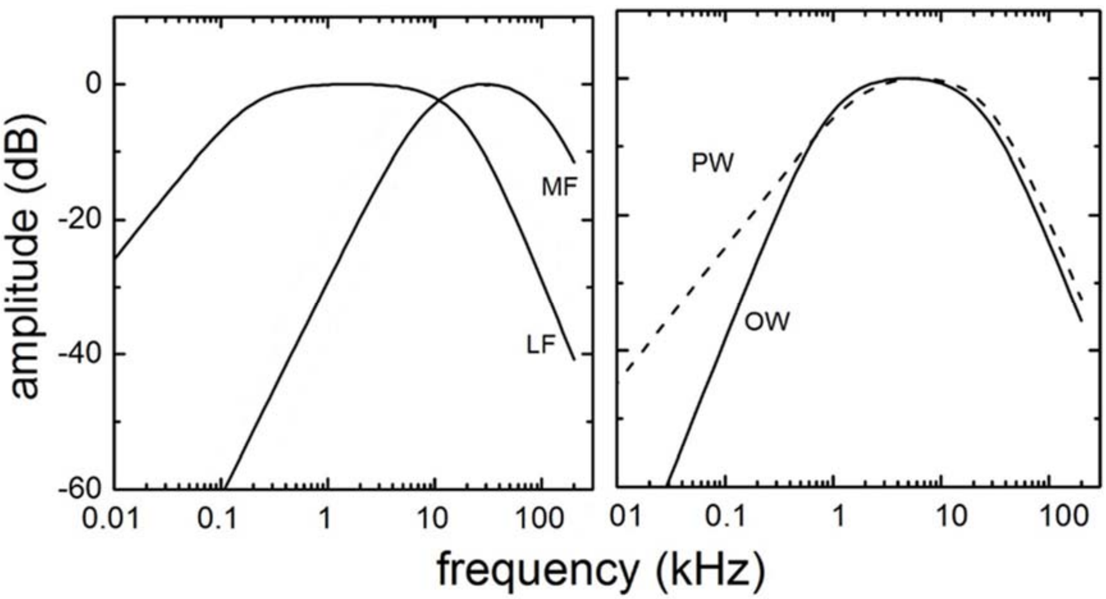
For marine mammals, the Navy, in coordination with the NMFS, established acoustic thresholds (for impulsive, non-impulsive sounds and explosives) using the best available science that identifies the received level of underwater sound above which exposed marine mammals would reasonably be expected to experience a potentially significant disruption in behavior, or to incur temporary threshold shifts (TTS) or permanent threshold shifts (PTS) of some degree. 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. Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is considered so unlikely as to be discountable under normal conditions and is therefore not considered further in this opinion for marine mammals.[1] Non-auditory injury from Navy air guns and pile driving is also considered so unlikely as to be discountable. 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 and sea turtles to effects from acoustic exposure.

2.2.1.1 Marine Mammal Criteria for Hearing Impairment, Non-Auditory Injury, and Mortality

The marine mammal criteria and thresholds for non-impulsive and impulsive sources for hearing impairment, non-auditory injury, and mortality, as applicable, are described below. The Navy's quantitative acoustic effects analysis used dual criteria to assess auditory injury (i.e., PTS) to different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive [explosives, air guns, impact pile driving] and non-impulsive [sonar, vibratory pile driving]). The criteria used in the analysis are described in *NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018). The Technical Guidance also identifies criteria to predict TTS, which is not considered injury.

[1] Non-auditory injury from sonar is not anticipated due to the lack of fast rise times, lack of high peak pressures, and the lack of high acoustic impulse of sonar. Note that non-auditory injury is possible from impulsive sources such as explosions.

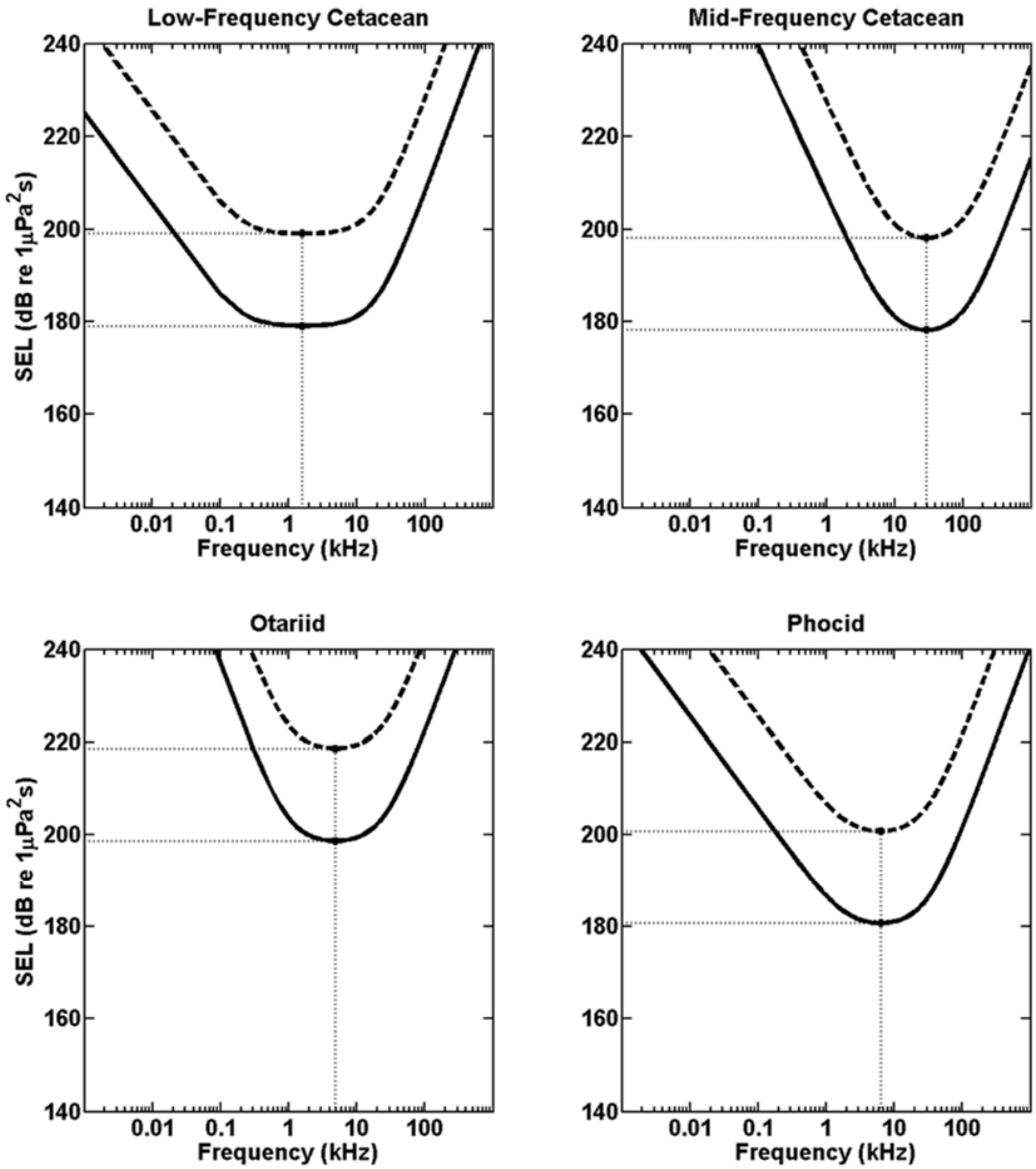
The Navy used auditory weighting and exposure functions to assess the varying susceptibility of marine mammals to effects from noise exposure. Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions 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 to calculate a weighted received sound level in units sound pressure level (SPL) or sound exposure level (SEL). They resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range, 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). 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.

For non-impulsive sources, the TTS and PTS exposure functions for marine mammals are presented in Figure 2.



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

Figure 2. TTS and PTS exposure functions for sonar and other acoustic sources for marine mammals (Navy 2018d).

Based on the exposure functions, the marine mammal thresholds for non-impulsive acoustic sources are summarized in Table 1.

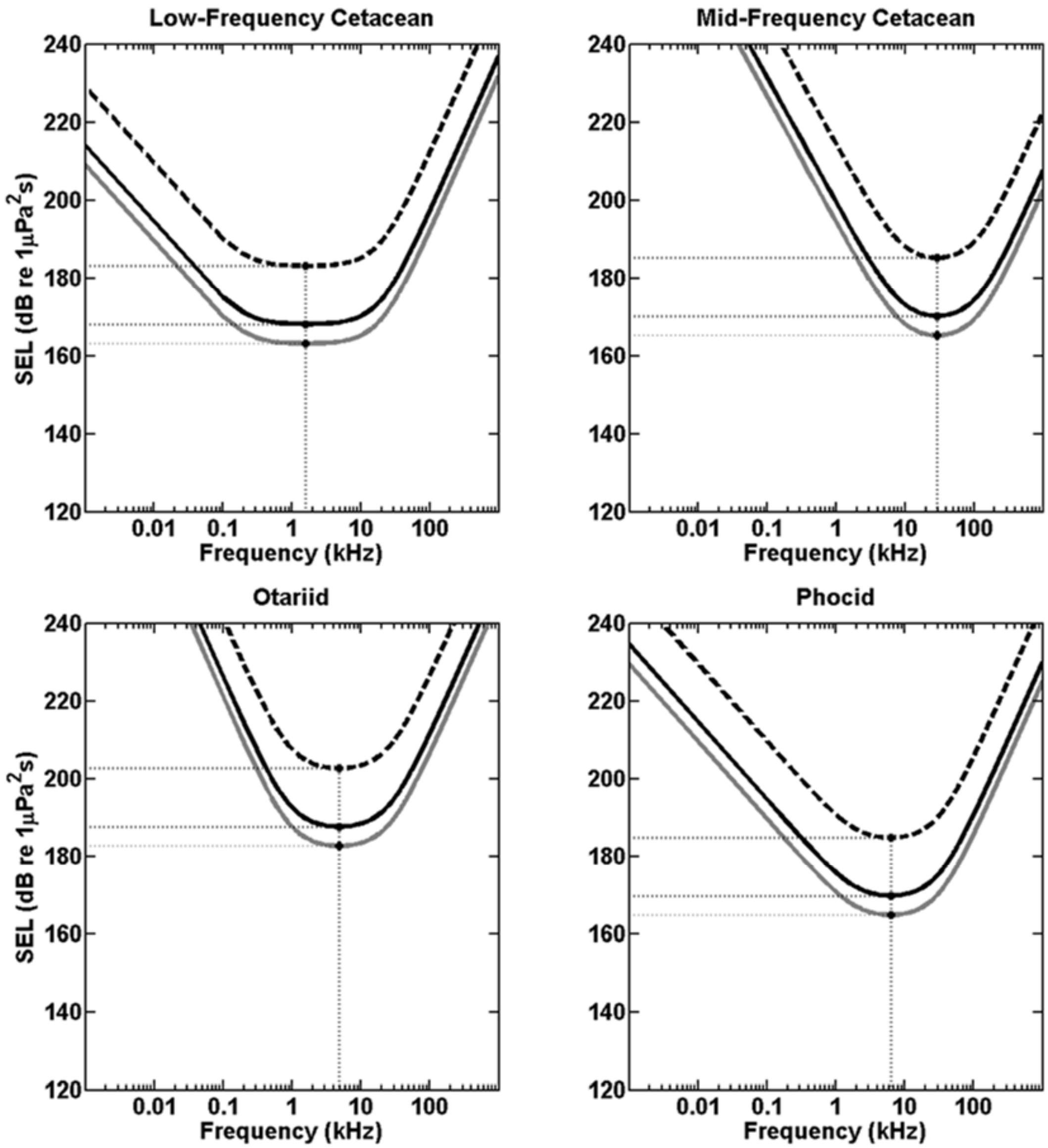
Table 1. Acoustic thresholds identifying the onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) for non-impulsive sound sources by functional hearing group (Navy 2017).

Functional Hearing Group	TTS Threshold (SEL [weighted])	PTS Threshold (SEL [weighted])
Low-Frequency Cetaceans	179	199
Mid-Frequency Cetaceans	178	198
Phocid Pinnipeds (Underwater)	181	201
Otariid Pinnipeds (Underwater)	199	219

Note: Sound Exposure Level (SEL) thresholds in dB re 1 μPa²s (decibels referenced to 1 micropascal).

For impulsive sources (inclusive of explosives, air guns, and impact pile driving), the TTS and PTS exposure functions for marine mammals are presented in Figure 2.[1]

[1] Note that this figure also depicts the marine mammal exposure functions for behavioral response from explosives. Additional information on explosives criteria for marine mammals is presented in section 2.2.1.2.3.



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 SEL threshold for behavioral response, TTS, and PTS onset at each group's most sensitive frequency (i.e., the weighted SEL threshold).

Figure 3. Behavioral, TTS, and PTS exposure functions for explosives (Navy 2018d).

Based on the exposure functions, the marine mammals onset TTS and PTS thresholds for impulsive sources are described in Table 2.

Table 2. Onset of TTS and PTS in marine mammals for explosives, air guns, and impact pile driving.

Functional Hearing Group	Species	Onset TTS	Onset PTS
Low-frequency cetaceans	All mysticetes	168 dB SEL (weighted) or 213 dB Peak SPL (unweighted)	183 dB SEL (weighted) or 219 dB Peak SPL (unweighted)
Mid-frequency cetaceans	All odontocetes	170 dB SEL (weighted) or 224 dB Peak SPL (unweighted)	185 dB SEL (weighted) or 230 dB Peak SPL (unweighted)
Phocid Pinnipeds (Underwater)	Hawaiian monk seal	170 dB SEL (weighted) or 212 dB Peak SPL (unweighted)	185 dB SEL (weighted) or 218 dB Peak SPL (unweighted)
Otariid Pinnipeds (Underwater)	Guadalupe fur seal	188 dB SEL (weighted) or 226 dB Peak SPL (unweighted)	203 dB SEL (weighted) or 232 dB Peak SPL (unweighted)

Unlike the other acoustic sources proposed for use by the 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 received impulse. Two sets of thresholds are provided for use in non-auditory injury assessment. The exposure thresholds are used to estimate the number of animals that may be affected during Navy training and testing activities (See second column of Table 3). The thresholds for the farthest range to effect are based on the received level at which one percent risk is predicted and are useful for informing mitigation zones (See third column of Table 3). Increasing animal mass and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). For masses used in impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. The derivation of these injury criteria and the species mass estimates are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (Navy 2017a).

Table 3. Criteria to quantitatively assess marine mammal and sea turtle non-auditory injury due to underwater explosions (second column) and criteria for estimating ranges to potential effect for mitigation purposes (third column).

Impact Category	Exposure Threshold	Threshold for Farthest Range to Effect*
Mortality (Impulse)**	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$
Injury (Impulse)**	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$	$47.5M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury (Peak Pressure)	243 dB re 1 μPa SPL peak	237 dB re 1 μPa SPL peak

** Threshold for one percent risk used to assess mitigation effectiveness.*
*** Impulse delivered over 20% of the estimated lung resonance period. See U.S. Department of the Navy (2017a).*
Notes: dB re 1 μPa: decibels referenced to 1 micropascal; Pa-s: pascal second; SPL: sound pressure level; D: depth of animal (m); M: mass of animal (kilograms).

2.2.1.2 Marine Mammal Criteria for Behavioral Response

Many of the behavioral responses estimated using the Navy's quantitative analysis are most likely to be of moderate severity (defined for the purposes of this impact analysis as reaction levels 4, 5, and 6 based on the behavioral response severity scale described in Southall et al. (2007a). Moderate severity responses would be considered significant if they were sustained for a duration long enough that they cause variations in an animal's daily behavior outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. Within the Navy's quantitative analysis, many behavioral reactions are predicted from exposure to sound that may exceed an animal's behavioral threshold momentarily. It is likely that some of the resulting estimated behavioral harassment takes would not constitute a significant distruption of normal behavior patterns. The Navy and NMFS have used the best available science to address the challenging differentiation between significant and non-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 degree of overestimation of the number of significant behavioral disruptions. Therefore, this analysis includes the maximum number of potential behavioral disturbances and responses that are reasonably certain to occur.

The following sections describe the criteria and thresholds used in the analysis for each acoustic source.

2.2.1.2.1 Impulsive and Non-Impulsive Sound Sources (Air Guns and Pile Driving) – Marine Mammals

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 animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Ellison et al. 2011; Southall et al. 2007a). Given the best available science and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, since 1997, NMFS has used generic sound exposure thresholds (i.e., not specific to a particular hearing group) to determine whether an activity produces underwater sounds (e.g., air guns or pile driving) that might result in behavioral disturbance of marine mammals (70 FR 1871). NMFS and the Navy used the following behavioral disturbance thresholds, expressed in root mean square (rms), for air guns and pile driving:

- Impulsive sound (e.g., impact pile driving and air guns): 160 decibel (dB) rms referenced to one microPascal (re 1µPa)
- Non-impulsive sound (e.g., vibratory pile driving): 120 dB rms (re 1 µPa)

2.2.1.2.2 Sonar – Marine Mammals

For Phase III activities, the Navy coordinated with NMFS to develop behavioral harassment criteria specific to the military readiness activities that utilize active sonar. The derivation of these criteria is discussed in detail in the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles Technical Report* (Navy 2017a). Developing the criteria for sonar involved multiple steps. All available behavioral response studies conducted both in the field and on captive animals were examined in order to understand the breadth of behavioral responses of marine mammals to sonar and other transducers. Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound. In most cases, these divisions were driven by taxonomic classifications (e.g., mysticetes, odontocetes). The data from the behavioral studies were analyzed by looking for significant disruptions of normal behavior patterns (e.g., breeding, feeding, sheltering), or lack thereof, for each experimental session. Due to the nature of behavioral response research to date, it is not currently possible to ascertain the types of observed reactions that would lead to an abandonment or significant alteration of a natural behavior pattern. Therefore, a methodology was developed to estimate the possible significance of behavioral reactions and impacts on normal behavior patterns.

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

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

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

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 4, Figure 5, and Figure 6). These divisions are driven by taxonomic classifications (e.g., odontocetes, mysticetes, pinnipeds).

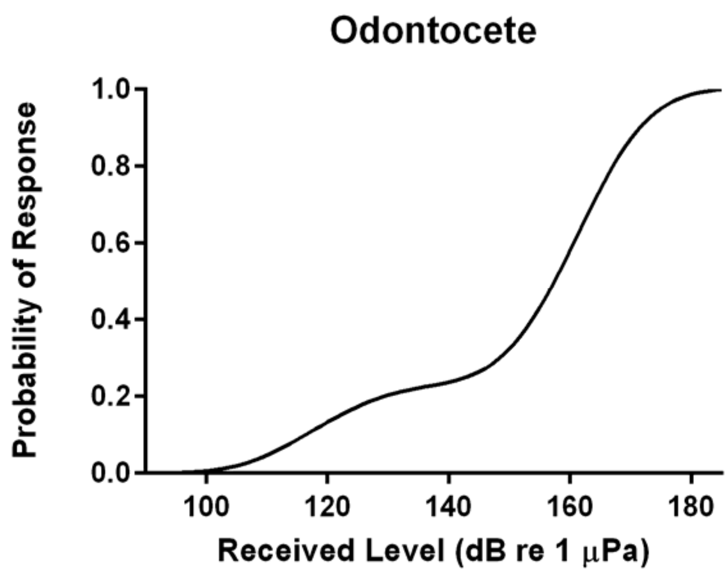


Figure 4. Behavioral response function for odontocetes (Navy 2017a).

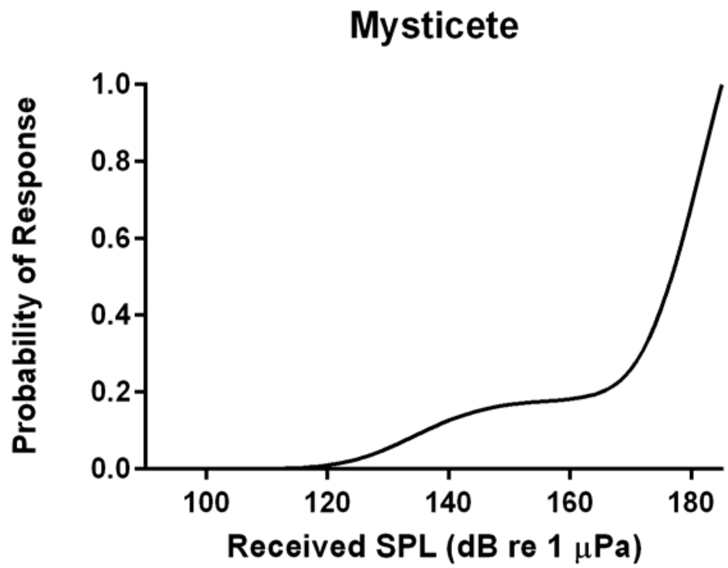


Figure 5. Behavioral response function for mysticetes (Navy 2017a).

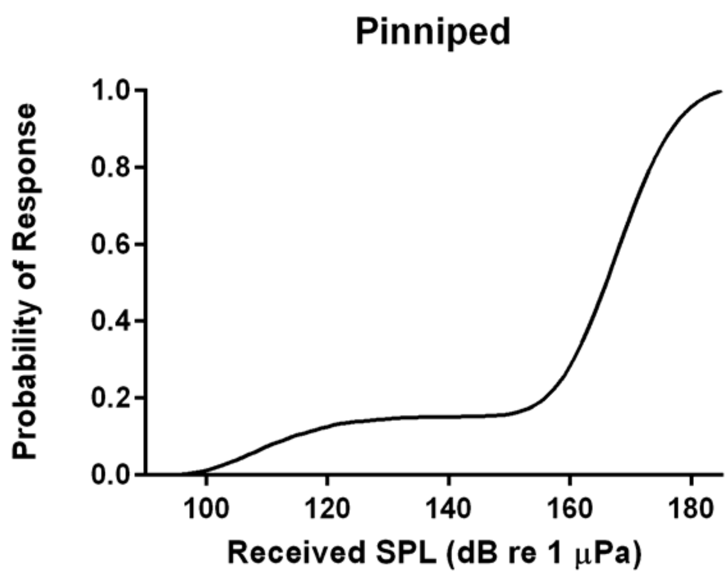


Figure 6. Behavioral response function for pinnipeds (Navy 2017a).

The analysis for active sonar used cutoffs distances beyond which recent research suggests the potential for significant behavioral responses (and therefore harassment under the ESA) is considered to be unlikely (Table 4). For animals within the cutoff distance, a behavioral response function based on a received SPL was used to predict the probability of a potential significant behavioral response. For training and testing events that contain multiple platforms or tactical sonar sources that exceed 215 dB re 1 μPa @ 1 m, this cutoff distance is substantially increased (i.e., doubled) from values derived from the literature. The use of multiple platforms and intense sound sources are factors that are expected to increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances. For this reason, and to be conservative in the analysis of potential effects, the Navy predicted significant behavioral responses at further ranges for these more intense activities.

Table 4. Cutoff distances for moderate source level, single platform training and testing events and events with multiple platforms or sonar with high sources levels[1] (Navy 2017a).

Species Group	Moderate Source Level / Single Platform Cutoff Distance	High Source Level / Multi-Platform Cutoff Distance
Odontocetes	10 km	20 km
Mysticetes	10 km	20 km
Pinnipeds	5 km	10 km

[1] High sources levels are defined as levels at or exceeding 215 dB 1 μPa at 1 meter; km = kilometer.

2.2.1.2.3 Explosives Criteria – Marine Mammals

Phase III explosive criteria for behavioral thresholds for marine mammals is the hearing group's TTS threshold minus 5 dB (See Table 2 above for the TTS thresholds for explosives) for events that contain multiple impulses from explosives underwater. Significant behavioral responses to solitary explosions are not anticipated due to the short duration of acoustic exposure from such explosions.

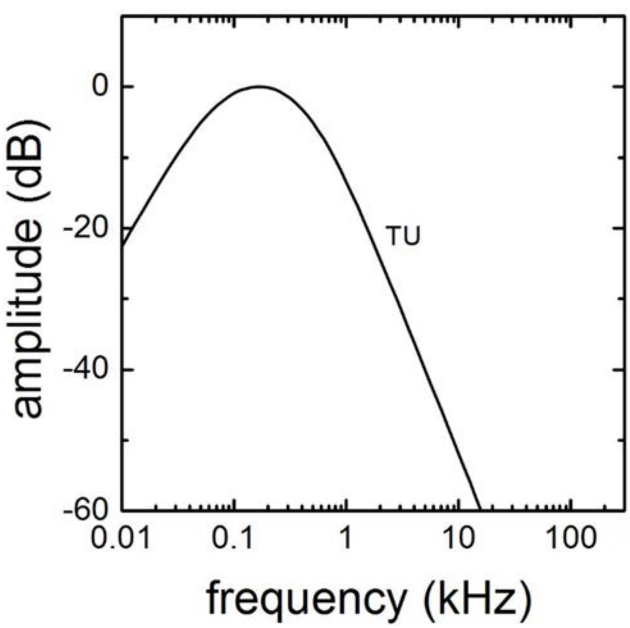
Table 5. Phase III behavioral thresholds for explosives for marine mammals underwater (Navy 2017a).

Functional Hearing Group	Sound Exposure Level (weighted)
Low-frequency cetaceans	163
Mid-frequency cetaceans	165
Phocid pinnipeds	165
Otariid pinnipeds	185

Note: Weighted SEL thresholds in dB re 1 μPa^{2}s underwater

2.2.1.3 Hearing Impairment Criteria – Sea Turtles

In order to develop some of the hearing thresholds of received sound sources for sea turtles, expected to produce TTS and PTS, the Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group. Measured or predicted auditory threshold data, as well as measured equal latency contours, 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. The same methods were then applied to other species for which TTS data did not exist. 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. Based on this composite audiogram and data on the onset of TTS in fishes, 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 7, 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 7. Auditory weighting function for sea turtles (Navy 2017).

2.2.1.4 Impulsive Sound Sources (Air Guns and Pile Driving) – Sea Turtles

In order to estimate exposure of ESA-listed sea turtles to impulsive sound sources such as air guns and pile driving), we relied on acoustic thresholds for PTS and TTS for impulsive sounds developed by Navy for Phase III activities. As described above, very limited information exists regarding hearing and sea turtles. To date, no studies have been conducted specifically related to the onset of TTS or PTS in sea turtles. Therefore, the thresholds used were developed from the most current literature on sea turtle hearing and recommendations made by Popper et al. (2014a), in *Sound Exposure Guidelines for Fishes and Sea Turtles ("2014 ANSI [American National Standards Institute]Guidelines")* that developed thresholds for fishes and sea turtles (Popper et al. 2014a). Moreover, the Navy's approach employs the same statistical methodology to derive thresholds as in NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018). The derivation of the auditory weighting function and sea turtle audiogram are described above.

Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to TTS. Data from fishes were used since there are currently no data on TTS for sea turtles and fishes are considered to have hearing more similar to sea turtles than do marine mammals (Popper et al. 2014a). Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by (Southall et al. 2007a). From these data and analyses, dual metric thresholds were established similar to those described for marine mammals and fishes, including a peak SPL metric (0-pk SPL) that does not incorporate the auditory weighting function nor the duration of exposure, and another based on cumulative sound exposure level (SEL_{cum}) that incorporates both the auditory weighting function and the exposure duration (Table 6).

Table 6. Acoustic thresholds identifying the onset of PTS and TTS for sea turtles exposed to impulsive sounds (U.S. Navy 2017).

Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Sea Turtles	30 Hz to 2 kHz	204 dB re 1 μPa²·s SEL_{cum} 232 dB re: 1 μPa SPL (0-pk)	189 dB re 1 μPa²·s SEL_{cum} 226 dB re: 1 μPa SPL (0-pk)

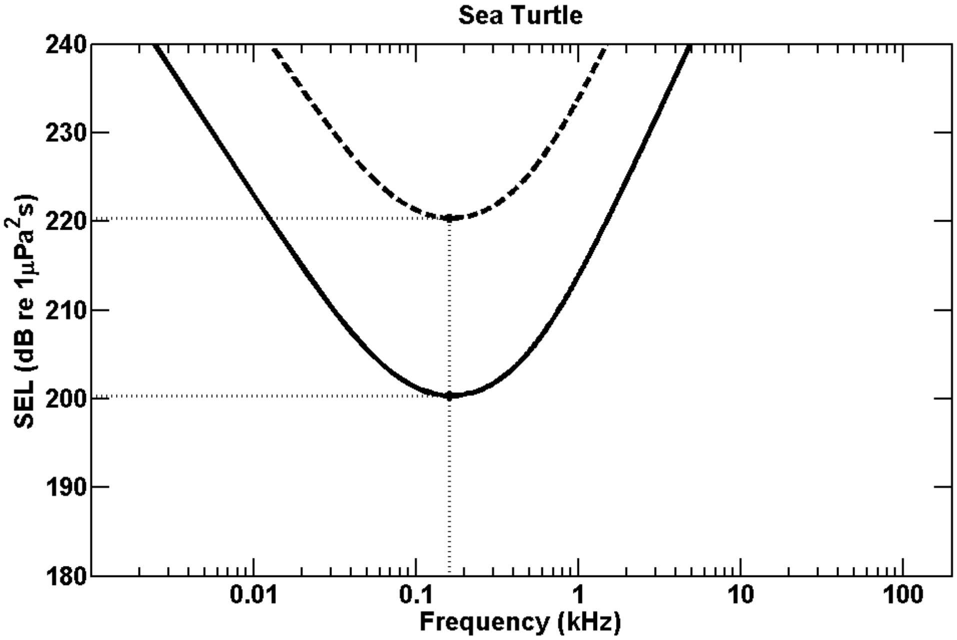
Hz = hertz

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by impulsive sound sources that would be expected to result in a behavioral response, we (and the Navy per our request) relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990b) and Mccauley et al. (2000a), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. O'Hara and Wilcox (1990b) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels up to 175 dB rms (re: 1 μPa), in a shallow canal. McCauley et al. (2000c) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: 1 μPa (rms). At 175 dB re: 1 μPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (Mccauley et al. 2000a). Based on these data, we assume that sea turtles would exhibit a behavioral response when exposed to received levels of 175 dB rms (re: 1 μPa) and higher.

2.2.1.5 Sonar Criteria – Sea Turtles

As mentioned above, no studies have been conducted specifically related to sea turtle hearing loss. The Navy evaluated sea turtle susceptibility to hearing loss (from sonar exposure) based upon what is known about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species such as marine mammals and fishes.

In general, sea turtles appear to be capable of detecting low-frequency sonar (less than 1000 Hz), whereas frequencies for the peak SPL for mid-frequency sonar (2000 to 8000 Hz) appear out of the range of sea turtle hearing sensitivity (Piniak 2012). However, it may be possible for sea turtles to detect high SPLs of mid-frequency sonar at increased sound pressure, but no studies have been conducted to date which expose sea turtles to these levels. Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by (Southall et al. 2007). Using this approach, dual metric thresholds were established for sea turtles for onset of PTS and TTS. This approach allows for the development of sea turtle exposure functions, shown below in Figure 8. These mathematical functions relate the SELs for onset of PTS or TTS to the frequency of the sonar sound. A full description of how the Navy derived these functions is provided in the technical report "*Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*" (Navy 2017a). Based upon this approach, sea turtle onset of TTS would be expected to occur if received sound levels exceed 200 dB, SEL_{cum} (re: 1 μPa^2-s) and PTS would occur for sounds that exceed 220 dB SEL_{cum} (re: 1 μPa^2-s) at an exposure frequency of 200Hz.



Note: dB re 1 μPa²s: decibels referenced to 1 micropascal second squared, kHz = kilohertz. The solid black curve is the exposure function for TTS and the dashed black curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL thresholds at the most sensitive frequency for TTS (200 dB) and PTS (220 dB).

Figure 8. TTS and PTS exposure functions for sonar and other transducers (Navy 2017).

To date, very little research has been done regarding sea turtle behavioral responses relative to sonar exposure. Because of this, the working group that prepared the 2014 ANSI Guidelines (Popper et al. 2014a) provide descriptors of sea turtle behavioral responses to sonar and other transducers. The working group estimated that the risk of a sea turtle responding to a low-frequency sonar (less than 1 kHz) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (1 to 10 kHz). However, for this analysis, similar to impulsive sounds, NMFS requested that the Navy estimate the number of sea turtles that could be exposed to sonar within their hearing range at received levels of 175 dB re: 1 μPa SPL (rms) or greater. This level is based upon work by Mccauley et al. (2000a), described for air guns. Sound levels that exceed this could cause sea turtles to exhibit a significant behavioral response such as erratic and increased swimming rates and avoidance of the sound source. Because data on sea turtle behavioral responses to non-impulsive sounds, such as sonars, is limited, the air gun data set is used to inform potential risk. We recognize this is a conservative approach, and that the relative risk of a sea turtle responding to air guns would likely be higher than the risk of responding to sonar; so it is likely that potential sea turtle behavioral responses to sonar exposures are a sub-set of sea turtles exposed to received levels of 175 dB rms (re: 1 μPa) or greater.

2.2.1.6 Explosives Criteria – Sea Turtles

As with all other species groups, NMFS and the Navy apply dual metric criteria to assess the potential onset of physical injury and hearing impairment from explosives for sea turtles. These criteria include both the peak pressure and the sound exposure level. 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 internally to organs and blood vessels. For sea turtles, the Navy developed criteria to determine the potential onset of hearing loss, physical injury (non-auditory) and non-injurious behavioral response to detonation exposure using the weighting function and hearing group described above, as well as the impulsive sound threshold criteria recommended by the 2014 ANSI Guidelines (Popper et al. 2014a). 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 dual metric criteria for non-auditory injury for sea turtles were provided above in Table 3. These thresholds also 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, have low juvenile survival rates, but those that make it past early life stages increase survival at later life stages. Based upon these factors, the following thresholds and range to farthest effects are described above in Table 3.

For hearing loss, the same thresholds applied for impulsive sound sources and sonar are also used for explosives and provided above in Table 6. Similarly, for behavioral response assessment, NMFS requested that the Navy estimate 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.

2.2.2 Density Estimates – Marine Mammals and Sea Turtles

Below we provide a summary on the methods used to derive the marine mammal and sea turtle density estimates used in the Navy's acoustic exposure analysis.[1] Additional details on the density data used for these analyses are provided in the Navy Marine Species Density Database (NMSDD) (Navy 2017d).

For most cetacean species, abundance is estimated using line-transect surveys or mark-recapture studies (e.g., Barlow 2010; Barlow and Forney 2007). The result provides one single density estimate value for each species across broad geographic areas. This is the general approach applied in estimating cetacean abundance in NMFS' marine mammal stock assessment reports. Although the single value provides a good average estimate of abundance (total number of individuals) for a specified area, it does not provide information on the species distribution or concentrations within that area, and it does not estimate density for other timeframes or seasons that were not surveyed. More recently, habitat modeling has been used to estimate cetacean densities (Barlow et al. 2009; Becker et al. 2012a; Becker et al. 2010; Becker et al. 2012b; Ferguson et al. 2006b; Forney et al. 2012; Redfern et al. 2006). These models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark recapture analyses. Within the geographic area that was modeled, densities can be predicted wherever these habitat variables can be measured or estimated.

To characterize the marine species density for large areas such as the HSTT action area, the Navy compiled data from several sources. The Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database includes seasonal density values for every marine mammal species present within the HSTT action area. This database is described in the technical report titled *U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area* (Navy 2017d), hereafter referred to as the density technical report.

A variety of density data and density models are needed in order to develop a density database that encompasses the entirety of the HSTT action area. Because this data is collected using different methods with varying amounts of accuracy and uncertainty, the Navy has developed a model hierarchy to ensure the most accurate data is used when available. The density technical report describes these models in detail and provides detailed explanations of the models applied to each species' density estimate. The below list describes possible models in order of preference.

[1] As noted above, the Navy did not estimate the number of instance of exposure to ESA-listed fish species due to a lack of density data for this species group in the action area.

1. Spatial density models are preferred and used when available because they provide an estimate with the least amount of uncertainty by deriving estimates for divided segments of the sampling area. These models (See Becker et al. 2016; Forney et al. 2015) predict spatial variability of animal presence as a function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.). This model is developed for areas, species, and, when available, specific timeframes (months or seasons) with sufficient survey data.
2. Stratified designed-based density estimates use line-transect survey data with the sampling area divided (stratified) into sub-regions, and a density is predicted for each sub-region (See Barlow 2016; Becker et al. 2016; Bradford et al. 2017; Campbell et al. 2015; Jefferson et al. 2014). While geographically stratified density estimates provide a better indication of a species' distribution within the study area, the uncertainty is typically high because each sub-region estimate is based on a smaller stratified segment of the overall survey effort.
3. Design-based density estimations use line-transect survey data from land and aerial surveys designed to cover a specific geographic area (See Carretta et al. 2015). These estimates use the same survey data as Stratified design-based estimates, but are not segmented into sub-regions and instead provide one estimate for a large surveyed area.
4. Existing Relative Environmental Suitability models include a high degree of uncertainty, but are applied when no other model is available. The majority of the world's oceans have not been surveyed in a manner that supports quantifiable density estimation of marine mammals and sea turtles. In the absence of empirical survey data, information on known or inferred associations between marine habitat features and (the likelihood of) the presence of specific species have been used to predict densities using model-based approaches. These habitat suitability models include Relative Environmental Suitability models. Habitat suitability models can be used to understand the possible extent and relative expected concentration of a marine species distribution. These models are derived from an assessment of the species occurrence in association with evaluated environmental explanatory variables that results in defining the Relative Environmental Suitability suitability of a given environment. A fitted model that quantitatively describes the relationship of occurrence with the environmental variables can be used to estimate unknown occurrence in conjunction with known habitat suitability. Abundance can thus be estimated for each Relative Environmental Suitability value based on the values of the environmental variables, providing a means to estimate density for areas that have not been surveyed.

2.2.3 Navy Acoustic Effects Model

NAEMO calculates sound energy propagation from sonars and other transducers (as well as air guns and explosives) during naval activities and the sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals and/or 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 in the Navy Marine Species Density Database (See Section 2.2.2 above) and distributes animats in the water column proportional to the known time that species spend at varying depths.

The model 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.

Assumptions in the Navy model intentionally err on the side of overestimation when there are unknowns. Naval activities are modeled as though they would occur regardless of proximity to marine mammals or sea turtles (i.e., mitigation is not incorporated in the model) and without any avoidance of the activity by the animals.

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 number of instances for which an effects threshold may be exceeded over the course of a year, but does not estimate the number of individual marine mammals or sea turtles that may be impacted over a year (Navy 2018g). The model also does not estimate whether a single individual is exposed multiple times.

A more detailed description of NAEMO is available in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g).

As described further in Section 3.4.2, 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. 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 the estimated ranges to injury (including PTS) for sonar sources and much of the range to injury for explosives. As mentioned previously, 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 quantified the potential for mitigation to reduce model-estimated PTS to TTS for exposures to sonar and other transducers, and to reduce model-estimated mortality due to injury from exposures to explosives. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, some model-estimated PTS is considered mitigated to the level of TTS. The impact analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects. Environmental conditions under which the training or testing activity could take place are also considered such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy estimated the ability of Navy Lookouts to observe the range to PTS for each training or testing event. The ability of Navy Lookouts to detect protected species in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. For example, based on small boat surveys between 2000 and 2012 in the Hawaiian Islands, pantropical spotted dolphins and striped dolphins were frequently observed leaping out of the water. This behavior is visible from a great distance and likely increases sighting distances and detections of these species.

The Navy did quantify the potential for animals to actively avoid potentially injurious sound sources. It is also well-documented (e.g., see Section 9.2.1.1.1.5) that marine mammals and sea turtles often avoid loud sound sources (e.g., those that could be injurious). Because marine mammals and sea turtles are assumed to initiate avoidance behavior when exposed to relatively high received levels of sound within their capacity to detect, an exposed animal could reduce its cumulative sound energy exposure from something like a sonar event with multiple pings (i.e., accumulated sound exposures) by leaving the area. This would reduce risk of both PTS and TTS, although the quantitative analysis only considers the potential to reduce instances of PTS by accounting for marine mammals or sea turtles swimming away to avoid repeated high-level sound exposures. All reductions in PTS sonar impacts from likely avoidance behaviors are instead considered TTS impacts.

A full description of this process is described in in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g).

2.3 Criteria and Thresholds to Predict Impacts to Fishes

A description of fish hearing according to their species' groups and sensitivity to sound is provided in the Status of the Species section (Section 7.2), as well as specific sections related to each sound source. For many of the acoustic stressors affecting fishes in the action area during the Navy's training and testing activities, the Navy relied primarily on the recommendations in the 2014 ANSI Guidelines. Where applicable, NMFS worked with the Navy to develop or use other thresholds based upon what NMFS considers to be the most appropriate given our current understanding of the effects of anthropogenic sounds on fishes as well as the best available science on the subject. For fishes, PTS has not been documented in any of the studies researching fish hearing and potential impairment from various sound sources. This is attributed to the ability for regeneration of inner ear hair cells in fishes, which differs from marine mammals and sea turtles. For this reason, thresholds for fish hearing impairment only includes the SPL related to the potential onset of TTS. A TTS in fishes is considered recoverable, although the rate of recovery is based upon the degree of the TTS sustained. Thus, auditory impairment in fishes is considered recoverable over some duration; and auditory impairment thresholds are based solely on the onset of TTS for fishes.

For barotrauma (e.g. physical injuries and mortality) in fishes, NMFS and the Navy apply dual metric criteria which includes both a peak pressure metric and SEL_{cum}. For hearing impairment (i.e., TTS), NMFS and the Navy apply an SEL_{cum} threshold. NMFS also applies an rms threshold for some acoustics sources to assess whether behavioral responses may be elicited during some sound exposures.

2.3.1 Air Guns and Pile Driving – Fishes

Impulsive sound sources such as those produced during impact hammer pile driving or air guns use are known to injure and kill fishes or elicit behavioral responses. For air guns, the Navy estimated impacts from sound produced by air guns using the recommendations that are consistent with the ANSI Guidelines (Popper et al. 2014e). These dual metric criteria are utilized to estimate zones of effects related to mortality and injury from air gun exposure. NMFS and the Navy assume that a specified effect will occur when either metric (peak SPL or $SEL_{cum)}$ is met or exceeded.

In the 2014 ANSI Guidelines, air gun thresholds are derived from the thresholds developed for impact pile driving exposures (Halvorsen et al. 2012c; Halvorsen et al. 2011c; Halvorsen et al. 2012d). This approach is consistent with the current impact hammer criteria NMFS applies for fishes with swim bladders (FHWG 2008; Stadler and Woodbury 2009). The interim criteria developed by the Fisheries Hydroacoustic Working Group (FHWG) include dual metric criteria wherein the onset of physical injury would be expected if either the peak SPL exceeds 206 dB re 1 μPa, or the SEL_{cum}, exceeds 187 dB re 1 μPa^2-s for fish two grams or larger, or 183 dB 1 μPa^2-s for fish smaller than two grams. However, at the time the interim criteria were developed, very little information was available regarding fish and pile driving effects. Therefore, the criteria largely used information available from air gun and explosive exposures. As such it is also often applied to other impulsive sound sources. In addition, the 2008 interim criteria did not specifically separate thresholds according to severity of injury such as TTS to recoverable injury to mortality, which was done in the 2014 ANSI Guidelines. Nor do they differentiate between fish with swim bladders and those without, despite the presence of a swim bladder affecting hearing capabilities and fish sensitivity to sound. The 2008 interim criteria based the lower SEL_{cum} thresholds (187 and 183 dB) upon when TTS or minor injuries would be expected to occur. Therefore, the criteria establish the starting point when the spectrum of potential physical effects may occur for fishes, from TTS to minor, recoverable injury, up to lethal injury (i.e., either resulting in either instantaneous or delayed mortality). Because some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities and influence of a swim bladder, we will separate ESA-listed fishes considered in this consultation based upon those anatomical features which result in varying degrees of hearing sensitivity (Casper et al. 2012b; Hastings and C. 2009; Popper et al. 2014a). Categories and descriptions of hearing sensitivities are further defined in this document (modified from Popper et al. 2014a) as the following[1]:

- Fishes without a swim bladder, but with hearing limited to particle motion detection at frequencies well below 1 kilohertz (kHz): include giant manta ray, oceanic whitetip shark, and scalloped hammerhead shark.
- Fishes with a swim bladder that is not involved in hearing, lack hearing specializations and primarily detect particle motion at frequencies below 1 kHz include steelhead trout.

For the Navy training and testing activities, air gun and pile driving thresholds for fishes are presented in Table 7:

Table 7. Sound exposure criteria for mortality and injury from impulsive sound sources (air guns and impact hammer pile driving).

Fish Hearing Group	Onset of Mortality		Onset of Injury	
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}
Fishes without a swim bladder	> 219	> 213	> 216	> 213
Fishes with a swim bladder not involved in hearing	210	> 207	203	> 207

Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa²-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 μPa]), > indicates that the given effect would occur above the reported threshold.

[1] The 2014 ANSI Guidelines and the Navy assessment provide distinctions between fish with and without swim bladders and fish with swim bladders involved in hearing. None of the ESA-listed fish species considered in this biological opinion have swim bladders involved with their hearing abilities. Thus, we simplified the distinction to fishes with or without swim bladders.

Criteria and thresholds to estimate TTS in fishes exposed to sound produced by air guns are pile driving are presented below in Table 8. Exposure to sound produced from an air gun at a cumulative SEL of 186 dB re 1 μPa^2-s has resulted in TTS in fishes (Popper et al. 2005b).[1] TTS is not known to occur in fishes without a swim bladder, but would likely occur above 186 dB SEL_{cum} (re 1 μPa^2-s).

Table 8. Fish hearing group sound exposure criteria for TTS from impulsive sound sources (air guns and impact hammer pile driving).

Fish Hearing Group	TTS (SEL_{cum})
Fishes without a swim bladder	NC
Fishes with a swim bladder not involved in hearing	> 186

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sound produced by air guns is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

For potential behavioral responses of fishes from exposure to anthropogenic sounds, there are no formal criteria yet established. This is largely due to the sheer diversity of fishes, their life histories and behaviors, as well as the inherent difficulties conducting studies related to fish behavior in the wild. NMFS applies a conservative threshold of 150 dB rms (re 1 μPa) to assess potential behavioral responses of fishes from acoustic stimuli, described below.

In a study conducted by Fewtrell et al. in 2003, fish were exposed to air guns and observed to exhibit alarm responses from sound levels of 158 to 163 dB (re 1 μPa). In addition, when the 2008 criteria were being developed, one of the technical panel experts, Dr. Mardi Hastings, recommended a "safe limit" of fish exposure, meaning where no injury would be expected to occur to fishes from sound exposure, set at 150 dB rms (re 1 μPa) based upon her research (Hastings 1990a; referenced in Sonalysts 1997). This "safe limit" was also referenced in a document investigating fish effects from underwater sounds generated from construction (Sonalysts 1997) where the authors mention two studies conducted by Dr. Hastings that noted no physical damage to fishes occurred when exposed to sound levels of 150 dB rms at frequencies between 100-2,000 Hz. In that same report, the authors noted they also observed fish behavioral responses during sound exposure of 160 dB rms, albeit at very high frequencies. More recently, Fewtrell and Mccauley (2012) exposed fishes to air gun sound between 147-151 dB SEL, and observed alarm responses in fishes as well as tightly grouped swimming or fast swimming speeds.[2]

[1] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 SEL_{cum}
[2] A more thorough discussion of fish behavior and sound criteria is provided in the status of the species sections as well as the effects analyses for individual sound sources later in this document.

None of the current research available on fish behavioral response to sound make recommendations for a behavioral threshold. The studies mentioned here, as with most data available on behavioral responses to anthropogenic sound for fishes have been obtained through controlled, laboratory studies. In other cases, behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not show normal behavioral responses which makes it difficult to extrapolate caged fish behavior to wild, unconfined fishes (Hawkins et al. 2014; Popper and N. 2014). It is also important to mention that some of the information regarding fish behavior while exposed to anthropogenic sounds has been obtained from unpublished documents such as monitoring reports, grey literature, or other non-peer reviewed documents with varying degrees of quality. Therefore, behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild. Nonetheless, potential behavioral responses must be considered as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until new data indicate otherwise, NMFS believes a 150 dB rms (re 1 μPa) threshold for behavioral responses of fishes is appropriate. This criterion is used to establish a sound level where responses of fishes may occur and could be a concern. For ESA-listed fishes, NMFS applies this criterion when considering the life stage affected, and any adverse effects that could occur from behavioral responses such as attentional disruption, which could lead to reduced foraging success, impaired predatory avoidance, leaving protective cover, release of stress hormones affecting growth rates, poor reproductive success rates and disrupted migration.

2.3.2 Sonar – Fishes

General categories and characteristics of Navy sonar systems proposed for use during activities considered are described in Section 6.1.3 (Sonar and Other Transducers). All ESA-listed fishes have the potential to be exposed to sonar and other transducers during Navy activities included in this biological opinion. Direct injury from sonar and other transducers is considered highly unlikely because injury from sound levels produced from sonar has not been documented in fishes (Halvorsen et al. 2012e; Kane et al. 2010; Popper et al. 2014a; Popper et al. 2007; Popper et al. 2013). The sound characteristics (e.g., non-impulsive) of sonar are considered to pose less risk to fishes because they have lower peak pressures and slow rise times. These non-impulsive, sound sources lack the strong shock wave such as that produced from an explosion. The most probable impacts from exposure to sonar and other transducers would be in the form of TTS and would likely occur after a long duration of exposure at low frequencies, longer than most of the sonar exposures that would occur during Navy training and testing activities. Therefore, in order to evaluate the effects of sonar use during Navy activities, NMFS and the Navy use the criteria for sonar and fishes based upon the recommendations provided in the 2014 ANSI Guidelines. These are provided in Table 9.

Table 9. Sound exposure criteria for TTS from sonar (Navy 2017).

Fish Hearing Group	TTS from Low-Frequency Sonar (SEL_{cum})	TTS from Mid-Frequency Sonar (SEL_{cum})
Fishes without a swim bladder	NC	NC
Fishes with a swim bladder not involved in hearing	> 210	NC

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sonar is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

2.3.3 Explosives – Fishes

For explosives, this consultation used the mortality criteria provided in the 2014 ANSI Guidelines, which also divides fish according to presence of a swim bladder and if the swim bladder is involved in hearing (described above). The 2014 ANSI Guidelines did not suggest numeric thresholds for injury or TTS due to explosives. Therefore, the Navy's HSTT Phase III BA (Navy 2018d) and the HSTT Draft EIS/OEIS (Navy 2017b) proposed to use the impact pile driving and air gun injury thresholds suggested by the ANSI Guidelines as surrogates. These criteria are used for this consultation as numeric thresholds for injury and TTS in fishes. Because we have no way of estimating the abundance and assemblage of fishes with or without these characteristics, NMFS assumes the zone of impact would encompass the distance it would take for the sound wave to reach the criteria for the most sensitive fish species. The onset of the lowest level of injury along the injury continuum, in this case would be either greater than 203 dB peak re 1 μPa, or greater than 186 dB SEL_{cum} dB re 1 μPa^2-s as indicated provided in Table 10.

Table 10. Sound exposure criteria for mortality, injury, and TTS from explosives (Navy 2018d).

Fish Hearing Group	Onset of Mortality	Onset of Injury		TTS
	SPL_{peak}	SEL_{cum}	SPL_{peak}	(SEL_{cum})
Fishes without a swim bladder	229	> 216	> 213	NC
Fishes with a swim bladder not involved in hearing	229	203	> 207	> 186

Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 μPa]), > indicates that the given effect would occur above the reported threshold. Notes: TTS = Temporary Threshold Shift. NC = no criteria, > indicates that the given effect would occur above the reported threshold.

During consultation, the Navy proposed an alternative peak pressure threshold for onset of injury in fishes from explosives (i.e., 220 dB peak re 1 μPa) compared with the criteria included in the Navy's BA (Navy 2018d) and the HSTT Draft EIS/OEIS (Navy 2017b). The alternative threshold is based on a compilation of data from a variety of studies on the effects of explosives on fishes with swimbladders (Gaspin 1975; Gaspin et al. 1976; Hubbs and Rechnitzer 1952a; Settle et al. 2002; Yelverton et al. 1975b) and is described in further detail in the Navy's Final EIS/OEIS (FEIS/OEIS). Note that while we did not use this peak pressure threshold in this consultation, the threshold we did use in this consultation is more protective of the species considered in this opinion (i.e., the threshold we used is lower). We will evaluate the use of the Navy's alternative threshold for future consultations.

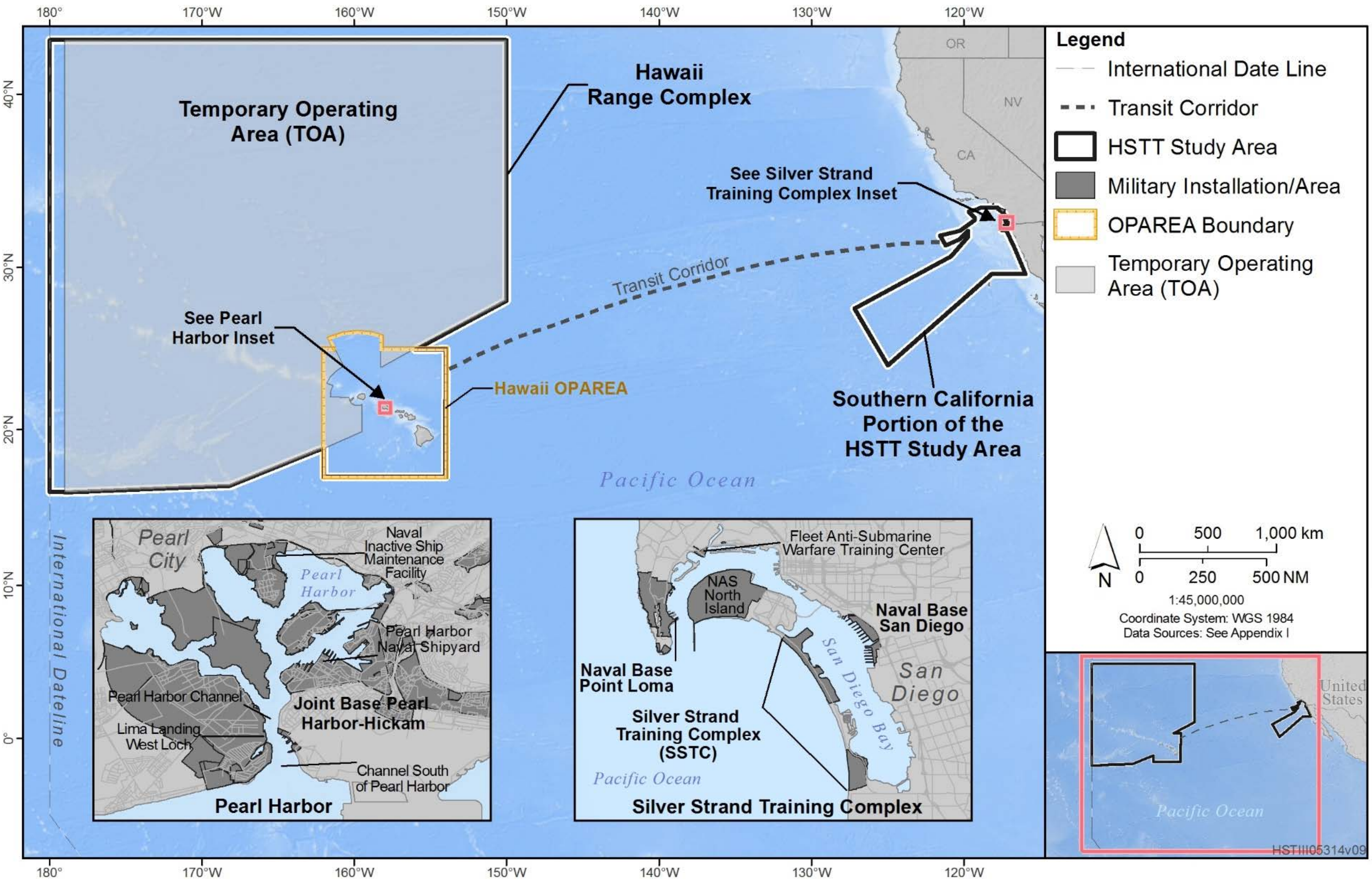
3 Description of the Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. "action area" means all areas to be affected directly or indirectly by the Federal "action" and not merely the immediate area involved in the action. 50 C.F.R. §402.02.

The Navy proposes to conduct military readiness training and testing ("testing" includes research, development, testing, and evaluation) activities in the HSTT action area (Figure 9). These military readiness training and testing activities include the use of active sonar and explosives within established operating and warning areas across the north-central Pacific Ocean, from the mean high tide line in Southern California west to Hawaii and the International Date Line. These military readiness activities are representative of training and testing the Navy has been conducting in the HSTT action area for decades.

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 HSTT activities from December 2018 to December 2023. 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.federalregister.gov/documents/2018/06/26/2018-13115/taking-and-importing-marine-mammals-taking-marine-mammals-incidental-to-the-us-navy-training-and. This consultation considers the MMPA regulations for the Navy to "take" marine mammals incidental to HSTT activities, as modified during ESA consultation. The final MMPA regulations, upon publication, will be available at the following website: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities*. 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 3.4.2 of this opinion). We also anticipate that the levels of take of ESA-listed marine mammals authorizaed 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 are needed, the reinitiation triggers described in Section 15 may apply.

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 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.



Note: HSTT = Hawaii-Southern California Training and Testing; NAS = Naval Air Station; NB = Naval Base.

Figure 9. Hawaii-Southern California Training and Testing Study Area (i.e., the action area).

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. 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.

The sections below (Sections 3.1, 3.2, 3.3, and 3.3.2.4) provide greater detail on the Navy's proposed training and testing activities in the action area. The NMFS Permits Division proposes to promulgate regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to these activities. 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 conclude this section by presenting information on the standard operating procedures and mitigation measures that will be implemented by the Navy as part of the training and testing activities.

3.1 Location

Proposed activities will occur in the action area (Figure 9), which includes the Hawaii Range Complex (HRC), Southern California (SOCAL) Range Complex, the Point Mugu Sea Range overlap, the Silver Strand Training Complex, ocean areas outside the bounds of existing range complexes (i.e., the transit corridor), pierside locations in Hawaii and Southern California, and San Diego Bay. The action area and typical transit corridor between Hawaii and Southern California are depicted in Figure 9. Regional maps contained in Figure 11 through Figure 21 are provided for additional detail of the range complexes and training areas. The total water surface area covered by the action area (excluding the transit corridor) is approximately 2,455,000 NM^2. The range complexes and components of these ranges are described in the following sections. The Navy's activities would occur well within the boundaries depicted on Figure 9, so that the effects of the action, including effects from sonar and explosives, would not extend beyond these boundaries.

A Navy range complex consists of geographic areas that include a water component (above and below the surface) an airspace, and may include a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occur.[9] Range complexes include established operating areas and special use airspace, which may be further divided to provide better control of the area for safety reasons. The terms used to describe the components of the range complexes are described below:

[9] Land components associated with the range complexes and testing ranges are not included in the action area because no activities on these land areas are included as part of the proposed action.

- **Airspace**
  - **Special Use Airspace**. Types of special use airspace most commonly found in range complexes include the following:
    - **Restricted Areas**. Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft Some areas are under strict control of the Department of Defense (DoD) and some are shared with non-military agencies.
    - **Warning Areas**. Areas of defined dimensions, extending from 3 nautical miles (NM) outward from the coast of the United States, which serve to warn non-participating aircraft of potential danger.
    - **Air Traffic Control Assigned Airspace**. Airspace of defined vertical/lateral limits, assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activity being conducted within the assigned airspace and other instrument flight rules traffic.
- **Sea and Undersea Space**
  - **Operating Areas (OPAREAs)**. An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. OPAREAs include restricted areas, which are defined water areas for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for government property and also provide protection to the public from the risks of damage or injury arising from the government's use of that area.

The range complexes and testing ranges are described in the following sections.

3.1.1 Hawaii Range Complex

The HRC is comprised of the Temporary Operating Area (OPAREA) and the Hawaii OPAREA. The ocean areas of the HRC extend from 16 degrees north latitude to 43 degrees north latitude and from 150 degrees west longitude to the International Date Line, forming an area approximately 1,700 by 1,600 NM.

The largest component of the HRC is the Temporary Operating Area (OPAREA), extending north and west from the island of Kauai, and comprising over 2 million square nautical miles (NM^2) of air and sea space. In spite of the Temporary OPAREA’s size, nearly all of the training and testing activities in the HRC take place within the smaller Hawaii OPAREA, that portion of the range complex immediately surrounding the island chain from Hawaii to Kauai. The Hawaii OPAREA geographically encompasses ocean areas located around the Hawaiian Islands chain. The Hawaii OPAREA consists of 235,000 NM^2 of special use airspace and ocean areas. Also, as shown in Figure 10, there is a relatively defined regional core use area within the HRC used for the majority of in-water Navy training and testing. This core use area encompasses 86,103 NM^2. Note that training and testing activities do occur outside of these core use areas, but due to a number of coordination, scheduling, logistic, timing, infrastructure (e.g., instrumented ranges), and safety reasons, the majority of in-water training occurs in this area.

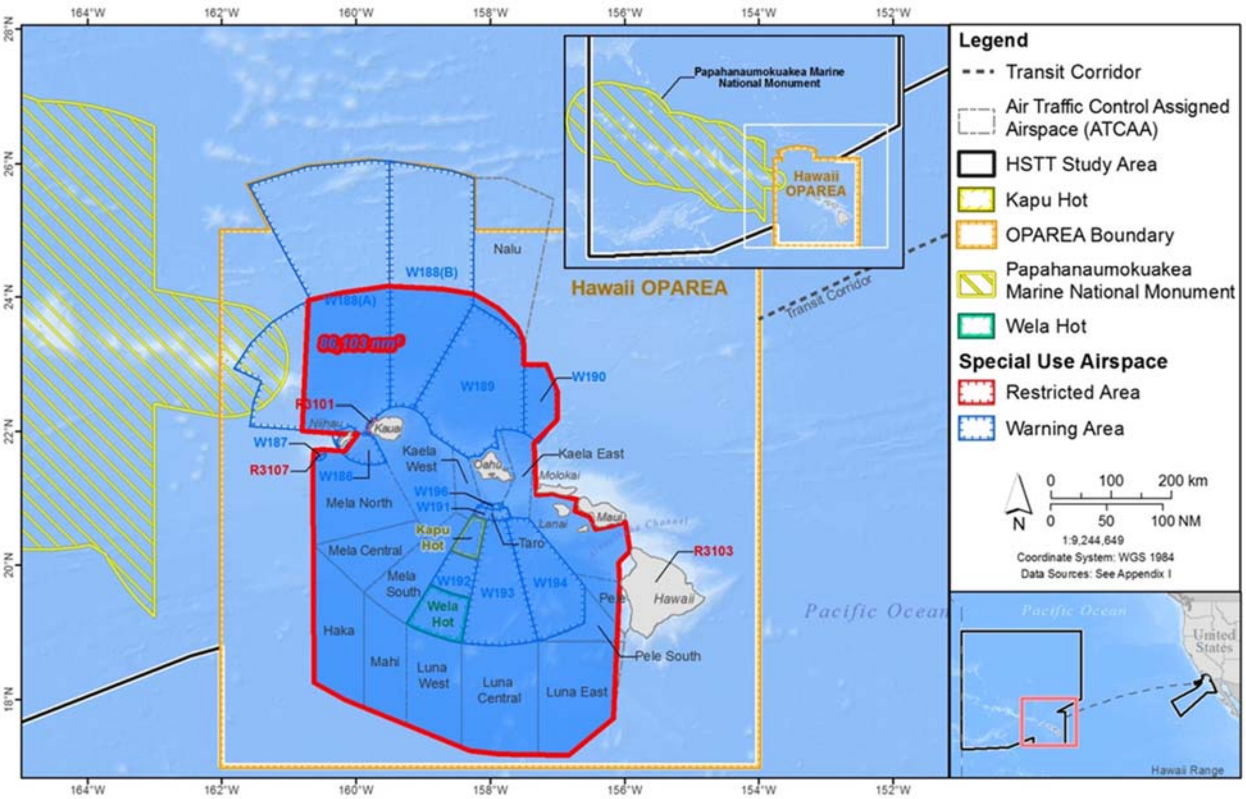


Figure 10. Hawaii Range Complex Core Area.

3.1.1.1 Airspace

The Hawaii OPAREA includes over 115,000 NM^2 of combined special use airspace and air traffic controlled assigned airspace. As depicted in Figure 11, this airspace is almost entirely over the ocean and includes warning areas, air traffic control assigned airspace, and restricted areas.

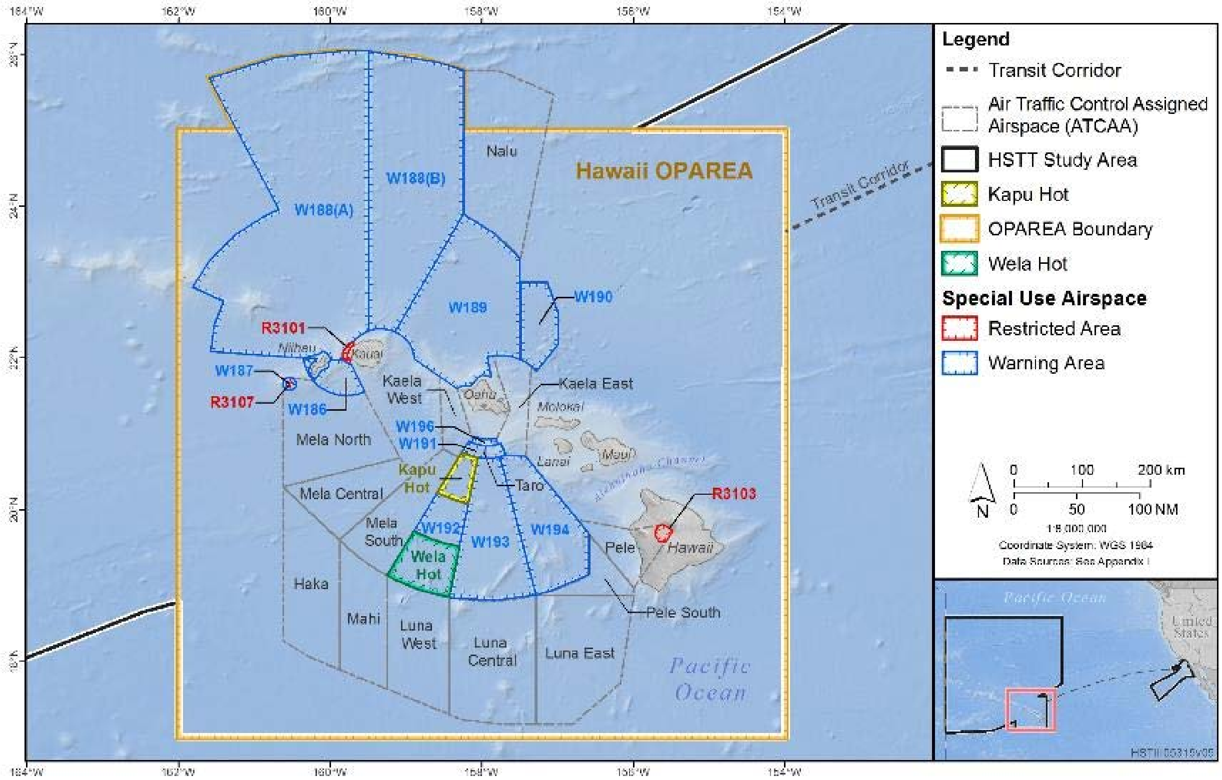


Figure 11. Hawaii Operating Area.

Warning Areas of the Hawaii OPAREA make up more than 58,000 NM^2 of special use airspace and include the following: W-186, W-187, W-188, W-189, W-190, W-191, W-192, W-193, W-194, and W-196.

The air traffic control assigned airspace areas of the HRC account for more than 57,000 NM^2 of airspace and include the following areas: Luna East, Luna Central, Luna West, Mahi, Haka, Mela South, Mela Central, Mela North, Nalu, Taro, Kaela East, Kaela West, Pele, and Pele South.

The restricted area airspace over or near land areas within the Hawaii OPAREA make up another 81 NM^2 of special use airspace and include R-3101, R-3103, and R-3107. Kaula Island is located completely within R-3107, west-southwest of Kauai.

3.1.1.2 Sea and Undersea Space

The Hawaii OPAREA includes the ocean areas as described above, as well as specific training areas around the islands of Kauai (Figure 12), Oahu (Figure 13), and Maui (Figure 14).

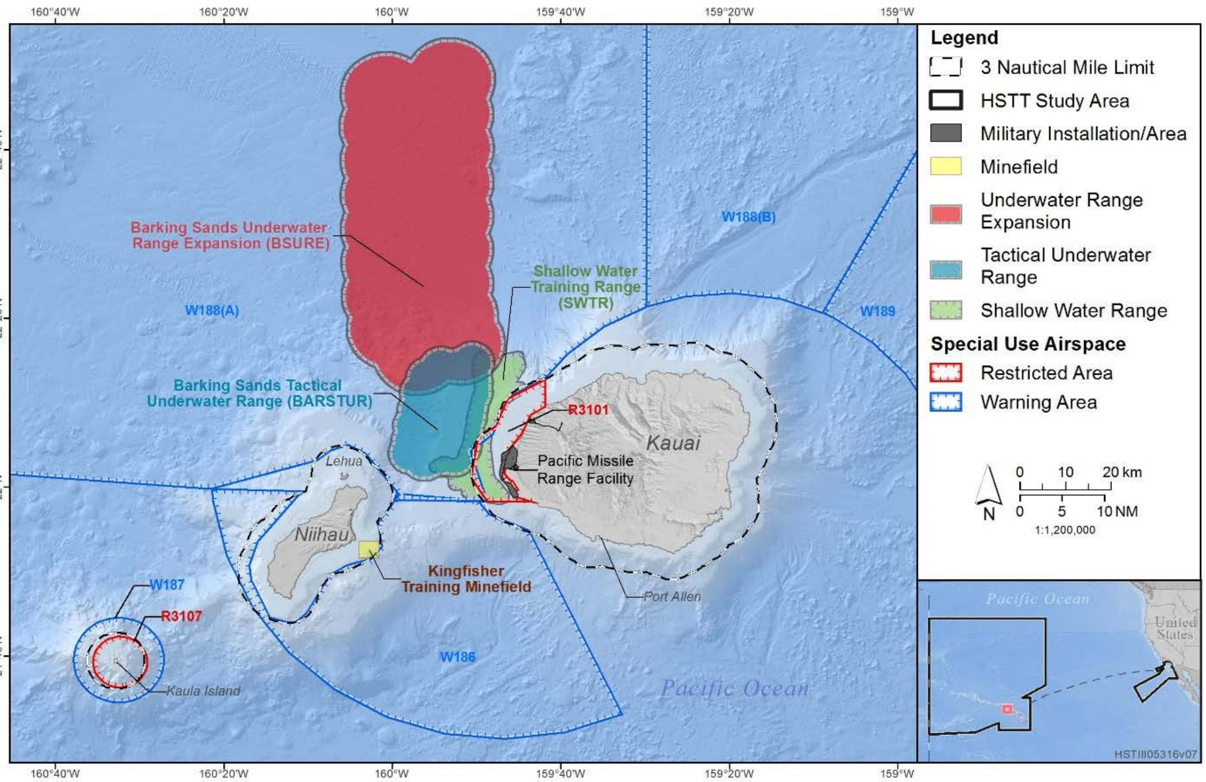


Figure 12. Navy training and testing areas around Kauai.

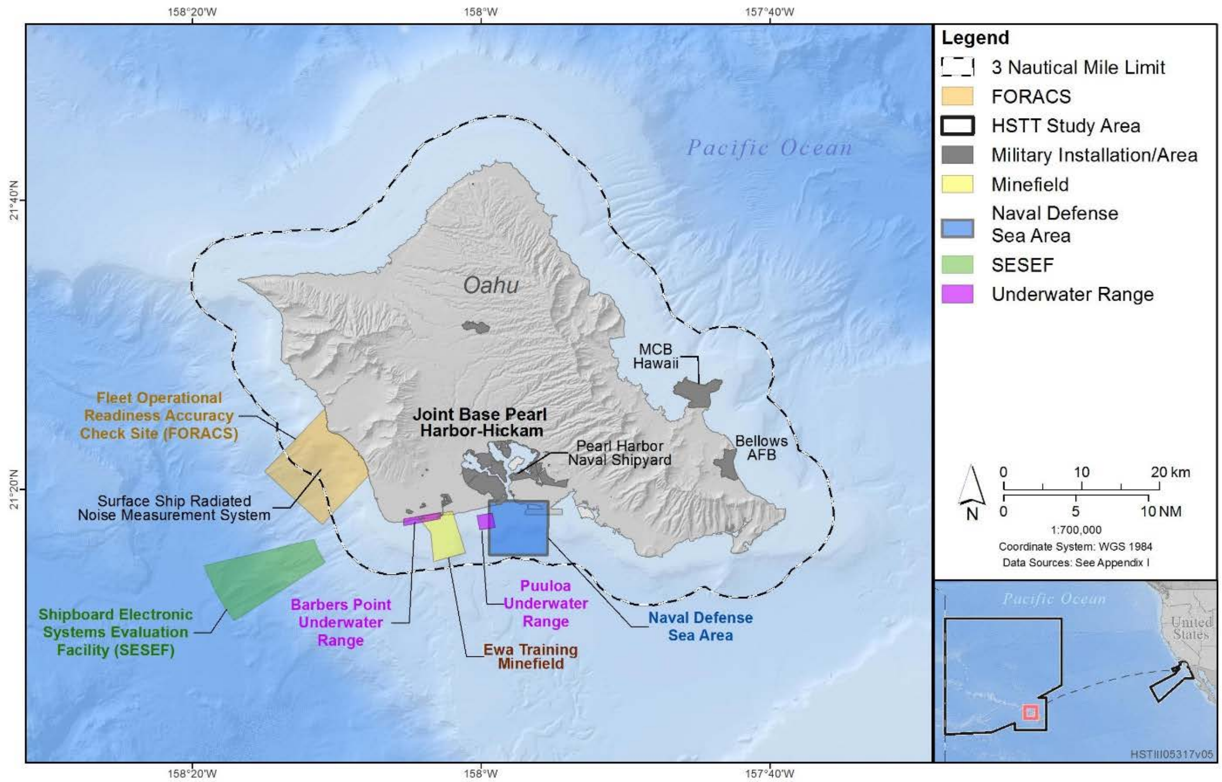


Figure 13. Navy training and testing areas around Oahu.

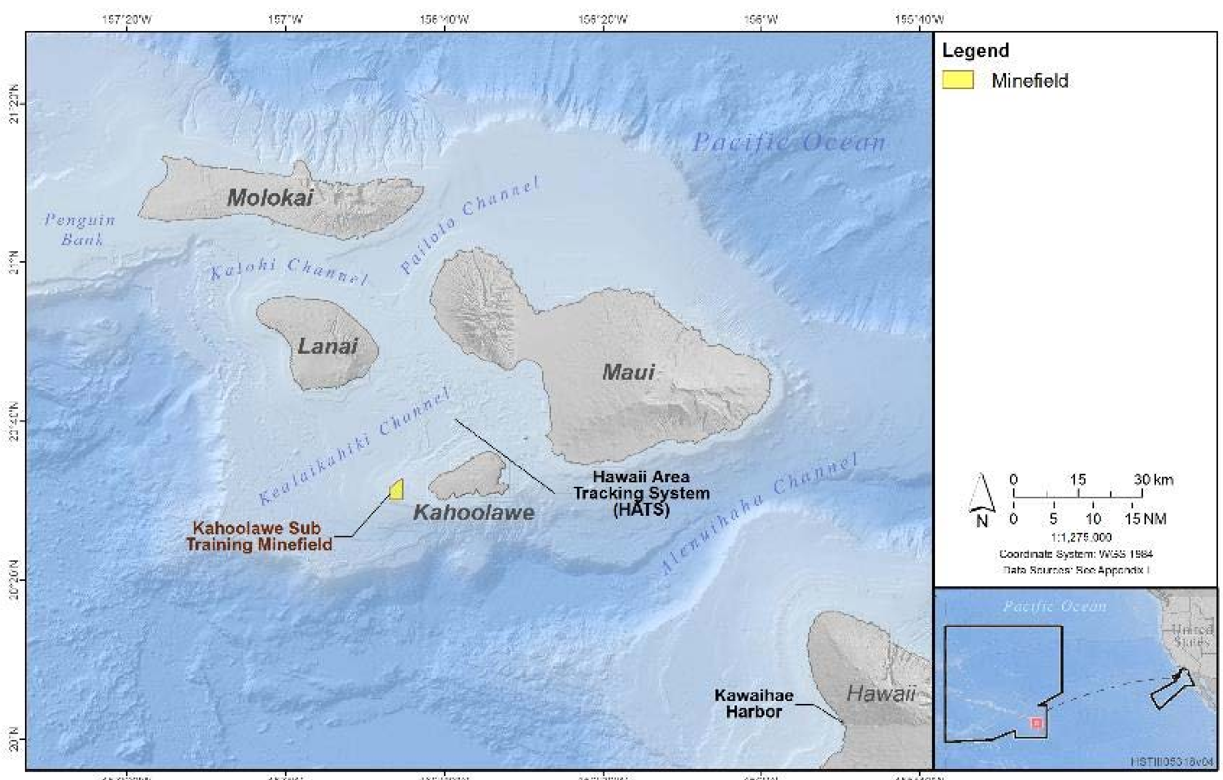


Figure 14. Navy training and testing areas around Maui.

- The Pacific Missile Range Facility around Kauai supports subsurface, surface, air, and space activities. It consists of 1,100 NM^2 of instrumented underwater ranges at depths between 129 feet (ft) and 15,000 ft. The Pacific Missile Range Facility provides major range services for training; tactics development; and evaluation of air, surface, and subsurface weapons systems for the Navy, other Department of Defense (DoD) agencies, foreign military forces, and private industry. The Pacific Missile Range Facility includes the following:
  - Barking Sands Tactical Underwater Range (Figure 12) is an instrumented underwater range that provides approximately 120 NM^2 of underwater tracking of participants and targets.
  - Barking Sands Underwater Range Expansion (Figure 12) extends the Barking Sands Tactical Underwater Range to the north and provides an additional 900 NM^2 of underwater tracking capability.
  - The Shallow Water Training Range (Figure 12) is an instrumented underwater range available for shallow water tracking.
  - The Kingfisher Training Minefield (Figure 12) is a training area approximately 2 miles off the southeast coast of Niihau that provides mine avoidance training for surface ships.
- The Fleet Operational Readiness Accuracy Check Site around Oahu (Figure 13) checks range and bearing accuracy for Navy and Coast Guard ships to ensure equipment function and calibration.
- The Surface Ship Radiated Noise Measurement System around Oahu (Figure 13) evaluates waterborne acoustic characteristics of Navy ships, which may provide information to determine corrective actions to reduce a ship's acoustic noise, thus reducing vulnerability to undersea warfare threats.
- The Shipboard Electronic Systems Evaluation Facility around Oahu (Figure 13) evaluates ship, shore, and aircraft systems that emit or detect electronic emissions.
- Barbers Point Underwater Range around Oahu (Figure 13) provides nearshore water space for mine neutralization training activities.
- Puuloa Underwater Range around Oahu (Figure 13) is a 1 NM^2 area in the open ocean outside and to the west of the entrance to Pearl Harbor providing nearshore water space for Explosive Ordnance Disposal training.
- Ewa Training Minefield around Oahu (Figure 13) is an ocean area extending from Ewa Beach approximately 2 NM toward Barbers Point, and out to sea approximately 4 NM. This restricted area provides water space for surface ship mine avoidance training.
- Hawaii Area Tracking System (Figure 14) is an ocean area approximately 9 NM off the southwest coast of the island of Maui, used for submarine training.

- Kahoolawe Sub Training Minefield (Figure 14) is an ocean area approximately 3 NM off the west coast of the island of Kahoolawe, used by submarines for mine avoidance training.

3.1.2 Southern California Portion of the Action Area

The Southern California portion of the action area is comprised of the SOCAL Range Complex, Point Mugu Sea Range Overlap, and Silver Strand Training Complex (See Figure 15).

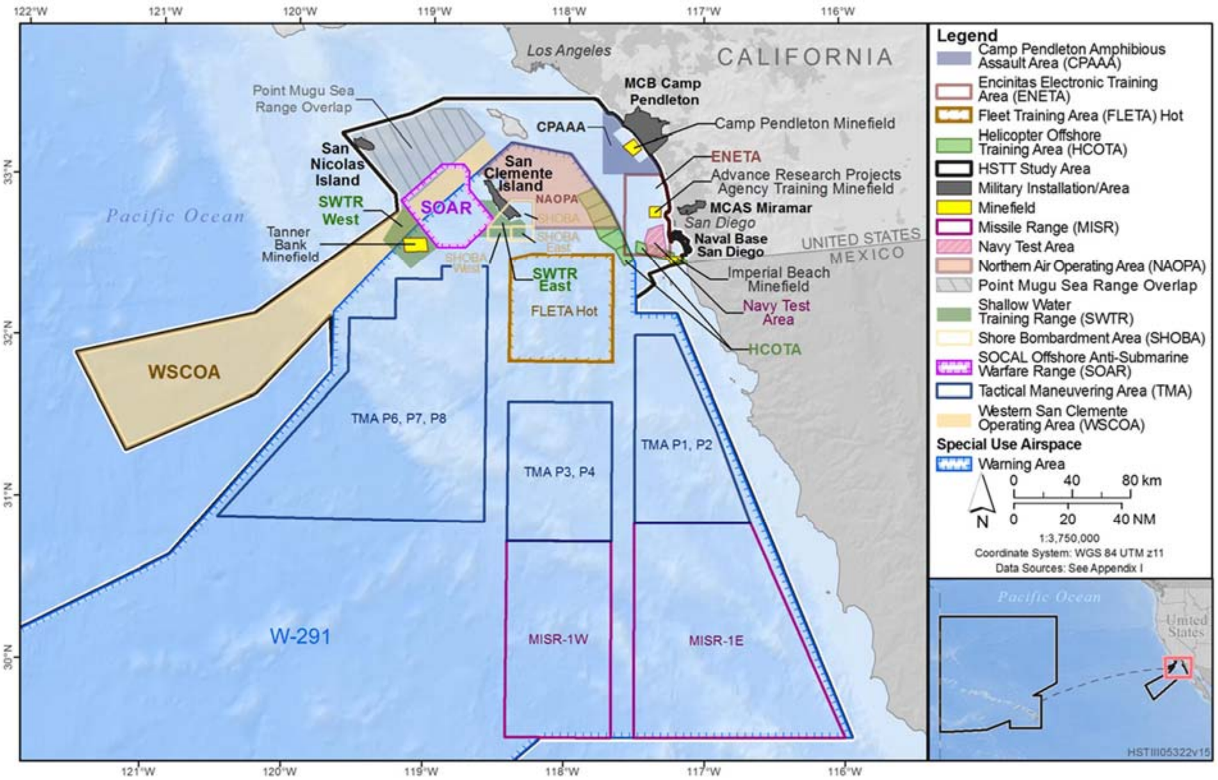


Figure 15. Southern California portion of the action area.

3.1.2.1 Southern California Range Complex

The SOCAL Range Complex is situated between Dana Point and San Diego, and extends more than 600 NM southwest into the Pacific Ocean (Figure 16 through Figure 18). Despite its size, most activities occur within the eastern portion of the range complex, nearer to shore and established range capabilities. The two primary components of the SOCAL Range Complex are the ocean OPAREAs and the special use airspace. These components encompass 120,000 NM^2 of sea space and 113,000 NM^2 of special use airspace.

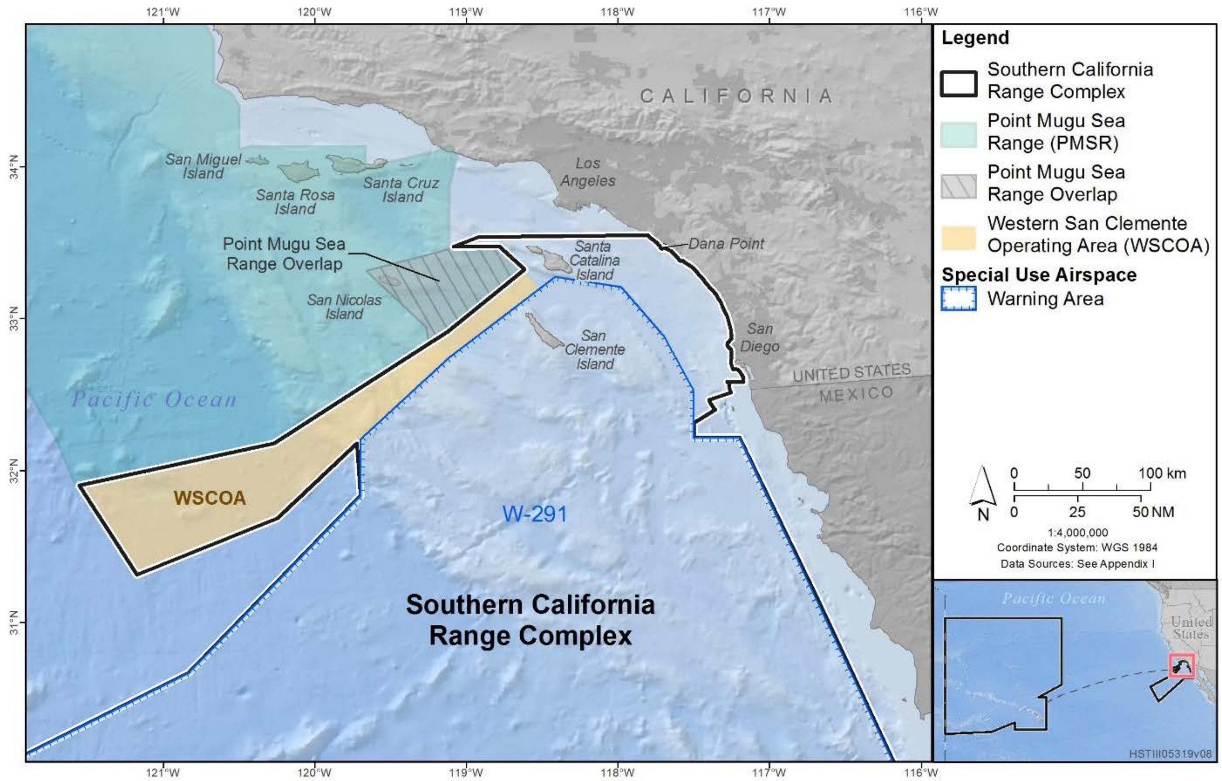


Figure 16. Southern California Range Complex.

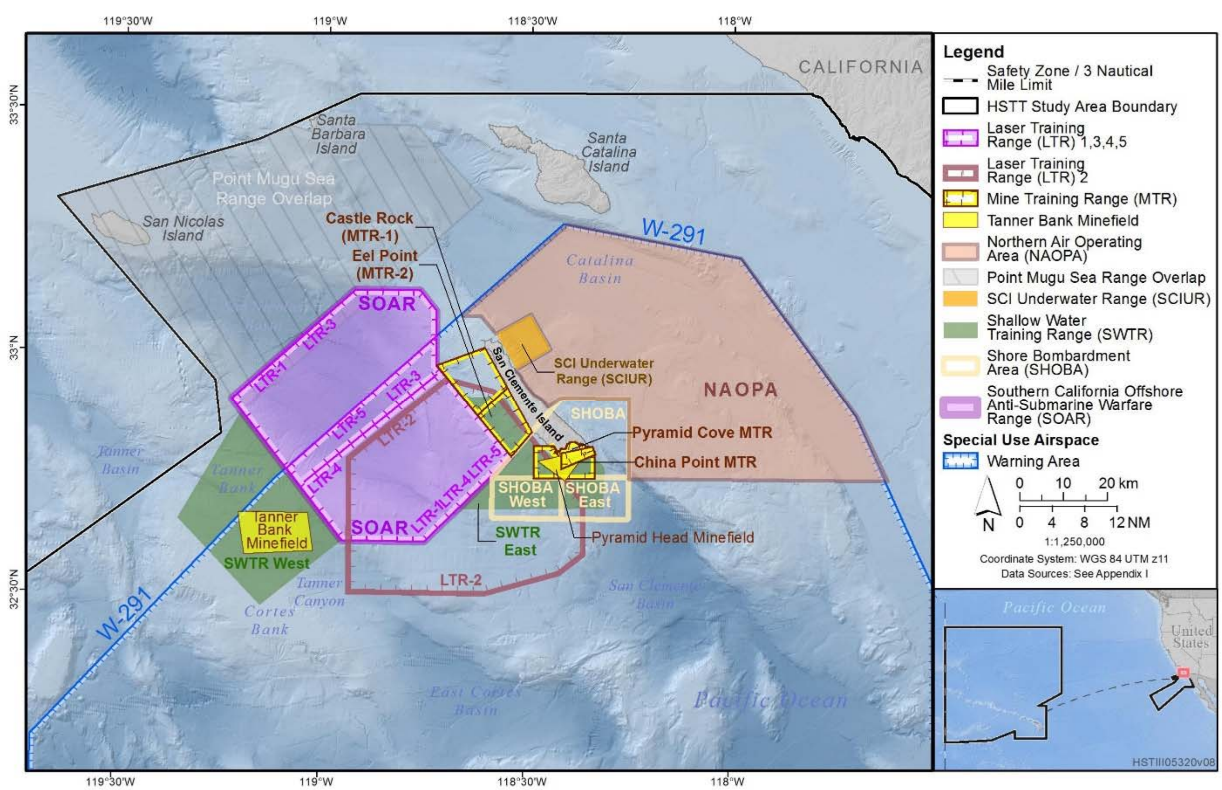


Figure 17. San Clemente Island Training and Testing Areas.

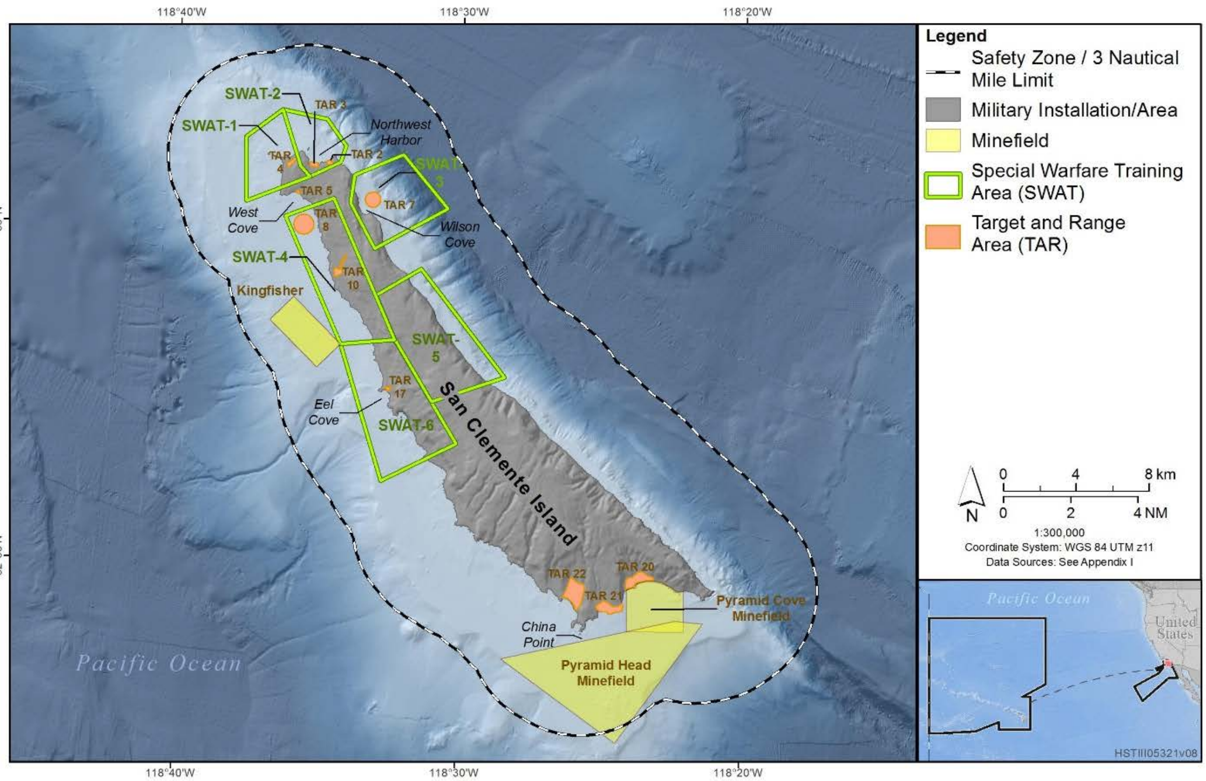


Figure 18. San Clemente Island Nearshore Training and Testing Areas.

Additionally, as shown in Figure 19, there is a relatively defined regional core use area within the SOCAL Range Complex used for the majority of in-water Navy training and testing. This core use area encompasses 19,733 NM^2. Note that training and testing activities do occur outside of these core use areas, but due to a number of coordination, scheduling, logistic, timing, infrastructure (e.g., instrumented ranges), and safety reasons, the majority of in-water training occurs in this area.

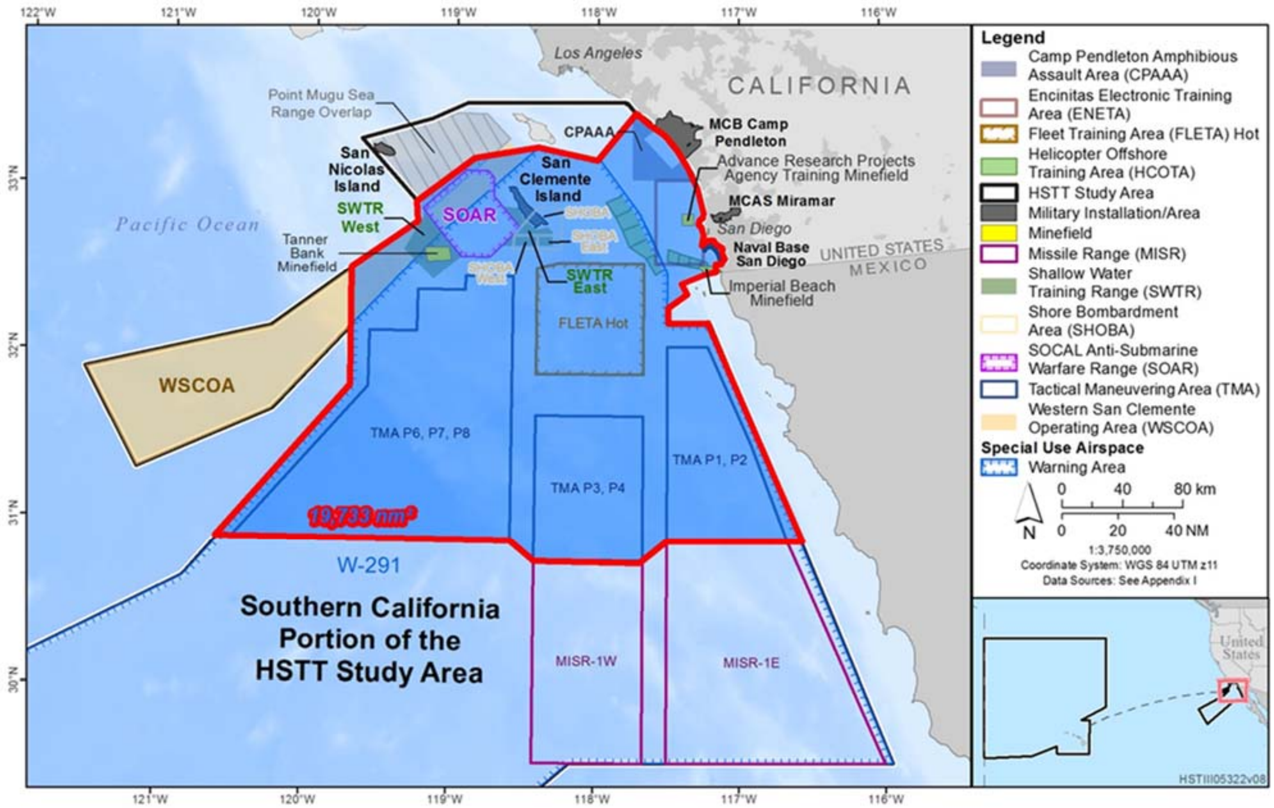


Figure 19. Southern California Range Complex Core Area.

3.1.2.2 Airspace

Most of the special use airspace in the SOCAL Range Complex is defined by Warning Area 291 (W-291) (Figure 16 through Figure 18). Warning Area 291 extends vertically from the ocean surface to 80,000 ft above mean sea level and encompasses 113,000 NM^2 of airspace. Airspace within or adjacent to W-291 includes the following areas:

- Western San Clemente OPAREA (Figure 16) is a special use airspace that extends from the surface to 5,000 ft above mean sea level.
- Two Helicopter Offshore Training Areas (Figure 16) located off the coast of San Diego, which extend from the surface to 1,000 ft above mean sea level.
- Tactical Maneuvering Areas (Figure 16) extend from 5,000 ft to 40,000 ft above mean sea level and provide airspace for air combat maneuvering, air intercept control aerobatics, and air-to-air gunnery. Ordnance use is permitted.
- Fleet Training Area Hot (Figure 16) extends from the ocean bottom to 80,000 ft above mean sea level and includes airspace that is used for hazardous operations, primarily surface-to-surface, surface-to-air, and air-to-air ordnance. Ordnance use is permitted.
- Missile Ranges 1 East and 1 West (Figure 16) extend from the ocean bottom to 80,000 ft above mean sea level and allow rocket and missile firing activities, anti-submarine

warfare, carrier and submarine operations, Fleet training, and surface and air gunnery. Ordnance use is permitted.

- Encinitas Naval Electronic Test Area (Figure 16) extends from the ocean bottom up to 700 ft above mean sea level. Fleet training and testing occurs here. Ordnance use is not permitted.

3.1.2.3 Sea and Undersea Space

The SOCAL Range Complex includes approximately 120,000 NM^2 of sea and undersea space, largely defined as that ocean area underlying the Southern California special use airspace described above. The SOCAL Range Complex also extends beyond this airspace to include the airspace, surface, and subsurface area from the northeastern border of W-291 to the coast of San Diego County, the Silver Strand Training Complex, and San Diego Bay. Specific training and testing areas within the SOCAL Range Complex include:

- Laser Training Ranges (Figure 17) are established to conduct over-the-water laser training and testing of the laser-guided Hellfire missile.
- Mine Training Ranges (Figure 17) are used for training of aircrews in offensive mine laying by delivery of non-explosive mine shapes from aircraft.
- Minefields (Figure 15, Figure 17, and Figure 18) provide mine detection training capabilities.
- San Clemente Island Underwater Range (Figure 17) has passive hydrophone arrays mounted on the seafloor and is used for antisubmarine warfare training and testing of undersea systems.
- Southern California Offshore Anti-Submarine Warfare Range (Figure 15 and Figure 17) is an underwater tracking range with the capability to provide three-dimensional underwater tracking of submarines, practice weapons, and targets.
- Shallow Water Training Range (Figure 15 and Figure 17) is an extension into shallow water of the deeper water tracking range.
- Shore Bombardment Area (Figure 15 and Figure 17) is the only eastern Pacific Fleet range that supports naval surface fire support training (only the water area surrounding the land portion of the range is included in the Study Area).
- Special Warfare Training Areas (Figure 18) support expeditionary and amphibious warfare training.
- Training Areas and Ranges (Figure 18) are littoral operating areas that support demolition, over-the-beach, and tactical ingress and egress training for Navy personnel.
- Camp Pendleton Amphibious Assault Area (Figure 15) provides an amphibious assault training environment.

3.1.2.4 Point Magu Sea Range Overlap

A relatively small portion (approximately 1,000 NM^2) of the Point Mugu Sea Range (hereafter referred to as the "Point Mugu Sea Range overlap") is included in the action area (Figure 16). Only that small portion of the Point Mugu Sea Range is used by the Navy for anti-submarine warfare training using active sonar during the course of major training exericises.

3.1.2.5 Silver Strand Training Complex

The Silver Strand Training Complex is an integrated set of training areas located on and adjacent to the Silver Strand, a narrow, sandy isthmus separating the San Diego Bay from the Pacific Ocean. It is divided into two non-contiguous areas: Silver Strand Training Complex-North and Silver Strand Training Complex-South (Figure 20). The Silver Strand Training Complex-North includes 10 oceanside boat training lanes (numbered as Boat Lanes 1–10), ocean anchorage areas (numbered 101–178), bayside water training areas (Alpha through Hotel), and the Lilly Ann drop zone. The boat training lanes are each 500 yards (yd) wide stretching 4,000 yd seaward and forming a 5,000 yd long contiguous training area. The Silver Strand Training Complex-South includes four oceanside boat training lanes (numbered as Boat Lanes 11-14) and the TA-Kilo training area.

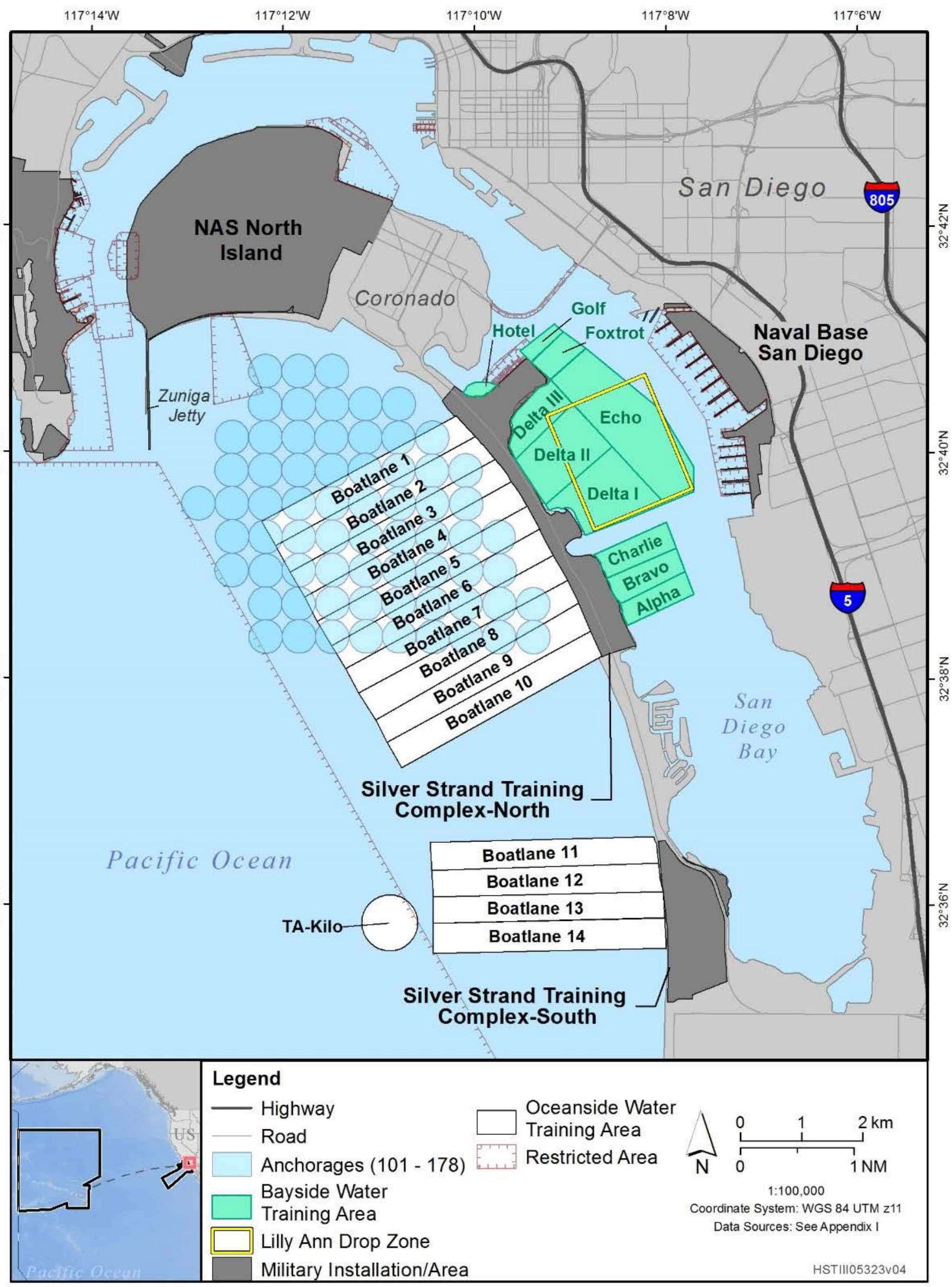


Figure 20. Silver Strand Training Complex.

The anchorages lie offshore of Coronado in the Pacific Ocean and overlap a portion of Boat Lanes 1–10. The anchorages are each 654 yd in diameter and are grouped together in an area located primarily due west of Silver Strand Training Complex-North, east of Zuniga Jetty and the restricted areas on approach to the San Diego Bay entrance.

3.1.3 Transit Corridor

Also included in the action area is a transit corridor between Southern California and Hawaii. The transit corridor, notionally defined by the great circle route (i.e., shortest distance) from San Diego to the center of the HRC, as depicted in Figure 9, is generally used by ships transiting between the SOCAL Range Complex and HRC. While in transit, ships and aircraft would, at times, conduct basic and routine unit level activities such as gunnery, bombing, and sonar training and maintenance, as long as the activities do not interfere with the primary objective of reaching their intended destination. In addition, some testing activities would occur in the transit corridor.

3.1.4 Pierside Locations and San Diego Bay

The action area also includes select pierside locations where Navy surface ship and submarine sonar maintenance testing occur. Pierside locations include channels and routes to and from Navy ports, and facilities associated with Navy ports and shipyards. These areas are located at Navy ports and naval shipyards in Pearl Harbor, Hawaii and San Diego Bay, California (Figure 21). In addition, some training and testing activities occur throughout San Diego Bay.

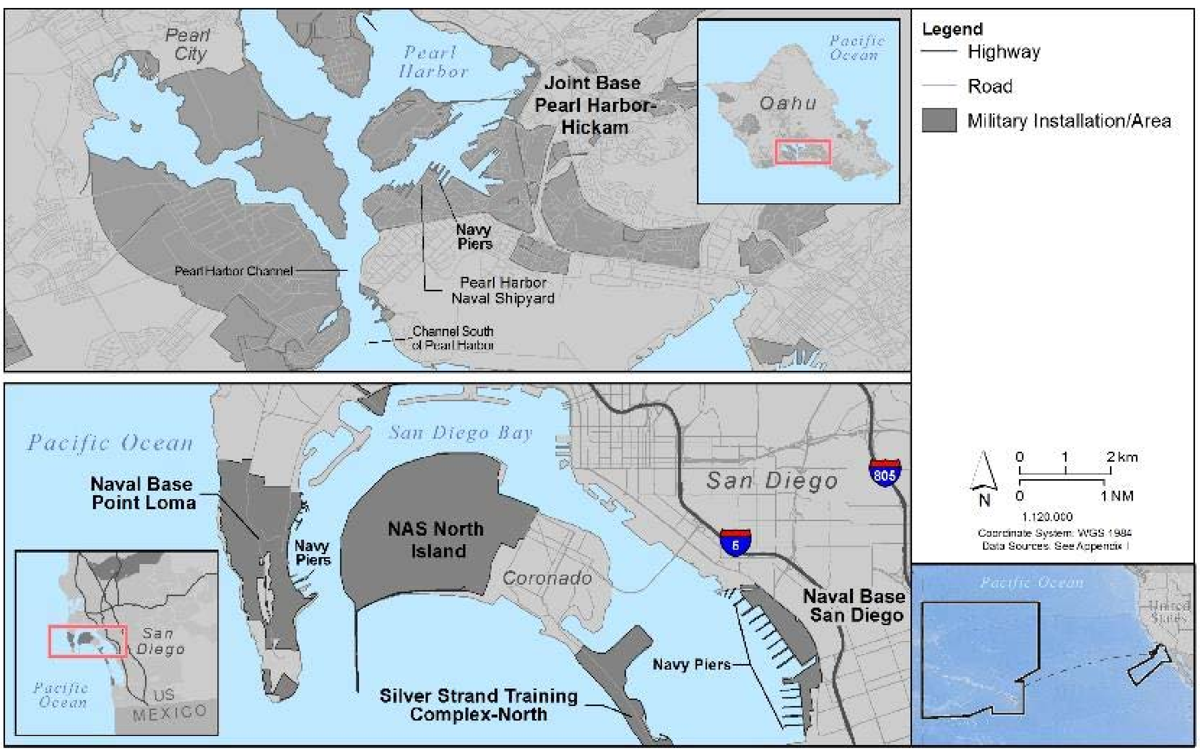


Figure 21. Navy piers and shipyards in Pearl Harbor and San Diego Bay.

3.2 Primary Mission Areas

The Navy categorizes its activities into functional warfare areas called primary mission areas. These activities generally fall into the following seven primary mission areas:

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

Most activities proposed by the Navy are categorized into one of these primary mission areas, though the testing community has three additional categories of activities for vessel evaluation, unmanned systems, and acoustic and oceanographic science and technology. Activities that do not fall within these areas are listed as "other activities" below. Each warfare community (surface, subsurface, aviation, and expeditionary warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes most, but not all, of its testing activities under these primary mission areas.

A detailed description of the sonar, munitions, targets, systems and other material used during training and testing activities within these primary mission areas is provided in Appendix A (Navy Activity Descriptions) of the HSTT DEIS/Overseas EIS (OEIS; Navy 2017b).

3.2.1 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.

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

3.2.2 Amphibious Warfare

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

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

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

3.2.3 Anti-Submarine Warfare

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

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

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

3.2.4 Electronic Warfare

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

Typical electronic warfare 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. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems' use against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems' use against flare deployment.

3.2.5 Expeditionary Warfare

The mission of expeditionary warfare is to provide security and surveillance in the littoral (at the shoreline), riparian (along a river), and coastal environments. Expeditionary warfare is wide ranging and includes defense of harbors, operation of remotely operated vehicles, defense against swimmers, and boarding/seizure operations.

Expeditionary warfare training activities include underwater construction team training, dive and salvage operations, and insertion/extraction via air, surface, and subsurface platforms.

3.2.6 Mine Warfare

The mission of mine warfare is to detect, classify, and avoid or neutralize (disable) mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of or deny the enemy access to sea space. Naval mines can be laid by ships, submarines, or aircraft.

Mine warfare neutralization training includes exercises in which ships, aircraft, submarines, underwater vehicles, unmanned vehicles, or marine mammal detection systems search for mine shapes. Personnel train to destroy or disable mines by attaching underwater explosives to or near the mine or using remotely operated vehicles to destroy the mine.

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

A small percentage of mine warfare tests require the use of high-explosive mines to evaluate and confirm the ability of the system to neutralize a high-explosive mine under operational conditions. The majority of mine warfare systems are deployed by ships, helicopters, and unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

3.2.7 Surface Warfare

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

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

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

3.3 Proposed Training and Testing Activities

The Navy has been conducting military readiness activities in the action area for decades. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and changes in force structure (organization of ships, weapons, and personnel). Such developments influence the frequency, duration, intensity, and location of required training and testing activities. The types and numbers of activities proposed by the Navy reflect the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements and account for fluctuations in training and testing in order to meet evolving or emergent military readiness requirements. The proposed training and testing activities are detailed in the following sections.

3.3.1 Training Activities

Training exercises vary in scale and duration. A major training exercise comprises several "unit level" type exercises conducted by several units operating together while commanded and controlled by a single commander. In a major training exercise, most of the operations and activities being directed and coordinated by the strike group commander are identical in nature to the operations conducted during individual, crew, and smaller unit level training events. In a major training exercise, however, these disparate training tasks are conducted in concert, rather than in isolation. Some integrated or coordinated anti-submarine warfare exercises[10] are similar in that they are composed of several unit level exercises but are generally on a smaller scale than a major training exercise, are shorter in duration, use fewer assets, and use fewer hours of hull-mounted sonar per exercise.

Three key factors are used by the Navy to identify and group exercises: 1) the scale of the exercise, 2) duration of the exercise, and 3) amount of hull-mounted sonar hours modeled/used for the exercise. Table 11 provides information regarding the differences between major anti-submarine warfare training events and smaller integrated/ coordinated anti-submarine exercises based on scale, duration, and sonar hours. As indicated above, unit level or smaller exercises are also proposed in the action area.

[10] Coordinated training exercises involve multiple units working together to meet unit-level training requirements, whereas integrated training exercises involve multiple units working together to certify for deployment.

Table 11. Major anti-submarine warfare training exercises and integrated/coordinated training (Navy 2018d).

	Exercise Group	Description	Scale	Duration	Location	Exercise Examples	Modeled Hull-mounted Sonar per Exercise
Major Training Exercises	Large Integrated ASW	Larger-scale, longer duration integrated ASW exercises	Greater than 6 surface ASW units (up to 30 with the largest exercises), 2 or more submarines, multiple ASW aircraft	Generally greater than 10 days	SOCAL HRC	RIMPAC, COMPTUEX	>500 hours
	Medium Integrated ASW	Medium-scale, medium duration integrated ASW exercises	Approximately 3-8 surface ASW units, at least 1 submarine, multiple ASW aircraft	Generally 4-10 days	SOCAL HRC	FLEETEX/ SUSTEX, USWEX	100-500 hours
Integrated/Coordinated Training	Small Integrated ASW	Small-scale, short duration integrated ASW exercises	Approximately 3-6 surface ASW units, 2 dedicated submarines, 2-6 ASW aircraft	Generally less than 5 days	SOCAL HRC	SWATT, NUWTAC	50-100 hours
	Medium Coordinated ASW	Medium-scale, medium duration, coordinated ASW exercises	Approximately 2-4 surface ASW units, possibly a submarine, 2-5 ASW aircraft	Generally 3-10 days	SOCAL HRC	SCC	Less than 100 hours
	Small Coordinated ASW	Small-scale, short duration, coordinated ASW exercises	Approximately 2-4 surface ASW units, possibly a submarine, 1-2 ASW aircraft	Generally 2-4 days	SOCAL HRC	ARG/MEU, ID CERTEX/ASW, Group Sail	Less than 50 hours

Notes: ASW: Anti-Submarine Warfare; SOCAL: Southern California; HRC: Hawaii Range Complex; RIMPAC: Rim of the Pacific; COMPTUEX: Composite Training Unit Exercise; FLEETEX/SUSTEX: Fleet Exercise/Sustainment Exercise; USWEX: Undersea Warfare Exercise; SWATT: Surface Warfare Advanced Tactical Training; NUWTAC: Naval Undersea Warfare Training Assessment Course; SCC: Submarine Command Course; ARG/MEU: Amphibious Ready Group/Marine Expeditionary Unit Exercise; ID CERTEX/ASW: Independent Deployer Certification Exercise/Tailored Anti-Submarine Warfare Training

The Navy proposes to conduct military readiness training activities into the reasonably foreseeable future, as necessary to meet current and future readiness requirements. These military readiness training activities include new activities, as well as activities that are currently ongoing and have historically occurred in the action area. For the purposes of this consultation and for the proposed MMPA rule, the Navy identified the number and duration of training activities that could occur over any 5-year period, beginning in December 2018. The proposed activity levels consider fluctuations in training cycles and deployment schedules that do not follow a traditional annual calendar but instead are influenced by in-theater demands and other external factors. The training activities proposed by the Navy are described in Table 12, which include the activity name and a short description of the activity. Appendix A (Navy Activity Descriptions) of the HSTT Draft EIS/OEIS (Navy 2017b) has more detailed descriptions of the activities. The numbers of all proposed training activities and their proposed locations are also provided in Table 12. The proposed training activities in Table 12 reflect a representative year of training to account for the natural fluctuation of training cycles and deployment schedules that generally influences the maximum level of training that may occur year after year in any 5-year period.

Table 12. A description of each of the proposed training activities and information on the number of events proposed annually in each location (Navy 2018d).

Activity Name	Activity Description	Annual # of Activities	Location
Major Training Exercises – Large Integrated Anti-Submarine Warfare			
Composite Training Unit Exercise	Aircraft carrier and its associated aircraft integrate with surface and submarine units in a challenging multi-threat operational environment in order to certify them for deployment. Only the anti-submarine warfare portion of a Composite Training Unit Exercises is included in this activity; other training objectives are met via unit level training described in each of the Primary Mission Areas below.	2-3	SOCAL
Rim of the Pacific Exercise	A biennial multinational training exercise in which navies from Pacific Rim nations and other allies assemble in Pearl Harbor, Hawaii, to conduct training throughout the Hawaiian Islands in a number of warfare areas. Components of a Rim of the Pacific exercise such as mine warfare, surface warfare, and amphibious training are conducted in the Southern California Range Complex.	0-1	HRC
		0-1	SOCAL
Major Training Exercises – Medium Integrated Anti-Submarine Warfare			
Fleet Exercise/ Sustainment Exercise	Aircraft carrier and its associated aircraft integrates with surface and submarine units in a challenging multi-threat operational environment in order to maintain their ability to deploy. Fleet Exercises and Sustainment Exercises are similar to Composite Training Unit Exercises, but are shorter in duration.	1	HRC
		5	SOCAL
Undersea Warfare Exercise	Elements of the anti-submarine warfare tracking exercise combine in this exercise of multiple air, surface, and subsurface units, over a period of several days.	3	HRC
Integrated/Coordinated Training			
Small Integrated Anti-Submarine Warfare Training	Multiple ships, aircraft, and submarines integrate the use of their sensors to search for, detect, classify, localize, and track a threat submarine in order to launch an exercise torpedo.	1	HRC
		2-3	SOCAL
Medium Coordinated Anti-	Multiple ships, aircraft, and submarines integrate the use of their sensors to search for, detect, classify, localize, and	2	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Submarine Warfare Training	track a threat submarine in order to launch an exercise torpedo. This training is of similar size, but longer duration compared to the Small Integrated Submarine Warfare Training.	2	SOCAL
Small Coordinated Anti-Submarine Warfare Training	Multiple ships, aircraft, and submarines coordinate the use of their sensors to search for, detect, classify, localize, and track a threat submarine in order to launch an exercise torpedo. This training is of similar size and duration compared to the Small Integrated Submarine Warfare Training.	2	HRC
		10-14	SOCAL
Air Warfare			
Air Combat Maneuver	Fixed-wing aircrews aggressively maneuver against threat aircraft to gain tactical advantage.	814	HRC
		6,000	SOCAL
Air Defense Exercise	Aircrew and ship crews conduct defensive measures against threat aircraft or simulated missiles.	185	HRC
		550	SOCAL
Gunnery Exercise Air-to-Air Medium-caliber	Fixed-wing aircraft fire medium-caliber guns at air targets.	5	SOCAL
Gunnery Exercise Surface-to-Air Large-caliber	Surface ship crews fire large-caliber guns at air targets.	51	HRC
		165	SOCAL
Gunnery Exercise Surface-to-Air Medium-caliber	Surface ship crews fire medium-caliber guns at air targets.	72	HRC
		195	SOCAL
		20	HSTT Transit Corridor
Missile Exercise Air-to-Air	Fixed-wing and helicopter aircrews fire air-to-air missiles at air targets.	62	HRC
		4	SOCAL
Missile Exercise Surface-to-Air	Surface ship crews fire surface-to-air missiles at air targets.	30	HRC
		36	SOCAL
Missile Exercise – Man-portable Air Defense System	Personnel employ shoulder-fired surface-to-air missiles at air targets.	4	SOCAL
Amphibious Warfare			
Amphibious Assault	Large unit forces move ashore from amphibious ships at sea for the immediate execution of inland objectives.	12	HRC
		18	SOCAL
Amphibious Assault – Battalion Landing	Marine Corps Battalion Landing Team forces launch an attack from sea to a hostile shore for the immediate execution of inland maneuvers.	2	SOCAL
Amphibious Marine Expeditionary Unit Exercise	Navy and Marine Corps forces conduct advanced integration training in preparation for deployment certification, for example the Amphibious Ready Group/Marine Expeditionary Unit Exercise.	2-3	SOCAL
Amphibious Marine Expeditionary Unit Integration Exercise	Navy and Marine Corps forces conduct integration training at sea in preparation for deployment certification.	2-3	SOCAL

Activity Name	Activity Description	Annual # of Activities	Location
Amphibious Raid	Small unit forces move from amphibious ships at sea to shore locations for a specific short-term mission. These are quick operations with as few personnel as possible.	2,426	SOCAL
Expeditionary Fires Exercise/Supporting Arms Coordination Exercise	Military units provide integrated and effective close air support, Naval Surface Fire Support fire, and Marine Corps artillery/mortar fire in support of amphibious operations.	8	SOCAL
Humanitarian Assistance Operations	Navy and Marine Corps forces evacuate noncombatants from hostile or unsafe areas or provide humanitarian assistance in times of disaster.	2	HRC
		1	SOCAL
Marine Expeditionary Unit Composite Training Unit Exercise	Amphibious Ready Group exercises are conducted to validate the Marine Expeditionary Unit's readiness for deployment and includes small boat raids; visit, board, search, and seizure training; helicopter and mechanized amphibious raids; and a non-combatant evacuation operation.	2-3	SOCAL
Naval Surface Fire Support Exercise-At Sea	Surface ship crews fire large-caliber guns at a passive acoustic hydrophone scoring system.	15	HRC
Naval Surface Fire Support Exercise – Land-Based Target	Surface ship crews fire large-caliber guns at land-based targets to support forces ashore.	55	SOCAL
Anti-Submarine Warfare			
Anti-Submarine Warfare Torpedo Exercise – Helicopter	Helicopter crews search for, track, and detect submarines. Recoverable air launched torpedoes are employed against submarine targets.	6	HRC
		104	SOCAL
Anti-Submarine Warfare Torpedo Exercise – Maritime Patrol Aircraft	Maritime patrol aircraft aircrews search for, track, and detect submarines. Recoverable air launched torpedoes are employed against submarine targets.	10	HRC
		25	SOCAL
Anti-Submarine Warfare Torpedo Exercise – Ship	Surface ship crews search for, track, and detect submarines. Exercise torpedoes are used.	50	HRC
		117	SOCAL
Anti-Submarine Warfare Torpedo Exercise – Submarine	Submarine crews search for, track, and detect submarines. Exercise torpedoes are used.	48	HRC
		13	SOCAL
Anti-Submarine Warfare Tracking Exercise – Helicopter	Helicopter crews search for, track, and detect submarines.	159	HRC
		524	SOCAL, PMSR
		6	HSTT Transit Corridor
Anti-Submarine Warfare Tracking Exercise – Maritime Patrol Aircraft	Maritime patrol aircraft aircrews search for, track, and detect submarines.	32	HRC
		56	SOCAL, PMSR
Anti-Submarine Warfare Tracking Exercise -Ship	Surface ship crews search for, track, and detect submarines.	224	HRC
		423	SOCAL, PMSR

Activity Name	Activity Description	Annual # of Activities	Location
Anti-Submarine Warfare Tracking Exercise - Submarine	Submarine crews search for, track, and detect submarines.	200	HRC
		50	SOCAL
		7	HSTT Transit Corridor
Service Weapons Test	Air, surface, or submarine crews employ explosive torpedoes against targets.	2	HRC
		1	SOCAL
Electronic Warfare			
Counter Targeting Chaff Exercise – Aircraft	Fixed-wing aircraft and helicopter aircrews deploy chaff to disrupt threat targeting and missile guidance radars.	19	HRC
		140	SOCAL
Counter Targeting Chaff Exercise – Ship	Surface ship crews deploy chaff to disrupt threat targeting and missile guidance radars.	37	HRC
		125	SOCAL
Counter Targeting Flare Exercise	Fixed-wing aircraft and helicopter aircrews deploy flares to disrupt threat infrared missile guidance systems.	19	HRC
		130	SOCAL
Electronic Warfare Operations	Aircraft and surface ship crews control the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions.	33	HRC
		350	SOCAL
Expeditionary Warfare			
Dive and Salvage Operations	Navy divers perform dive operations and salvage training.	12	HRC
Personnel Insertion/ Extraction – Surface and subsurface	Personnel are inserted into and extracted from an objective area by small boats or subsurface platforms.	182	HRC
		449	SOCAL
Personnel Insertion/ Extraction Training – Swimmer/Diver	Divers and swimmers infiltrate harbors, beaches, or moored vessels and conduct a variety of tasks.	495	HRC
		330	SOCAL
Small Boat Attack	Afloat units defend against attacking watercraft. For this activity, one or two small boats or personal watercraft conduct attack activities on units afloat.	6	HRC
		115	SOCAL
Mine Warfare			
Airborne Mine Countermeasure – Mine Detection	Helicopter aircrews detect mines using towed or laser mine detection systems.	10	SOCAL
Civilian Port Defense –Homeland Security Anti-Terrorism/Force Protection Exercise	Maritime security personnel train to protect civilian ports against enemy efforts to interfere with access to those ports.	1	Pearl Harbor, HI
		1-3	San Diego, CA
Limpet Mine Neutralization System	Navy Explosive Ordnance Disposal divers place a small charge on a simulated underwater mine.	4	HRC
		90	SOCAL
Marine Mammal Systems	The Navy deploys trained bottlenose dolphins (Tursiops truncatus) and California sea lions (Zalophus californianus) as part of the marine mammal mine-hunting and object-recovery system.	10	HRC
		175	SOCAL
		30	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Mine Countermeasures - Ship Sonar	Ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.	92	SOCAL
Mine Countermeasure Exercise - Surface	Mine countermeasure ship crews detect, locate, identify, and avoid mines while navigating restricted areas or channels, such as while entering or leaving port.	266	SOCAL
Mine Countermeasures Mine Neutralization Remotely Operated Vehicle	Ship, small boat, and helicopter crews locate and disable mines using remotely operated underwater vehicles.	6	HRC
		372	SOCAL
Mine Countermeasures – Towed Mine Neutralization	Helicopter aircrews and unmanned vehicles tow systems through the water, which are designed to disable or trigger mines.	340	SOCAL
Mine Laying	Fixed-wing aircraft drop non-explosive mine shapes.	6	HRC
		18	SOCAL
Mine Neutralization Explosive Ordnance Disposal	Personnel disable threat mines using explosive charges.	20	HRC
		170	SOCAL
Submarine Launched Mobile Mines Exercise	Submarine crews practice deploying submarine launched mobile mines.	1	HRC
		1	SOCAL
Submarine Mine Exercise	Submarine crews practice detecting mines in a designated area.	40	HRC
		12	SOCAL
Surface Ship Object Detection	Ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.	42	Pearl Harbor, HI
		164	San Diego, CA
Underwater Demolitions Multiple Charge – Mat Weave and Obstacle Loading	Military personnel use explosive charges to destroy barriers or obstacles to amphibious vehicle access to beach areas.	18	SOCAL
Underwater Demolition Qualification and Certification	Navy divers conduct various levels of training and certification in placing underwater demolition charges.	25	HRC
		120	SOCAL
Surface Warfare			
Bombing Exercise Air-to-Surface	Fixed-wing aircrews deliver bombs against surface targets.	187	HRC
		640	SOCAL
		5	HSTT Transit Corridor
Gunnery Exercise Air-to-Surface Medium- caliber	Fixed-wing and helicopter aircrews fire medium-caliber guns at surface targets.	217	HRC
		363	SOCAL
Gunnery Exercise		585	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Air-to-Surface Small-caliber	Helicopter and tilt-rotor aircrews use small-caliber guns to engage surface targets.	2,040	SOCAL
Gunnery Exercise Surface-to-Surface Boat Medium-Caliber	Small boat crews fire medium-caliber guns at surface targets.	10	HRC
		14	SOCAL
Gunnery Exercise Surface-to-Surface Boat Small-Caliber	Small boat crews fire small-caliber guns at surface targets.	25	HRC
		200	SOCAL
Gunnery Exercise Surface-to-Surface Ship Large-caliber	Surface ship crews fire large-caliber guns at surface targets.	32	HRC
		200	SOCAL
		13	HSTT Transit Corridor
Gunnery Exercise Surface-to-Surface Ship Medium-Caliber	Surface ship crews fire medium-caliber guns at surface targets.	50	HRC
		180	SOCAL
		40	HSTT Transit Corridor
Gunnery Exercise Surface-to-Surface Ship Small-Caliber	Surface ship crews fire small-caliber guns at surface targets.	65	HRC
		355	SOCAL
		20	HSTT Transit Corridor
Independent Deployer Certification Exercise /Tailored Anti-Submarine Warfare Training	Multiple ships and helicopters integrate the use of their sensors, including sonobuoys, to search for, detect, classify, localize and track a threat submarine to launch a torpedo.	1	SOCAL
Integrated Live Fire Exercise	Naval Forces defend against multiple surface threats (ships or small boats) with bombs, missiles, rockets, and small-, medium- and large-caliber guns.	1	HRC
		1	SOCAL
Laser Targeting - Aircraft	Aircrews illuminate targets with lasers.	50	HRC
		910	SOCAL
Maritime Security Operations	Helicopter, surface ship, and small boat crews conduct security operations at sea, to include visit, board, search and seizure; maritime interdiction operations; force protection; and anti-piracy operations.	70	HRC
		250	SOCAL
Missile Exercise Air-to-Surface	Fixed-wing and helicopter aircrews fire air-to-surface missiles at surface targets.	10	HRC
		210	SOCAL
Missile Exercise Air-to-Surface Rocket	Helicopter aircrews fire both precision-guided and unguided rockets at surface targets.	227	HRC
		246	SOCAL
Missile Exercise Surface-to-Surface	Surface ship crews defend against surface threats (ships or small boats) and engage them with missiles.	20	HRC
		10	SOCAL
Sinking Exercise	Aircraft, ship, and submarine crews deliberately sink a seaborne target, usually a decommissioned ship made environmentally safe for sinking according to U.S. Environmental Protection Agency standards, with a variety of munitions.	1-3	HRC
		0-1	SOCAL

Activity Name	Activity Description	Annual # of Activities	Location
Other Training			
Elevated Causeway System	A temporary pier is constructed off the beach. Support pilings are driven into the sand and then later removed.	2	SOCAL
Kilo Dip	Functional check of the dipping sonar prior to conducting a full test or training event on the dipping sonar.	60	HRC
		2,400	SOCAL
Offshore Petroleum Discharge System	Personnel transfer petroleum from ship to shore (water is used to simulate petroleum during the training).	4	HRC
		6	SOCAL
Precision Anchoring	Surface ship crews release and retrieve anchors in designated locations.	20	HRC
		75	SOCAL
Submarine Navigation	Submarine crews operate sonar for navigation and object detection while transiting into and out of port during reduced visibility.	220	Pearl Harbor, HI
		80	San Diego Bay, CA
Submarine Sonar Maintenance and Systems Checks	Maintenance of submarine sonar systems is conducted pierside or at sea.	260	HRC
		260	Pearl Harbor, HI
		93	SOCAL
		92	San Diego Bay, CA
		10	HSTT Transit Corridor
Submarine Under Ice Certification	Submarine crews train to operate under ice. Ice conditions are simulated during training and certification events.	12	HRC
		6	SOCAL
Surf Zone Test Detachment/ Equipment Test and Evaluation	Navy personnel test and evaluate the effectiveness of new detection and neutralization equipment designed for surf conditions.	200	SOCAL
Surface Ship Sonar Maintenance and Systems Checks	Maintenance of surface ship sonar systems is conducted pierside or at sea.	75	HRC
		80	Pearl Harbor, HI
		250	SOCAL
		250	San Diego, CA
		8	HSTT Transit Corridor
Unmanned Aerial System Training and Certification	Submarines launch unmanned aerial vehicles while submerged.	20	HRC
		10	SOCAL
		25	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Unmanned Underwater Vehicle Training - Certification and Development	Unmanned underwater vehicle certification involves training with unmanned platforms to ensure submarine crew proficiency. Tactical development involves training with various payloads, for multiple purposes to ensure that the systems can be employed effectively in an operational environment.	10	SOCAL
Waterborne Training	Small boat crews conduct a variety of training, including boat launch and recovery, operation of crew-served unmanned vehicles, mooring to buoys, anchoring, and maneuvering. Small boats include rigid hull inflatable boats, and riverine patrol, assault, and command boats up to approximately 50 ft in length.	500	HRC
		500	SOCAL

[1]PMSR indicates only the portion of the Point Mugu Sea Range that overlaps the Southern California portion of the action area, as described in Section 3.1.2.4 (Point Mugu Sea Range Overlap).

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California Range Complex, PMSR = Point Mugu Sea Range Overlap, HSTT = Hawaii-Southern California Training and Testing

3.3.2 Testing Activities

The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (e.g., missiles, radar, and sonar) and platforms (e.g., surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions. The individual commands within the research and acquisition community included in the proposed action are Naval Air Systems Command, Naval Sea Systems Command, Space and Naval Warfare Systems Command, and the Office of Naval Research.

Testing activities occur in response to emerging science or fleet operational needs. For example, future Navy experiments to develop a better understanding of ocean currents and future Navy operations within a specific geographic area may require development of modified Navy assets to address local conditions. Such modifications must be tested in the field to ensure they meet fleet needs and requirements. Accordingly, generic descriptions of some of these activities are provided below.

Some testing activities are similar to training activities conducted by the fleet. For example, both the fleet and the research and acquisition community fire torpedoes. While the firing of a torpedo might look identical to an observer, the difference is in the purpose of the firing. The fleet might fire the torpedo to practice the procedures for such a firing, whereas the research and acquisition community might be assessing a new torpedo guidance technology or testing it to ensure the torpedo meets performance specifications and operational requirements.

3.3.2.1 Naval Air Systems Command Testing Activities

The majority of testing activities conducted by Naval Air Systems Command are similar to fleet training activities, and many platforms and systems currently being tested are already being used by the fleet or will ultimately be integrated into fleet training activities. Naval Air Systems Command activities include, but are not limited to, the testing of new aircraft platforms (e.g., the F-35 Joint Strike Fighter aircraft), weapons, and systems (e.g., newly developed sonobuoys) that will ultimately be integrated into fleet training activities. Some testing activities may be conducted in different locations and in a different manner than similar fleet training activities and, therefore, the analysis for those events and the potential environmental effects may differ.

Table 13 describes Naval Air Systems Command's testing activities and provides a list of the proposed testing activities.

Table 13. Naval Air Systems Command proposed testing activities.

Activity Name	Activity Description	Annual # of Activities	Location
Air Warfare			
Air Combat Maneuver Test	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.	22	HRC
		110	SOCAL
Air Platform Weapons Integration Test	Testing performed to quantify the compatibility of weapons with the aircraft from which they would be launched or released. Non-explosive weapons or shapes are used.	10	SOCAL
Air Platform-Vehicle Test	Testing performed to quantify the flying qualities, handling, airworthiness, stability, controllability, and integrity of an air platform or vehicle. No explosive weapons are released during an air platform-vehicle test.	35	SOCAL
Intelligence, Surveillance, and Reconnaissance Test	Aircrews use all available sensors to collect data on threat vessels.	14	HRC
		254	SOCAL
Anti-Submarine Warfare			
Anti-Submarine Warfare – Torpedo Test	This event is similar to the training event torpedo exercise. Test evaluates anti-submarine warfare systems onboard rotary-wing and fixed-wing aircraft and the ability to search for, detect, classify, localize, track, and attack a submarine or similar target.	17-22	HRC
		35-71	SOCAL
Anti-Submarine Warfare Tracking Test – Helicopter	This event is similar to the training event anti-submarine tracking exercise-helicopter. The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications.	30-132	SOCAL
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft	The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.	54-61	HRC
		58-68	SOCAL
Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot or group of sonobuoys in advance of delivery to the fleet for operational use.	160	SOCAL
Electronic Warfare			
Chaff Test		5	HRC

Activity Name	Activity Description	Annual # of Activities	Location
	This event is similar to the training event counter targeting chaff exercise – aircraft . Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems against chaff deployment. Tests may also train pilots and aircrew in the use of new chaff dispensing equipment. Chaff tests are often conducted with flare tests and air combat maneuver events, as well as other test events, and are not typically conducted as standalone tests.	19	SOCAL
Electronic Systems Evaluation	Test that evaluates the effectiveness of electronic systems to control, deny, or monitor critical portions of the electromagnetic spectrum. In general, electronic warfare testing will assess the performance of three types of electronic warfare systems: electronic attack, electronic protect, and electronic support.	4	SOCAL
Flare Test	This event is similar to the training event flare exercise. Flare tests evaluate newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems against flare deployment. Tests may also train pilots and aircrew in the use of newly developed or modified flare deployment systems. Flare tests are often conducted with chaff tests and air combat maneuver events, as well as other test events, and are not typically conducted as standalone tests.	5	HRC
		15	SOCAL
Mine Warfare			
Airborne Dipping Sonar Minehunting Test	A mine-hunting dipping sonar system that is deployed from a helicopter and uses high-frequency sonar for the detection and classification of bottom and moored mines	0-12	SOCAL
Airborne Laser-Based Mine Detection System Test	An airborne mine hunting test of a laser-based mine detection system, that is operated from a helicopter and evaluates the system's ability to detect, classify, and fix the location of floating and near-surface, moored mines. The system uses a non-weaponized laser to locate mines.	20	SOCAL
Airborne Mine Neutralization System Test	A test of the airborne mine neutralization system evaluates the system's ability to detect and destroy mines from an airborne mine countermeasures capable helicopter. The Airborne Mine Neutralization System uses up to four unmanned underwater vehicles equipped with high-frequency sonar, video cameras, and explosive and non-explosive neutralizers.	11-31	SOCAL
Airborne Sonobuoy Minehunting Test	A mine-hunting system made up of sonobuoys deployed from a helicopter. A field of sonobuoys, using high-frequency sonar, is used to detect and classify bottom and moored mines.	3-9	SOCAL
		1	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Mine Laying Test	Fixed-wing aircraft evaluate the performance of mine laying equipment and software systems to lay mines. A mine test may also train aircrew in laying mines using a new or enhanced mine deployment system.	2	SOCAL
Surface Warfare			
Air-to-Surface Bombing Test	This event is similar to the training event bombing exercise air-to-surface. Fixed-wing aircraft test the delivery of bombs against surface maritime targets with the goal of evaluating the bomb, the bomb carry and delivery system, and any associated systems that may have been newly developed or enhanced.	8	HRC
		14	SOCAL
Air-to-Surface Gunnery Test	This event is similar to the training event gunnery exercise (air to surface). Fixed-wing and rotary-wing aircrews evaluate new or enhanced aircraft guns against surface maritime targets to test that the gun, gun ammunition, or associated systems meet required specifications or to train aircrew in the operation of a new or enhanced weapon system.	5	HRC
		30-60	SOCAL
Air-to-Surface Missile Test	This event is similar to the training event missile exercise air-to-surface. Test may involve both fixed-wing and rotary-wing aircraft launching missiles at surface maritime targets to evaluate the weapons system or as part of another system's integration test.	18	HRC
		48-60	SOCAL
High Energy Laser Weapons Test	High energy laser weapons tests would evaluate the specifications, integration, and performance of an aircraft mounted high-energy laser which can be used as a weapon to disable small surface vessels.	54	HRC
		54	SOCAL
Laser Targeting Test	Aircrews illuminate enemy targets with lasers.	5	SOCAL
Rocket Test	Rocket tests are conducted to evaluate the integration, accuracy, performance, and safe separation of guided and unguided 2.75-inch rockets fired from a hovering or forward flying helicopter.	2	HRC
		18-22	SOCAL
Other Testing Activities			
Acoustic and Oceanographic Research	Active transmissions within the band 10 hertz-100 kilohertz from sources deployed from ships and aircraft	2	HRC
		3	SOCAL
Air Platform Shipboard Integrate Test	Fixed wing and rotary wing aircraft are tested to determine operability from shipboard platforms and performance of shipboard physical operations, and to verify and evaluate communications and tactical data links.	7	HRC
		110	SOCAL
Kilo Dip	Functional check of a helicopter deployed dipping sonar system prior to conducting a testing or training event using the dipping sonar system.	0-6	SOCAL

Activity Name	Activity Description	Annual # of Activities	Location
Shipboard Electronic Systems Evaluation	Tests measure ship antenna radiation patterns and test communication systems with a variety of aircraft.	26	SOCAL
Undersea Range System Test	Post installation node survey and test and periodic testing of range Node transmit functionality.	11-28	HRC

3.3.2.2 Naval Sea Systems Command Testing Activities

Naval Sea Systems Command proposed testing activities are generally aligned with the primary mission areas used by the fleets. Naval Sea Systems Command activities include, but are not limited to, new ship construction, life cycle support, and other weapon system development and testing. Testing activities are conducted throughout the life of a Navy ship, from construction through deactivation from the fleet, to verification of performance and mission capabilities. Activities include pierside and at-sea testing of ship systems, including sonar, acoustic countermeasures, radars, torpedoes, weapons, unmanned systems, and radio equipment; tests to determine how the ship performs at sea (sea trials); development and operational test and evaluation programs for new technologies and systems; and testing on all ships and systems that have undergone overhaul or maintenance.

Table 14 describes Naval Sea Systems Command's testing activities and provides a list of the proposed testing activities.

Table 14. Naval Sea Systems Command Proposed Testing Activities.

Activity Name	Activity Description	Annual # of Activities	Location
Anti-Submarine Warfare			
Anti-Submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial systems) detect, localize, and prosecute submarines.	22	HRC
		23	SOCAL
At-Sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.	16	HRC
		1	HRC SOCAL
		20-21	SOCAL
Countermeasure Testing	Countermeasure testing involves the testing of systems that will detect, localize, and track incoming weapons including marine vessel targets. Testing includes surface ship torpedo defense systems and marine vessel stopping payloads.	8	HRC
		4	HRC SOCAL
		11	SOCAL
		2	HSTT Transit Corridor
Pierside Sonar Testing	Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.	7	Pearl Harbor, HI
		7	San Diego, CA
Submarine Sonar Testing/ Maintenance	Pierside and at-sea testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.	4	HRC
		17	Pearl Harbor, HI
		24	San Diego, CA
Surface Ship Sonar Testing/ Maintenance	Pierside and at-sea testing of ship systems occur periodically following major maintenance periods and for routine maintenance.	3	HRC
		3	Pearl Harbor, HI
		3	San Diego, CA
		3	SOCAL
Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive and non-explosive torpedoes against artificial targets.	8	HRC
		3	HRC SOCAL
		8	SOCAL
Torpedo (Non-Explosive) Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels.	8	HRC
		9	HRC SOCAL
		8	SOCAL
Electronic Warfare			

Activity Name	Activity Description	Annual # of Activities	Location
Radar and Other System Testing	Test may include radiation of military or commercial radar, communication systems (or simulators), or high-energy lasers. Testing may occur aboard a ship against drones, small boats, rockets, missiles, or other targets.	6	HRC SOCAL
		6	HRC
		1	Pearl Harbor, HI
		1	San Diego, CA
		40-46	SOCAL
Mine Warfare			
Mine Countermeasure and Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines and mine-like objects.	11	SOCAL
Mine Countermeasure Mission Package Testing	Vessels and associated aircraft conduct mine countermeasure operations.	19	HRC
		58	SOCAL
Mine Detection and Classification Testing	Air, surface, and subsurface vessels and systems detect, classify, and avoid mines and mine-like objects. Vessels also assess their potential susceptibility to mines and mine-like objects.	2	HRC
		2	HRC SOCAL
		11	SOCAL
Surface Warfare			
Gun Testing – Large-Caliber	Surface crews test large-caliber guns to defend against surface targets.	7	HRC
		72	HRC SOCAL
		7	SOCAL
Gun Testing – Medium-Caliber	Surface crews test medium-caliber guns to defend against surface targets.	4	HRC
		48	HRC SOCAL
		4	SOCAL
Gun Testing – Small- Caliber	Surface crews test small-caliber guns to defend against surface targets.	1	HRC
		24	HRC SOCAL
		2	SOCAL
Kinetic Energy Weapon Testing	A kinetic energy weapon uses stored energy released in a burst to accelerate a projectile.	56	HRC
Missile and Rocket Testing	Missile and rocket testing includes various missiles or rockets fired from submarines and surface combatants. Testing of the launching system and ship defense is performed.	13	HRC
		24	HRC SOCAL
		20	SOCAL
Unmanned Systems			
		3	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Unmanned Surface Vehicle System Testing	Testing involves the production and/or upgrade of unmanned surface vehicles. This may include testing of mine detection capabilities, evaluating the basic functions of individual platforms, or complex events with multiple vehicles.	4	SOCAL
Unmanned Underwater Vehicle Testing	Testing involves the production and/or upgrade of unmanned underwater vehicles. This may include testing of mine detection capabilities, evaluating the basic functions of individual platforms, or complex events with multiple vehicles.	3	HRC
		291	SOCAL
Vessel Evaluation			
Air Defense Testing	Test the ship's capability to detect, identify, track, and successfully engage live and simulated targets. Gun systems are tested using explosive and non-explosive rounds.	4	HRC
		9	SOCAL
In-Port Maintenance Testing	Each combat system is tested to ensure they are functioning in a technically acceptable manner and are operationally ready to support at-sea Combat System Ship Qualification Trial events.	4	Pearl Harbor, HI
		24	Pearl Harbor, HI San Diego, CA
		5	San Diego, CA
Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths).	1	HRC
		13	HRC SOCAL
		10-11	SOCAL
Submarine Sea Trials – Propulsion Testing	Submarine is run at high speeds in various formations and depths.	1	HRC
		1	SOCAL
Submarine Sea Trials – Weapons System Testing	Submarine weapons and sonar systems are tested at-sea to meet integrated combat system certification requirements.	1	HRC
		1	SOCAL
Surface Warfare Testing	Tests capability of shipboard sensors to detect, track, and engage surface targets. Testing may include ships defending against surface targets using explosive and non-explosive rounds, gun system structural test firing and demonstration of the response to Call for Fire against land based targets (simulated by sea based locations).	9	HRC
		63	HRC SOCAL
		14-16	SOCAL
		7	HRC

Activity Name	Activity Description	Annual # of Activities	Location
Undersea Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance, weapons engagement and communications systems. This tests ship's ability to detect, track, and engage undersea targets.	12-16	HRC SOCAL
		11	SOCAL
Vessel Signature Evaluation	Surface ship, submarine, and auxiliary system signature assessments. This may include electronic, radar, acoustic, infrared, and magnetic signatures.	4	HRC
		36	HRC SOCAL
		24	SOCAL
Other Testing Activities			
Chemical and Biological Simulant Testing	Chemical-biological agent simulants are deployed against surface ships.	1	HRC
		1	SOCAL
Insertion/ Extraction	Testing of submersibles capable of inserting and extracting personnel and payloads into denied areas from strategic distances.	220	HRC
		220	SOCAL
Non-Acoustic Component Testing	Tests of towed or floating buoys for communications through radio-frequencies or two-way optical communications between an aircraft and underwater system(s).	8	HRC
		16-17	SOCAL
Signature Analysis Operations	Surface ship and submarine testing of electromagnetic, acoustic, optical, and radar signature measurements.	2	HRC
		1	SOCAL

3.3.2.3 Office of Naval Research Testing Activities

As the Department of the Navy's science and technology provider, the Office of Naval Research provides technology solutions for Navy and Marine Corps needs. Testing conducted by the Office of Naval Research in the action area includes acoustic and oceanographic research, large displacement unmanned underwater vehicle (innovative naval prototype) research, and emerging mine countermeasure technology research.

Table 15 describes the Office of Naval Research's testing activities and provides a list of the proposed testing activities.

Table 15. Proposed Office of Naval Research Testing Activities.

Activity Name	Activity Description	Annual # of Activities	Location
Acoustic and Oceanographic Science and Technology			
Acoustic and Oceanographic Research	Research using active transmissions from sources deployed from ships, aircraft, and unmanned underwater vehicles. Research sources can be used as proxies for current and future Navy systems.	2	HRC
		4	SOCAL
Large Displacement Unmanned Underwater Vehicle Testing	Autonomy testing and environmental data collection with Large Displacement Unmanned Underwater Vehicles	2	HRC
		2	SOCAL
		2	HSTT Transit Corridor
Long Range Acoustic Communications	Low-frequency bottom-mounted acoustic source off of the Hawaiian Island of Kauai will transmit a variety of acoustic communications sequences.	3	HRC

3.3.2.4 Space and Naval Warfare Systems Command Testing Activities

Space and Naval Warfare Systems Command is the information warfare systems command for the U.S. Navy. Space and Naval Warfare Systems Command Systems Center Pacific is the research and development part of Space and Naval Warfare Systems Command focused on developing and transitioning technologies in the area of command, control, communications, computers, intelligence, surveillance, and reconnaissance. Space and Naval Warfare Systems Command Systems Center Pacific conducts research, development, test, and evaluation projects to support emerging technologies for intelligence, surveillance, and reconnaissance; anti-terrorism and force protection; mine countermeasures; anti-submarine warfare; oceanographic research; remote sensing; and communications. These activities include, but are not limited to, the testing of surface and subsurface vehicles; intelligence, surveillance, and reconnaissance/information operations sensor systems; underwater surveillance technologies; and underwater communications.

Table 16 describes the typical and anticipated Space and Naval Warfare Systems Command and Space and Naval Warfare Systems Command Systems Center Pacific test and evaluation activities proposed in the action area.

Table 16. Space and Naval Warfare Systems Command Proposed Testing Activities.

Activity Name	Activity Description	Annual # of Activities	Location
Anti-Terrorism/Force Protection	Testing sensor systems that can detect threats to naval piers, ships and shore infrastructure.	14	San Diego Bay
		16	SOCAL
Communications	Testing of underwater communications and networks to extend the principles of FORCEnet below the ocean surface.	0-1	HRC
		10	SOCAL
Energy and Intelligence, Surveillance, and Reconnaissance/ Information Operations Sensor Systems	Develop, integrate, and demonstrate ISR systems and in-situ energy systems to support deployed systems	11-15	HRC
		49-55	SOCAL
		8	HSTT Transit Corridor
Vehicle Testing	Testing of surface and subsurface vehicles and sensor systems, which may involve unmanned underwater vehicles, gliders, unmanned surface vehicles and unmanned aerial systems.	4	HRC
		166	SOCAL
		2	HSTT Transit Corridor

3.4 Standard Operating Procedures and Mitigation Measures

Standard operating procedures have been developed by the Navy through years of experience and are implemented during Navy training and testing activities to provide for safety and mission success. This is the primary purpose of these procedures, though in many cases there are environmental benefits resulting from the implementation of standard operating procedures as well. Mitigation measures, on the other hand, are designed specifically for the purpose of avoiding or reducing environmental impacts from the proposed activities. The standard operating procedures and mitigation measures the Navy will incorporate in their training and testing activities in the action area are described below.

3.4.1 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.

3.4.1.1 Vessel Safety

The standard operating procedures for vessel safety could result in a secondary benefit 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. 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 employ visual search techniques, including the use of binoculars and scanning techniques. After sunset and prior to sunrise, watch personnel employ night visual search techniques, which could include the use of night vision devices.

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.

Navy vessels operate in accordance with applicable international law and the navigation rules established by the U.S. Coast Guard. All vessels operating on the water are required to follow Inland Navigation Rules (33 Code of Federal Regulations 83) and International Regulations for Preventing Collisions at Sea (72 COLREGS). Navigation rules are formalized in the Convention on the International Regulations for Preventing Collisions at Sea, 1972. Applicable navigation requirements include, but are not limited to, the presence of lookouts and the requirement that vessels proceed at a safe speed at all times so that proper and effective action can be taken to avoid collision if necessary and so they can be stopped within a distance appropriate to the prevailing circumstances and conditions.

3.4.1.2 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.

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 result in a benefit to marine mammals, sea turtles, fish, and corals by reducing the potential for physical disturbance and strike, entanglement, and ingestion of applicable targets and any associated decelerators/parachutes.

3.4.1.3 Target Deployment Safety

Target Deployment and Retrieval SafetyThe 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[11] number 4 conditions (i.e., winds 11 to 16 knots, small waves 1 to 4 ft becoming longer, numerous whitecaps) or better to ensure safe operating conditions during target deployment and recovery. This standard operating procedure could result in a benefit to marine mammals and sea turtles through a reduction in the potential for interaction with weapons firing activities associated with the use of applicable targets.

3.4.1.4 Towed In-Water Device Safety

As a standard collision avoidance procedure, prior to deploying a towed in-water device 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. This standard operating procedure could

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

result in a benefit to marine mammals and sea turtles through a reduction in the potential for physical disturbance and strike by a towed in-water device.

3.4.1.5 Pile Driving Safety

Pile driving is required during elevated causeway construction (Table 12). Due to pile driving system design and operation, the Navy performs soft starts during impact installation of each pile to ensure proper operation of the diesel impact hammer. During a soft start, an initial set of strikes from the impact hammer at reduced energy are performed before it can be operated at full power and speed. This standard operating procedure could result in a benefit to marine mammals and sea turtles because soft starts may "warn" these resources and cause them to move away from the sound source before impact pile driving increases to full operating capacity.

3.4.2 Mitigation Measures[12]

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 marine mammals, sea turtles, and fish. These mitigation measures fall into two categories: procedural mitigation and mitigation areas. Procedural mitigation is mitigation that the Navy will implement whenever and wherever an applicable training or testing activity takes place within the action area. Mitigation areas are geographic locations in the action area where the Navy will implement additional measures during all or a part of the year. Additional detail on both proposed procedural mitigation and mitigation areas is provided in the sections below.

In order to ensure compliance with the proposed mitigation measures, the Navy provides environmental awareness and education to appropriate personnel (e.g., lookouts) to aid in visual observation, environmental compliance, and reporting responsibilities. Appropriate personnel (including civilian personnel) involved in mitigation and training or testing activity reporting complete one or more modules of the U.S Navy Afloat Environmental Compliance Training Series. The Afloat Environmental Compliance Training program helps Navy personnel from the most junior Sailors to Commanding Officers gain a better understanding of their personal environmental compliance roles and responsibilities. It helps to ensure Navy-wide compliance with environmental requirements. Modules include the following:

- 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

[12] We consider these mitigation mesures measures "conservation measures": actions that will be taken by the Navy and serve to 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.

activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship.

- Marine Species Awareness Training – All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare and mine warfare rotary-wing aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including floating vegetation, jellyfish aggregations, and flocks of seabirds.The most recent Marine Species Awareness Training was released in 2014 and approved by NMFS (Navy 2018d).
- U.S. Navy Protective Measures Assessment Protocol – This module provides the necessary instruction for accessing mitigation requirements during the event planning phase using the Protective Measures Assessment Protocol software tool.
- U.S. Navy Sonar Positional Reporting System and Marine Mammal Incident Reporting – This module provides instruction on the procedures and activity reporting requirements for the Sonar Positional Reporting System and marine mammal incident reporting.

According to the Navy's BA, Navy scientists and planners have observed demonstrated enhanced knowledge and understanding about the Navy's environmental compliance responsibilities among Lookouts and members of the operational community since the development of the U.S. Navy Afloat Environmental Compliance Training Series (Navy 2018d). As an example, since the Navy implemented the original Marine Species Awareness Training in 2007, the average rate of Navy vessel strikes of large whales has decreased by three times when compared with the prior 10-year period (1997-2006). It is likely that the implementation of the Marine Species Awareness Training starting in 2007, and the additional U.S. Navy Afloat Environmental Compliance Training Series modules starting in 2014, has contributed to this reduction in strikes. This indicates that the environmental awareness and education program is helping to improve the effectiveness of mitigation implementation.

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. A complete discussion of the mitigation measures, as well as measures considered by the Navy but not proposed, and the evaluation process used by the Navy to develop, assess, and select mitigation measures, can be found in Chapter of the HSTT Final EIS/OEIS (Navy 2018e). 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.

3.4.2.1 Procedural Mitigation

Procedural mitigation generally involves: (1) the use of one or more trained Lookouts to observe for specific biological resources within a mitigation zone[13]; (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate watch station for information dissemination; and (3) requirements for the watch station to implement mitigation (e.g., halt an activity) until certain recommencement conditions have been met.

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, incoming aircraft). Lookouts have an additional duty of helping meet the Navy's mitigation requirements by visually observing mitigation zones 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. In this consultation, the term "floating vegetation" refers specifically to floating concentrations of detached kelp paddies. 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. The Navy proposes to observe for these additional biological resources during certain activities to protect ESA-listed species or to offer an additional layer of protection for marine mammals and sea turtles.

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.

The Navy's passive acoustic devices (e.g., remote acoustic sensors, expendable sonobuoys, passive acoustic sensors on submarines) can complement visual observations when passive acoustic assets are already participating in an activity. When in use, the passive acoustic assets can detect vocalizing marine mammals within the frequency bands already being monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected

[13] Mitigation zones are areas at the surface of the water (measured as the radius from a stressor) within which training or testing activities would be halted, powered down, or modified to protect specific biological resources from an injurious impact (e.g., PTS, vessel strike).

animals, and therefore cannot be used to determine an animal's location or confirm its presence in a mitigation zone. Marine mammal detections made with the use of passive acoustic devices will be communicated to Lookouts to alert them of possible marine mammal presence in the vicinity. Lookouts will use any information on possible presence of animals from passive acoustic monitoring to assist in their visual observations of the mitigation zone.

The Navy takes several courses of action in response to a sighting of an applicable biological resource (e.g., ESA-listed species, floating kelp paddies) 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., powering down sonar, halting an explosion, maneuvering a vessel). If floating vegetation is observed prior to the initial start of an activity, the activity will either be relocated to an area where floating vegetation is not observed, or the initial start of the activity will be halted until the mitigation zone is clear of floating vegetation (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 five 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 or the use of a stressor 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;
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; or
5) For activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal or sea turtle sightings within the mitigation zone).

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 (min) wait period to activities conducted from vessels and activities that involve aircraft that are not typically fuel constrained (e.g., maritime patrol aircraft) because 30 min. is the maximum amount of time that those activities can be halted without preventing the activity from meeting its intended objective (Navy 2018d). A 30-min. 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 min for activities that involve aircraft with fuel constraints (e.g., rotary-wing aircraft [i.e., helicopters], fighter aircraft) because 10 min. is the maximum amount of time that those activities can be halted without compromising safety due to aircraft fuel restrictions (Navy 2018d). A 10-min. period covers a portion of the marine mammal and sea turtle dive times, but not the average dive times of all species.

The procedural mitigation measures described below are organized by stressor type and activity category. For sonar and explosive sources, proposed mitigation is dependent on the sonar source and the net explosive weight of the detonation. In order to better organize and facilitate the analysis of, and implementation of mitiation for, approximately 300 individual sources of underwater sound deliberately employed by the Navy including sonars, other transducers (devices that convert energy from one form to another—in this case, to sound waves), air guns, and explosives, the Navy developed a series of source classifications, or source bins. The source classification bins do not include the broadband sounds produced incidental to pile driving; vessel and aircraft transits; and weapons firing. Sonar source bins are listed in Table 17. Explosives were classified into bins based on net explosive weight as described in Table 18, and as explained in more detail in Section 6.2. In general, the Navy's mitigation aims to reduce the potential for injury of ESA-listed marine mammals and sea turtles to occur. Additionally, implementing the mitigation could help avoid or reduce the potential for exposure to higher levels of sound that may result in less severe effects (e.g., TTS). [14]

Table 17. Sonar sources used in the action area and their bin classification (Navy 2018d).

Source Class Category	Bin	Description
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	LF sources greater than 200 dB
	LF4	LF sources equal to 180 dB and up to 200 dB
	LF5	LF sources less than 180 dB
	LF6	LF sources greater than 200 dB with long pulse lengths
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)
	MF1K	Kingfisher mode associated with MF1 sonars
	MF2	Hull-mounted surface ship sonars (e.g., AN/SQS-56)

[14] That is, the mitigation zone typically covers much of the range to auditory injury, but implementing the mitigation could also reduce the potential for exposures that could result in TTS, particularly more severe instances of TTS.

Source Class Category	Bin	Description
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK 84)
	MF8	Active sources (greater than 200 dB) not otherwise binned
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%
	MF13	MF sonar source
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	HF2	HF Marine Mammal Monitoring System
	HF3	Other hull-mounted submarine sonars (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB) not otherwise binned
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)
	ASW5[3]	MF sonobuoys with high duty cycles
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)
	TORP2	Heavyweight torpedo (e.g., MK-48)
	TORP 3	Heavyweight torpedo (e.g., MK 48)

Source Class Category	Bin	Description
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns
	FLS3	VHF sources with short pulse lengths, narrow beam widths, and focused beam patterns
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged *swimmers*	SD1 –SD2	HF and VHF sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems
	SAS2	HF SAS systems
	SAS3	VHF SAS systems
	SAS4	MF to HF broadband mine countermeasure sonar
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB4	LF to MF oceanographic source
	BB7	LF oceanographic source
	BB9	MF optoacoustic source

Table 18. Explosive bins proposed for use in the action area.

Bin	Net Explosive Weight[1] (lb)	Example Explosive Source
E1	0.1–0.25	Medium-caliber projectile
E2	> 0.25–0.5	Medium-caliber projectile
E3	> 0.5–2.5	Large-caliber projectile
E4	> 2.5–5	Mine neutralization charge
E5	> 5–10	5 inch projectile
E6	> 10–20	Hellfire missile
E7	> 20–60	Demo block/ shaped charge
E8	> 60–100	Lightweight torpedo
E9	> 100–250	500 lb bomb
E10	> 250–500	Harpoon missile
E11	> 500–650	650 lb mine
E12	> 650–1,000	2,000 lb bomb
E13	> 1,000–1,740	Multiple mat weave charges

[1] Net Explosive Weight refers to the equivalent amount of trinitrotoluene (TNT) the actual weight of a munition may be larger due to other components. lb = pounds.

3.4.2.1.1 Active Sonar

As described in Table 19, the Navy proposes to implement procedural mitigation to avoid the potential for marine mammals and sea turtles to be exposed to levels of sound that could result in injury (i.e., PTS) from active sonar to the maximum extent practicable.

Table 19. Procedural mitigation for active sonar (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Low-frequency active sonar, mid-frequency active sonar, high-frequency active sonar o For vessel-based activities, mitigation applies only to sources that are positively controlled and deployed from manned surface vessels (e.g., sonar sources towed from manned surface platforms). o For aircraft-based activities, mitigation applies only to sources that are positively controlled and deployed from manned aircraft that do not operate at high altitudes (e.g., rotary-wing aircraft). Mitigation does not apply to active sonar sources deployed from unmanned aircraft or aircraft operating at high altitudes (e.g., maritime patrol aircraft).
Resource Protection Focus • Marine mammals • Sea turtles (only for sources <2 kHz)
Number of Lookouts and Observation Platform • Hull-mounted sources: o 1 Lookout: Platforms with space or manning restrictions while underway (at the forward part of a small boat or ship) and platforms using active sonar while moored or at anchor (including pierside) o 2 Lookouts: Platforms without space or manning restrictions while underway (at the forward part of the ship) • Sources that are not hull-mounted: o 1 Lookout on the ship or aircraft conducting the activity
Mitigation Requirements • Mitigation zones: o 1,000 yd power down, 500 yd power down, and 200 yd shut down for low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar o 200 yd shut down for low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar • Prior to the initial start of the activity (e.g., when maneuvering on station): 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 active sonar transmission. • During the activity: o Low-frequency active sonar ≥200 decibels (dB) and hull-mounted mid-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); power down active sonar transmission by 6 dB if observed within 1,000 yd of the sonar source; power down an additional 4 dB (10 dB total) within 500 yd; cease transmission within 200 yd. o Low-frequency active sonar <200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); cease active sonar transmission if observed within 200 yd of the sonar source. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation

Procedural Mitigation Description
zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-deployed sonar sources or 30 min. for vessel-deployed sonar sources; (4) for mobile activities, the active sonar source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or (5) for activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal sightings within the mitigation zone).

For low-frequency active sonar at 200 dB or more and hull-mounted mid-frequency active sonar, sources in bin mid frequency 1 (MF1; Table 17) have the longest predicted ranges to PTS. For sources within bin MF1, the 1,000 yd and 500 yd power down mitigation zones extend beyond the average ranges to PTS for all functional hearing groups.[15] The 200-yd shut down mitigation zone for bin MF1 extends beyond the average range to PTS for all hearing groups with ESA-listed species. The impact ranges for the 200-yd shut down mitigation zone were calculated based on full power transmissions and do not consider that the impact ranges will be reduced if one or both of the power down mitigations is implemented as required. The mitigation will be even more protective for low-frequency active sonar at 200 dB or more and hull-mounted mid-frequency active sonar sources used at lower source levels with shorter impact ranges.

For low-frequency active sonar below 200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar, sources in bin high-frequency 4 (HF4; Table 18) have the longest predicted ranges to PTS. For sources within bin HF4, the 200- yd shut down mitigation zone extends beyond the average range to PTS for all functional hearing groups. The mitigation will be even more protective for low-frequency active sonar below 200 dB, mid-frequency active sonar sources that are not hull-mounted, and high-frequency active sonar sources that fall within lower source bins with shorter impact ranges.

3.4.2.1.2 Air Guns

Table 20 describes the procedural mitigation proposed for the use of air guns. For 10 air gun pulses (the maximum number of pulses expected for air gun activities in the action area), the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation will be even more protective for air gun activities that use fewer than 10 pulses, since these activities have even shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for exposure to higher levels of sound that may result in threshold shifts that are recoverable (i.e., TTS). The small mitigation zone size and proximity to the observation platform will help increase the likelihood that Lookouts will detect all marine mammals and sea turtles. The 30 min. recommencement wait period will cover the average dive

[15] Functional hearing groups were defined by NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals NOAA. 2018. 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0).

times of the marine mammal species that could be present in the mitigation zone. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources.

Table 20. Procedural mitigation for air guns (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Air guns
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on a ship or pierside
Mitigation Requirements • Mitigation zone: o 150 yd around the air gun • Prior to the initial start of the activity (e.g., when maneuvering 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 air gun use. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease air gun use. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 air gun use) 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 air gun; (3) the mitigation zone has been clear from any additional sightings for 30 min.; or (4) for mobile activities, the air gun has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

3.4.2.1.3 Pile Driving

Table 21 describes the proposed procedural mitigation for pile driving. The ranges to effect from impact pile driving are longer than the ranges to effect for vibratory pile extraction. For impact pile driving, the mitigation zone extends beyond the maximum ranges to PTS for all functional hearing groups. The mitigation will be even more protective for vibratory pile extraction, since it has shorter impact ranges. The small mitigation zone size and proximity to the observation platform will help increase the likelihood that Lookouts will detect marine mammals and sea turtles in the area.

Table 21. Procedural mitigation for pile driving (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Pile driving and pile extraction sound during Elevated Causeway System training
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the shore, the elevated causeway, or a small boat
Mitigation Requirements • Mitigation zone: o 100 yd around the pile • Prior to the initial start of the activity (for 30 min.): o Observe the mitigation zone for floating vegetation; if observed, delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, delay the start of pile driving or vibratory pile extraction. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease impact pile driving or vibratory pile extraction. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 pile driving or pile extraction) 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 pile driving location; or (3) the mitigation zone has been clear from any additional sightings for 30 min.

3.4.2.1.4 Weapons Firing Noise

Table 22 describes the proposed procedural mitigation measures for weapons firing noise. The mitigation zone extends beyond the distance to which marine mammals and sea turtles would be expected to experience PTS from weapons firing noise. The small mitigation zone size and proximity to the observation platform will help increase the likelihood that Lookouts would detect marine mammals and sea turtles in the area where weapons will be or are being fired.

Table 22. Procedural mitigation for weapons firing noise (Navy 2018e).

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 o Depending on the activity, the Lookout could be the same one described for Explosive Medium-Caliber and Large-Caliber Projectiles or Small-, Medium, and Large-Caliber Non-Explosive Practice Munitions.
Mitigation Requirements • Mitigation zone: o 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: 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 weapons firing. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease weapons firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 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.

3.4.2.1.5 Explosive Sonobuoys

Table 23 describes the proposed procedural mitigation for the use of explosive sonobuoys.

Table 23. Procedural mitigation for explosive sonobuoys (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Explosive sonobuoys
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft or on small boat • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 600 yd around an explosive sonobuoy • Prior to the initial start of the activity (e.g., during deployment of a sonobuoy field, which typically lasts 20–30 min.): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. o Visually observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of sonobuoy or source/receiver pair detonations. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease sonobuoy or source/receiver pair detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonobuoy; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (e.g., prior to maneuvering off station): 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 marine mammals or 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.

Explosive sonobuoys in bin E4 (e.g., Improved Extended Echo Ranging Sonobuoys) have longer impact ranges than other explosive sonobuoys used in the action area. For bin E4, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation will be more protective for explosive sonobuoys in bin E1 or bin E3 with shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

Some activities that use explosive sonobuoys involve detonations of a single sonobuoy or sonobuoy pair, while other activities involve deployment of a field of sonobuoys that may be dispersed over a large distance. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing the mitigation zone around a single sonobuoy, sonobuoy pair, or a smaller sonobuoy field than when observing a sonobuoy field dispersed over a large distance. When observing large sonobuoy fields, Lookouts will be more likely to detect large visual cues (e.g., whale blows) than individual marine mammals, cryptic marine mammal species, and sea turtles.

3.4.2.1.6 Explosive Torpedoes

Table 24 describes the proposed procedural mitigation for the use of explosive torpedoes.

Table 24. Procedural mitigation for explosive torpedoes (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Explosive torpedoes
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: o 2,100 yd around the intended impact location • Prior to the initial start of the activity (e.g., during deployment of the target): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. o Visually observe the mitigation zone for marine mammals, sea turtles, and jellyfish aggregations; if observed, relocate or delay the start of firing. • During the activity: o Observe the mitigation zone for marine mammals, sea turtles, and jellyfish aggregations; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 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

Procedural Mitigation Description
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): 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 marine mammals or 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.

Bin E11 has the longest impact ranges for explosive torpedoes used in the action area. For bin E11, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups except low-frequency cetaceans and phocids. The mitigation will be more protective for explosive torpedoes in lower bins (e.g., bin E8) with shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

Explosive torpedo activities involve detonations at a target that is located down range of the firing platform. Due to the distance between the mitigation zone and the observation platform, Lookouts will have a better likelihood of detecting large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. Some species of sea turtles forage on jellyfish, and some of the locations where explosive torpedo activities could occur support high densities of jellyfish during part of the year. Observing for indicators of marine mammal and sea turtle presence (including jellyfish aggregations) will further help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.7 Explosive Medium-Caliber and Large-Caliber Projectiles

Table 25 describes the proposed procedural mitigation measures for the use of explosive medium-caliber and large-caliber projectiles.

Table 25. Procedural mitigation for explosive medium-caliber and large-caliber projectiles (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive medium-caliber and large-caliber projectiles o Mitigation applies to activities using a 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 o For activities using explosive large-caliber projectiles, depending on the activity, the Lookout could be the same as the one described 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: o 200 yd around the intended impact location for air-to-surface activities using explosive medium-caliber projectiles o 600 yd around the intended impact location for surface-to-surface activities using explosive medium-caliber projectiles o 1,000 yd around the intended impact location for surface-to-surface activities using explosive large-caliber projectiles • Prior to the initial start of the activity (e.g., when maneuvering on station): 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 firing. • During the activity: o 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: 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 firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-based firing or 30 min. for vessel-based firing; or (4) for activities using mobile targets, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): 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 marine mammals or ESA-listed species are observed, follow established incident reporting procedures.

Procedural Mitigation Description
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.

Of the activities that will implement the 1,000 yd mitigation zone, explosive large-caliber projectiles in bin E5 (e.g., 5 inch projectiles) have the longest impact ranges. For bin E5, the 1,000 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups except low-frequency cetaceans. Of the activities that will implement the 600 yd or 200 yd mitigation zones, explosive medium-caliber projectiles in bin E2 (e.g., 40-millimeter [mm] projectiles) have the longest impact ranges. For bin E2, both the 600 yd mitigation zone and 200 yd mitigation zone extend beyond the average ranges to PTS for all functional hearing groups. The mitigation zones will be even more protective during the use of the smaller explosive projectiles (e.g., bin E1) with shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

Large-caliber gunnery activities involve the firing of projectiles at a target located up to 6 NM down range from the firing ship. Medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets that may be located up to 4,000 yd from the firing platform, although typically the targets for these activities are much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets that are 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 or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. When aircraft are firing, Lookouts will have a better vantage point for observing the mitigation zone, particularly when the target is located far from the firing platform because the lookout will be stationed with a better view of the mitigation zone. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zone, particularly when observing from aircraft and when the target is located close to the firing platform.

3.4.2.1.8 Explosive Missiles and Rockets

Table 26 describes the proposed procedural mitigation for the use of explosive missiles and rockets.

Table 26. Procedural mitigation for explosive missiles and rockets (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed explosive missiles and rockets o Mitigation applies to activities using a surface target
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 zones: o 900 yd around the intended impact location for missiles or rockets with 0.6–20 lb net explosive weight o 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): 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 firing. • During the activity: o 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: 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 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): 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 marine mammals or 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.

For explosive missiles with 21 to 500 pound (lb) net explosive weight, missiles in bin E10 (e.g., Harpoon missiles) have the longest impact ranges. For bin E10, the 2,000 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation will be even more protective for smaller explosive projectiles with shorter impact ranges (e.g., missiles in bin E9). Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

For explosive missiles and rockets with 0.6–20 lb net explosive weight, missiles in bin E6 (e.g., Hellfire missiles) have the longest impact ranges. For bin E6, the 900 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation would be even more protective during the use of smaller explosive projectiles with shorter impact ranges (e.g., rockets in bin E3). Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

Missile and rocket exercises involve a ship or aircraft firing munitions at a target that is typically located up to 15 NM away, and infrequently up to 75 NM away from the firing platform. The mitigation only applies to aircraft-deployed missiles and rockets because aircraft can fly over the intended impact area prior to firing a missile. Observation of the mitigation zone is not possible when missiles and rockets are fired from a ship due to the distance between the firing ship and the intended impact location. Even when aircraft are firing, 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. Observing for indicators of marine mammal and sea turtle presence (e.g., presence of jellyfish or floating vegetation) will further help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.9 Explosive Bombs

Table 27 describes the proposed procedural mitigation for the use of explosive bombs (Navy 2018d).

Table 27. Procedural mitigation for explosive bombs (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform

Procedural Mitigation Description
• 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: o 2,500 yd 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 target approach): 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 before 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. • 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 marine mammals or 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.

Explosive bombs in bin E12 (e.g., 2,000 lb bombs) have the longest impact ranges of any bomb used in the action area. For bin E12, the 2,500 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation will be more protective during the use of smaller bombs with shorter impact ranges (e.g., 250 lb bombs, 500 lb bombs). Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

Bombing exercises involve a participating 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, and Lookouts will, by necessity for safety and mission success, primarily focus their attention on the water surface below and surrounding the location of bomb deployment. The Lookout’s vantage point will serve as an advantage for observing marine mammals and sea turtles within this area. Lookouts will have a better likelihood of detecting individual marine mammals and sea turtles that are in the central portion of the mitigation zone (around the target location where Lookout attention will be focused), and will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles near the perimeter of the mitigation zone. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zone.

3.4.2.1.10 Sinking Exercises

Table 28 describes the proposed procedural mitigation during sinking exercises.

Table 28. Procedural mitigation for sinking exercises (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Sinking exercises
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 2 Lookouts (one positioned in an aircraft and one on a vessel) • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 2.5 NM around the target ship hulk • Prior to the initial start of the activity (90 min. prior to the first firing): o Conduct aerial observations of the mitigation zone for floating vegetation; delay the start until the mitigation zone is clear. o Conduct aerial observations of the mitigation zone for marine mammals, sea turtles, and jellyfish aggregations; if observed, delay the start of firing. • During the activity: o Conduct passive acoustic monitoring for marine mammals; use information from detections to assist visual observations. o Visually observe the mitigation zone for marine mammals and sea turtles from the vessel; if observed, cease firing. o Immediately after any planned or unplanned breaks in weapons firing of longer than 2 hours, observe the mitigation zone for marine mammals and sea turtles from the aircraft and vessel; if observed, delay recommencement of firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the target ship hulk; or (3) the mitigation zone has been clear from any additional sightings for 30 min. • After completion of the activity (for 2 hours after sinking the vessel or until sunset, whichever comes first): o Observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures. 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.

Bin E12 has the longest impact ranges for the types of explosives used during a sinking exercise in the action area. For bin E12, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation will be even more protective for explosives in lower bins with shorter impact ranges used during a sinking exercise (e.g., bin E5 and bin E10). A sinking exercise is a specialized training exercise that provides an opportunity for ship, submarine, and aircraft crews to use multiple weapons systems to deliver explosive ordnance to deliberately sink a deactivated vessel. The exercise occurs only in daylight hours and typically lasts from four to eight hours over the course of one to two days. Because the activity is scheduled to ensure that it is conducted only in daylight hours, it is unlikely that the 2-hour post-activity observation period will be shortened due to nightfall.; Therefore, the Navy expects to be able to complete the full 2-hour post-activity observation period during each sinking exercise. 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 distant firing position). The Lookout positioned on the vessel will have a better likelihood of detecting individual marine mammals and sea turtles that are in the central portion of the mitigation zone (near the target ship hulk). Near the perimeter of the mitigation zone, the Lookout will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. The Lookout positioned in an aircraft will be able to assist the vessel-based Lookout by observing the entire mitigation zone, including near the perimeter, because the aircraft would be able to transit a larger area more quickly (e.g., during range clearance), and will offer a better vantage point. Some species of sea turtles forage on jellyfish in the region where this activity occurs. Observing for indicators of marine mammal and sea turtle presence, like aggregations of jellyfish, will help avoid or reduce impacts on these resources within the mitigation zone. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.11 Explosive Mine Countermeasure and Neutralization Activities

Table 29 describes the proposed procedural mitigation when conducting explosive mine countermeasure and neutralization activities.

Table 29. Procedural mitigation for explosive mine countermeasure and neutralization activities (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Explosive mine countermeasure and neutralization activities
Resource Protection Focus • Marine mammals • Sea turtles • Birds
Number of Lookouts and Observation Platform • 1 Lookout positioned on a vessel or in an aircraft when implementing the smaller mitigation zone

Procedural Mitigation Description
• 2 Lookouts (one positioned in an aircraft and one on a small boat) when implementing the larger mitigation zone • 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: o 600 yd around the detonation site for activities using 0.1–5-lb net explosive weight o 2,100 yd around the detonation site for activities using 6–650 lb net explosive weight (including high explosive target mines) • Prior to the initial start of the activity (e.g., when maneuvering on station; typically, 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained): 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 detonations. • During the activity: o Observe the mitigation zone for marine mammals, sea turtles, concentrations of seabirds, and individual foraging seabirds; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity or a sighting of seabird concentrations or individual foraging seabirds during the activity: o The Navy will allow a sighted animal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to detonation site; or (3) the mitigation zone has been clear from any additional sightings for 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained. • After completion of the activity (typically 10 min. when the activity involves aircraft that have fuel constraints, or 30 min. when the activity involves aircraft that are not typically fuel constrained): o Observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures. 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.

For activities using 6 to 650 lb net explosive weight, charges in bin E11 (e.g., 650 lb high explosive target mines) have the longest impact ranges. For bin E11, the 2,100 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups except low-frequency cetaceans and phocids. For activities using 0.1 to 5 lb net explosive weight, charges in bin E4 (e.g., 5 lb net explosive weight charges) have the longest impact ranges. For bin E4, the 600 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. The mitigation zones will be more protective during the use of smaller explosive charges (e.g., bin E2) with shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

The types of charges used in these activities are positively controlled, which means the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation. Due to their lower vantage point, Lookouts on small boats will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) or splashes of individual marine mammals than cryptic marine mammal species and sea turtles near the mitigation zone perimeter. The use of an aircraft in addition to a vessel to observe a larger mitigation zone will help increase the chance that marine mammals and sea turtles will be observed. Observing for indicators of marine mammal and sea turtle presence will help avoid or reduce impacts on these resources within the mitigation zones. The post-activity observations for marine mammals and sea turtles will help the Navy determine if any resources were injured during the activity.

3.4.2.1.12 Explosive Mine Neutralization Activities Involving Navy Divers

Table 30 describes the proposed procedural mitigation for explosive mine neutralization activities involving Navy divers.

Table 30. Procedural mitigation for explosive mine neutralization activities involving Navy divers (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Explosive mine neutralization activities involving Navy divers
Resource Protection Focus • Marine mammals • Sea turtles • Birds • Fish (scalloped hammerhead sharks)
Number of Lookouts and Observation Platform • 2 Lookouts (two small boats with one Lookout each, or one Lookout on a small boat and one in a rotary-wing aircraft) when implementing the smaller mitigation zone • 4 Lookouts (two small boats with two Lookouts each), and a pilot or member of an aircrew will serve as an additional Lookout if aircraft are used during the activity, when implementing the larger mitigation zone • All divers placing the charges on mines will support the Lookouts while performing their regular duties and will report applicable sightings to their supporting small boat or Range Safety Officer. • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zones: o 500 yd around the detonation site during activities under positive control using 0.1–20 lb net explosive weight o 1,000 yd around the detonation site during activities using time-delay fuses (0.1–29 lb net explosive weight) and during activities under positive control using 21–60 lb net explosive weight charges • Prior to the initial start of the activity (e.g., when maneuvering on station for activities under positive control; 30 min. for activities using time-delay firing devices): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.

Procedural Mitigation Description
o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of detonations or fuse initiation. • During the activity: o Observe the mitigation zone for marine mammals, sea turtles, concentrations of seabirds, and individual foraging seabirds (in the water and not on shore); if observed, cease detonations or fuse initiation. o Within the Southern California Range Complex, divers will notify their supporting small boat or Range Safety Officer of hammerhead shark sightings (of any hammerhead species, due to the difficulty of differentiating species). Detonations will cease if divers sight a hammerhead shark when setting the charge and will recommence when the shark is no longer observed. o To the maximum extent practicable depending on mission requirements, safety, and environmental conditions, boats will position themselves near the mid-point of the mitigation zone radius (but outside of the detonation plume and human safety zone), will position themselves on opposite sides of the detonation location (when two boats are used), and will travel in a circular pattern around the detonation location with one Lookout observing inward toward the detonation site and the other observing outward toward the perimeter of the mitigation zone. o If used, aircraft will travel in a circular pattern around the detonation location to the maximum extent practicable. o The Navy will not set time-delay firing devices (0.1–29 lb net explosive weight) to exceed 10 min. o During activities conducted in shallow water, a shore-based observer will survey the mitigation zone with binoculars for birds before and after each detonation. If training involves multiple detonations, the second (or third, etc.) detonation will occur either immediately after the preceding detonation (i.e., within 10 seconds) or after 30 min. to avoid potential impacts on birds foraging underwater. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity or a sighting of seabird concentrations or individual foraging seabirds during the activity: o The Navy will allow a sighted animal to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the detonation site; or (3) the mitigation zone has been clear from any additional sightings for 10 min. during activities under positive control with aircraft that have fuel constraints, or 30 min. during activities under positive control with aircraft that are not typically fuel constrained and during activities using time-delay firing devices. • After completion of an activity (for 30 min): o Observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures. 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.

The types of charges used during explosive mine neutralization activities involving Navy divers are either positively controlled (i.e., the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation), or initiated using a time-delay fuse (i.e., the detonation is fused with a specified time-delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated, but cannot be terminated once the fuse is initiated due to human safety concerns). For activities using the 1,000 yd mitigation zone, explosives in bin E7 (e.g., 60 lb net explosive weight charges) have the longest impact ranges. For bin E7, the 1,000 yd mitigation zone extends beyond the average ranges to PTS for all functional hearing groups except low-frequency cetaceans and phocids. All activities using a time-delay fuse (which have a maximum charge size of 29 lb net explosive weight) will implement the 1,000 yd mitigation zone. The mitigation will be more protective during the use of smaller charges with shorter impact ranges, including those using time-delay fuses (e.g., bin E6). Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

For activities using the 500 yd mitigation zone, positive control charges in bin E6 (e.g., 20 lb net explosive weight) have the longest impact ranges. For bin E6, the 500 yd mitigation zone also extends beyond the average ranges to PTS for all functional hearing groups except low-frequency cetaceans and phocids. The mitigation will be more protective during the use of smaller positive control charges (e.g., bin E5, bin E4) with shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

For the 1,000 yd mitigation zone, the use of two additional Lookouts increases the likelihood that Lookouts will detect marine mammals and sea turtles across the larger mitigation zone size. For the 500 yd mitigation zone, the smaller mitigation zone size increases the likelihood that Lookouts will detect marine mammals and sea turtles. Due to their low vantage point on the water, Lookouts in small boats will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) or the splashes of individual marine mammals than cryptic marine mammal species and sea turtles near the perimeter of the mitigation zone. When rotary-wing aircraft are used, Lookouts positioned in an aircraft will have a better vantage point for observing out to the perimeter of either mitigation zone size. For activities using a time-delay fuse, there is a remote chance that animals may swim into the mitigation zone after the fuse has been initiated. During activities under positive control, the Navy can cease detonations at any time in response to a sighting of a marine mammal or sea turtle. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zones. The additional mitigation within the SOCAL Range Complex will help the Navy avoid or reduce impacts on ESA-listed scalloped hammerhead sharks.

3.4.2.1.13 Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading

Table 31 describes the proposed procedural mitigation for underwater demolition multiple charge – mat weave and obstacle loading.

Table 31. Procedural mitigation for underwater demolition multiple charge – mat weave and obstacle loading exercises (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading exercises
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 2 Lookouts (one on a small boat and one on shore from an elevated platform) • 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: o 700 yd around the detonation location • Prior to the initial start of the activity: o For 30 min. prior to the first detonation, the Lookout positioned on a small boat will observe the mitigation zone for floating vegetation, marine mammals, and sea turtles; if observed, delay the start of detonations. o For 10 min. prior to the first detonation, the Lookout positioned on shore will use binoculars to observe the mitigation zone for marine mammals and sea turtles; if observed, delay the start of detonations until the mitigation zone has been clear of any additional sightings for a minimum of 10 min. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the detonation location; or (3) the mitigation zone has been clear from any additional sightings for 10 min. (as determined by the shore observer). • After completion of the activity (for 30 min.): o The Lookout positioned on a small boat will observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures. 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.

Bin E13 has the longest impact ranges of any explosive charge used during Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading training exercises in the action area. For bin E13, the 700 yd mitigation zone likely extends beyond the average ranges to PTS for all of the functional hearing groups that are likely to be present at the locations where this activity occurs except phocids. Mitigation will be more protective during the use of smaller charges (e.g., bin E10) with shorter impact ranges. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS).

The mitigation zone's proximity to shore and the use of two Lookouts from different observation platforms will help increase the likelihood that Lookouts will detect marine mammals and sea turtles throughout the mitigation zone, including near the perimeter. The Navy will implement a 10 min. recommencement wait period because this activity is conducted in the shallow waters of San Clemente Island (e.g., Northwest Harbor) where marine mammals will not be expected to undergo deep or prolonged dives. Shore-based Lookouts will have an enhanced vantage point for observing the mitigation zone to help determine that it is clear of marine mammals and sea turtles. Observing for indicators of marine mammal and sea turtle presence will likely further help avoid or reduce impacts on these resources within the mitigation zone.

3.4.2.1.14 Maritime Security Operations – Anti-Swimmer Grenades

Table 32 describes the proposed procedural mitigation during maritime security operations – anti-swimmer grenades.

Table 32. Procedural mitigation for maritime security operations – anti-swimmer grenades (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Maritime Security Operations – Anti-Swimmer Grenades
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the small boat conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 200 yd around the intended detonation location • Prior to the initial start of the activity (e.g., when maneuvering 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 detonations. • During the activity: o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease detonations. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before 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 detonations) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended detonation location; (3) the mitigation zone has been clear from any additional sightings for 30 min.; or (4) the intended detonation location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • 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 marine mammals or 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.

Explosives used during Maritime Security Operations – Anti-Swimmer Grenades exercises are in bin E2 (e.g., 0.5 lb net explosive weight). For bin E2, the mitigation zone extends beyond the average ranges to PTS for all functional hearing groups. Implementing the mitigation will likely help avoid or reduce the potential for some exposures to higher levels of energy that may result in threshold shifts that are recoverable (i.e., TTS). The small mitigation zone size will help increase the likelihood that Lookouts will detect marine mammals and sea turtles, and observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zone.

3.4.2.1.15 Vessel Movement

Table 33 describes proposed procedural mitigation for vessel movement.

Table 33. Procedural mitigation for vessel movement (Navy 2018e).

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., during launching and recovery of aircraft or landing craft, during towing activities, when mooring, etc.), (3) the vessel is operated autonomously, or (4) when impractical based on mission requirements (e.g., during Amphibious Assault – Battalion Landing exercises)
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 yd around whales o 200 yd around other marine mammals (except bow-riding dolphins and pinnipeds hauled out on 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.

3.4.2.1.16 Towed In-Water Devices

Table 34 describes proposed procedural mitigation for towed in-water devices. Vessels involved in towing in-water devices will implement the mitigation described for vessel movement in Table 34, in addition to the mitigation outlined for vessel movement in Table 33.

Table 34. Procedural mitigation for towed in-water devices (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Towed in-water devices o Mitigation applies to devices that are towed from a manned surface platform or manned aircraft o The mitigation will not be applied if the safety of the towing platform or in-water device is threatened
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the manned towing platform
Mitigation Requirements • Mitigation zones: o 250 yd around marine mammals o Within the vicinity of sea turtles • During the activity (i.e., when towing an in-water device): o Observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance.

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

Table 35 describes proposed procedural mitigation for the use of small-, medium-, and large-caliber non-explosive practice munitions.

Table 35. Procedural mitigation for small-, medium-, and large-caliber non-explosive practice munitions (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using small-, medium-, and large-caliber non-explosive practice munitions o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the platform conducting the activity o Depending on the activity, the Lookout could be the same as the one described for Weapons Firing Noise.
Mitigation Requirements • Mitigation zone: o 200 yd around the intended impact location • Prior to the initial start of the activity (e.g., when maneuvering on station):

Procedural Mitigation Description
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 firing. • During the activity: o 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: 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 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.

The mitigation zone for this activity is several times larger than the impact footprint for all projectiles used for these activities (See Appendix F, Military Expended Material and Direct Strike Impact Analysis, of the HSTT DEIS/OEIS for additional detail).

Large-caliber gunnery activities involve the firing of projectiles at a target located up to 6 NM down range from the firing ship. Small- and medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets that may be located up to 4,000 yd from the firing platform, although typically the targets for these activities are much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets that are 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 or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles.

3.4.2.1.18 Non-Explosive Missiles and Rockets

Table 36 describes the proposed procedural mitigation for the use of non-explosive missiles and rockets.

Table 36. Procedural mitigation for non-explosive missiles and rockets (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Aircraft-deployed non-explosive missiles and rockets o Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform

Procedural Mitigation Description
• 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: o 900 yd around the intended impact location • Prior to the initial start of the activity (e.g., during a fly-over of the mitigation zone): 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 firing. • During the activity: o 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: 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 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.

The mitigation zone for this activity is several times larger than the impact footprint for all non-explosive missiles and rockets proposed for use (See Appendix F, Military Expended Material and Direct Strike Impact Analysis, of the HSTT DEIS/OEIS for further detail).

Missile and rocket exercises involve a participating ship or aircraft firing munitions at a target that is typically located up to 15 NM away, and infrequently up to 75 NM away. The mitigation only applies to aircraft-deployed missiles and rockets because aircraft can travel close to the intended impact area prior to commencing firing. Observation of the mitigation zone is not possible when missiles and rockets are fired from a ship due to the distance between the firing ship and the intended impact location. Even when aircraft are firing, 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 distant 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, but are not likely to detect these resources once positioned at the firing location. Observing for indicators of marine mammal and sea turtle presence will further help avoid or reduce impacts on these resources within the mitigation zone during the close-range observations.

3.4.2.1.19 Non-Explosive Bombs and Mine Shapes

Table 37 describes the proposed procedural mitigation for the use of non-explosive bombs and mine shapes.

Table 37. Procedural mitigation for non-explosive bombs and mine shapes (Navy 2018e).

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs • Non-explosive mine shapes during mine laying activities
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 yd around the intended target • Prior to the 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 or mine laying. • During the activity (e.g., during approach of the target or intended minefield location): o Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment or mine laying. • 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 or mine laying) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target or minefield location; (3) the mitigation zone has been clear from any additional sightings for 10 min.; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

The mitigation zone for this activity is several times larger than the impact footprint for non-explosive bombs and mine shapes (See Appendix F, Military Expended Material and Direct Strike Impact Analysis, of the HSTT DEIS/OEIS for further detail).

Bombing exercises and activities involving mine laying involve a participating aircraft deploying munitions or mine shapes at a surface target or in an intended minefield location beneath the platform. During approach of the target or intended minefield location, aircraft maintain a relatively steady altitude of approximately 1,500 ft, and Lookouts will, by necessity for safety and mission success, primarily focus their attention on the water surface below and surrounding the location of bomb or mine shape deployment. Due to the mitigation zone size and vantage point from an aircraft, Lookouts should be able to observe the entire mitigation zone while still maintaining situational awareness (Navy 2018d). Observing for indicators of marine mammal and sea turtle presence will help avoid or reduce impacts on these resources within the mitigation zone.

3.4.2.2 Mitigation Areas

In addition to procedural mitigation, the Navy will implement mitigation measures within specified areas to avoid potential impacts on marine mammals (including ESA-listed species) and seafloor resources (which serve valuable ecosystem functions and provide habitat for ESA-listed species and their prey). Mitigation areas are geographic locations in the action area where the Navy will implement additional avoidance and minimization measures during all or a part of the year.

The Navy considered several factors when determining the location of proposed geographic mitigation areas. First, they evaluated whether the mitigation area would be effective in reducing impacts to resources of biological or ecological importance. Next, the Navy operational community assessed how and to what degree implementation of mitigation measures would be compatible with planning, scheduling, and conducting proposed training and testing activities. A more thorough discussion on the factors used by the Navy to determine which areas to propose for geographic mitigation is provided in Appendix K of the HSTT DEIS/OEIS (Navy 2017b).

Information on mitigation the Navy proposes to implement within specific geographic areas is provided in the following sections. The mitigation applies year-round unless specified otherwise.

3.4.2.2.1 Mitigation Areas for Seafloor Resources

As described in Table 38 and shown in Figure 22 and Figure 23, the Navy proposes to implement mitigation to avoid and minimize impacts to seafloor resources from explosives, physical disturbance, and strike stressors in mitigation areas throughout the action area. Mitigation would help the Navy avoid or reduce impacts from explosives, physical disturbance, and strike stressors on seafloor resources, and consequently to any ESA-protected resources that inhabit, shelter, rest, feed, or occur in the mitigation areas.

Table 38. Mitigation areas for seafloor resources (Navy 2018e).

Mitigation Area Description
Stressor or Activity • Explosives • Physical disturbance and strikes
Resource Protection Focus • Shallow-water coral reefs • Precious coral beds • Live hard bottom • Artificial reefs • Shipwrecks
Mitigation Area Requirements (year-round) • **Within the anchor swing circle of shallow-water coral reefs, precious coral beds, live hard bottom, artificial reefs, and shipwrecks:** o The Navy will not conduct precision anchoring (except in designated anchorages in the Hawaii Range Complex and Southern California portion of the Action Area, such as areas adjoining the boat lanes off Silver Strand Training Complex and Naval Amphibious Base Coronado). • **Within a 350-yd radius of live hard bottom, artificial reefs, and shipwrecks:** o The Navy will not conduct explosive mine countermeasure and neutralization activities or explosive mine neutralization activities involving Navy divers (except in designated areas in the Hawaii Range Complex and Southern California portion of the Action Area, such as the nearshore areas of San Clemente Island and in the Silver Strand Training Complex, where these features will be avoided to the maximum extent practicable). o The Navy will not place mine shapes, anchors, or mooring devices on the seafloor (except in designated areas in the Hawaii Range Complex and Southern California portion of the Action Area, such as the nearshore areas of San Clemente Island and in the Silver Strand Training Complex, where these features will be avoided to the maximum extent practicable). • **Within a 350-yd radius of shallow-water coral reefs and precious coral beds:** o The Navy will not conduct explosive or non-explosive small-, medium-, and large-caliber gunnery activities using a surface target; explosive or non-explosive missile and rocket activities using a surface target; explosive or non-explosive bombing and mine laying activities; explosive or non-explosive mine countermeasure and neutralization activities; and explosive or non-explosive mine neutralization activities involving Navy divers (except in designated areas in the Hawaii Range Complex and Southern California portion of the Action Area, such as the nearshore areas of San Clemente Island and in the Silver Strand Training Complex, where these features will be avoided to the maximum extent practicable). o The Navy will not place mine shapes, anchors, or mooring devices on the seafloor (except in designated areas in the Hawaii Range Complex and Southern California portion of the Action Area, such as the nearshore areas of San Clemente Island and in the Silver Strand Training Complex, where these features will be avoided to the maximum extent practicable).

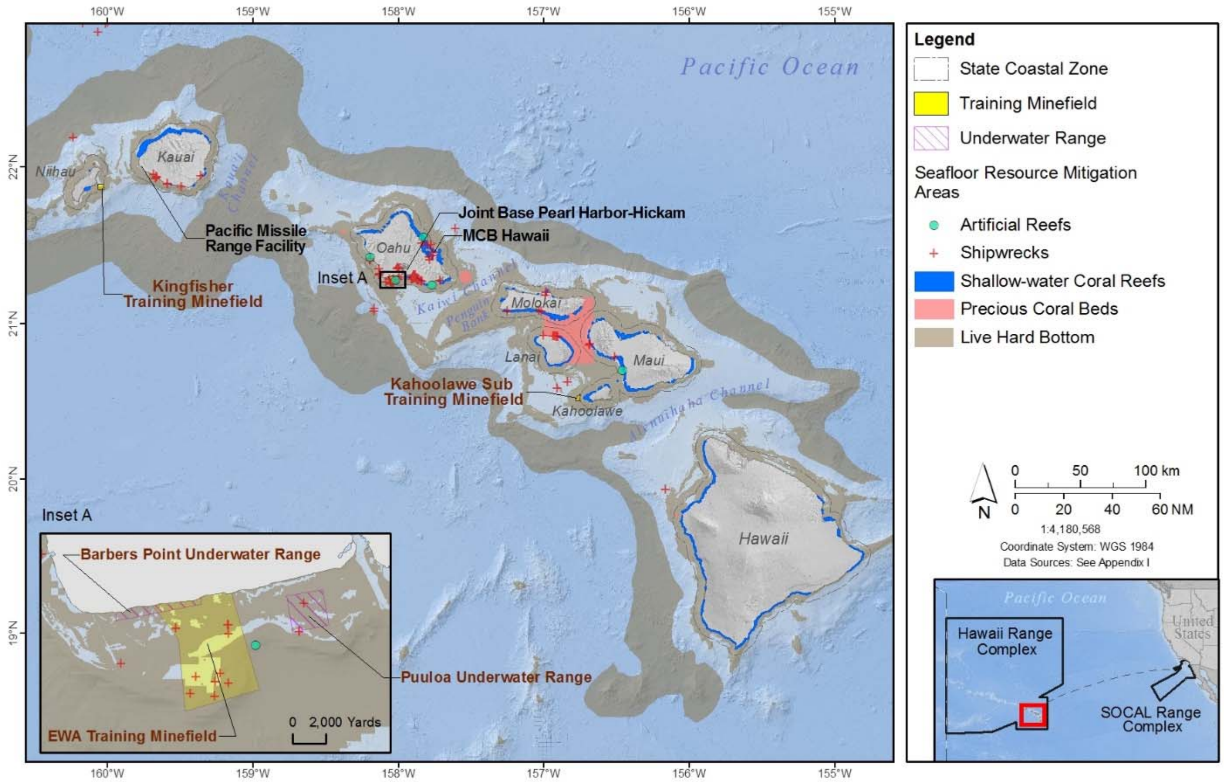


Figure 22. Seafloor resource mitigation areas in the Hawaii Range Complex (Navy 2018e).

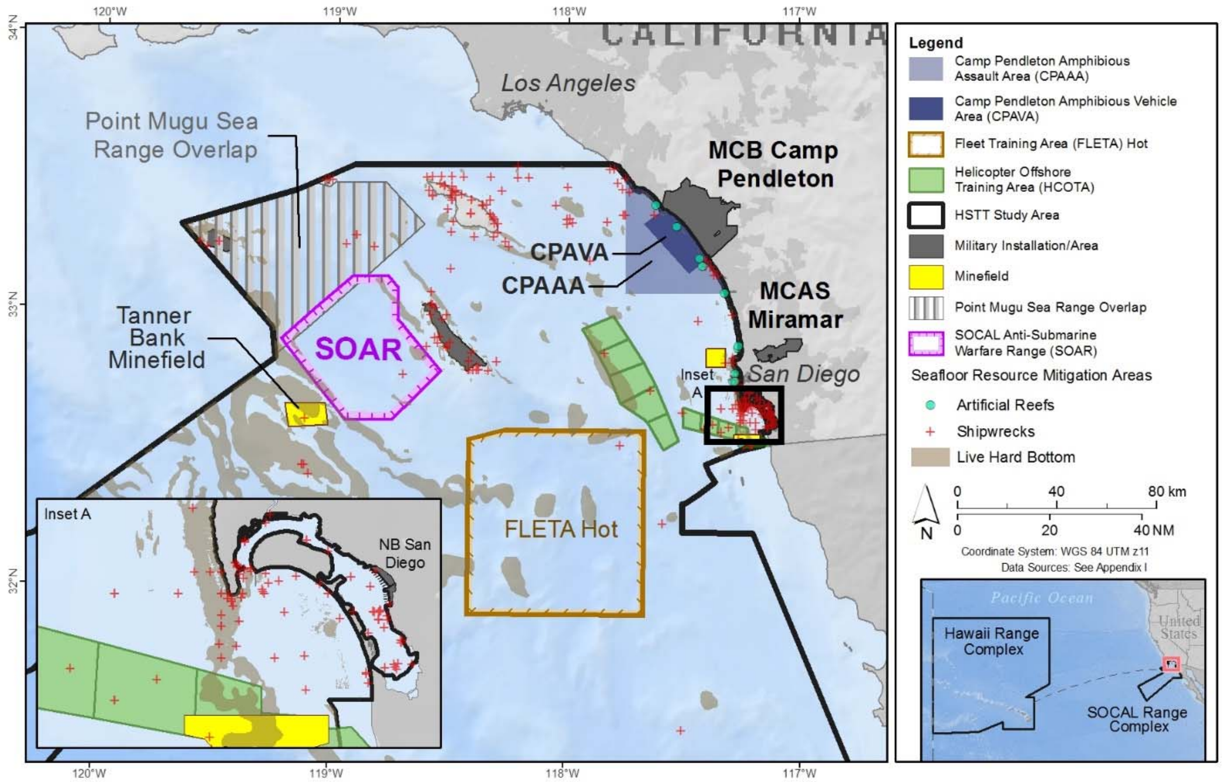


Figure 23. Seafloor resource mitigation areas in the Southern California portion of the action area (Navy 2018e).

The Navy developed proposed mitigation areas as either the anchor swing circle diameter or a 350-yd radius around a mapped seafloor resource, as indicated by the best available georeferenced data. Mitigating within the anchor swing circle will allow protection of seafloor resources during precision anchoring activities when factoring in environmental conditions that could affect anchoring position and swing circle size (such as winds, currents, and water depth). For other activities applicable to the mitigation, a 350-yd radius around a seafloor resource is a conservatively sized mitigation area that will provide protection well beyond the maximum expected impact footprint (e.g., crater and expelled material radius) of the explosives and non-explosive practice munitions used in the action area. As described further in Appendix F (Military Expended Material and Direct Strike Impact Analysis) of the HSTT DEIS/OEIS (Navy 2017b), the military expended material with the largest footprint that applies to the mitigation is an explosive mine with a 650-lb net explosive weight, which has an estimated impact footprint of approximately 14,800 square ft and an associated radius of 22.7 yd.

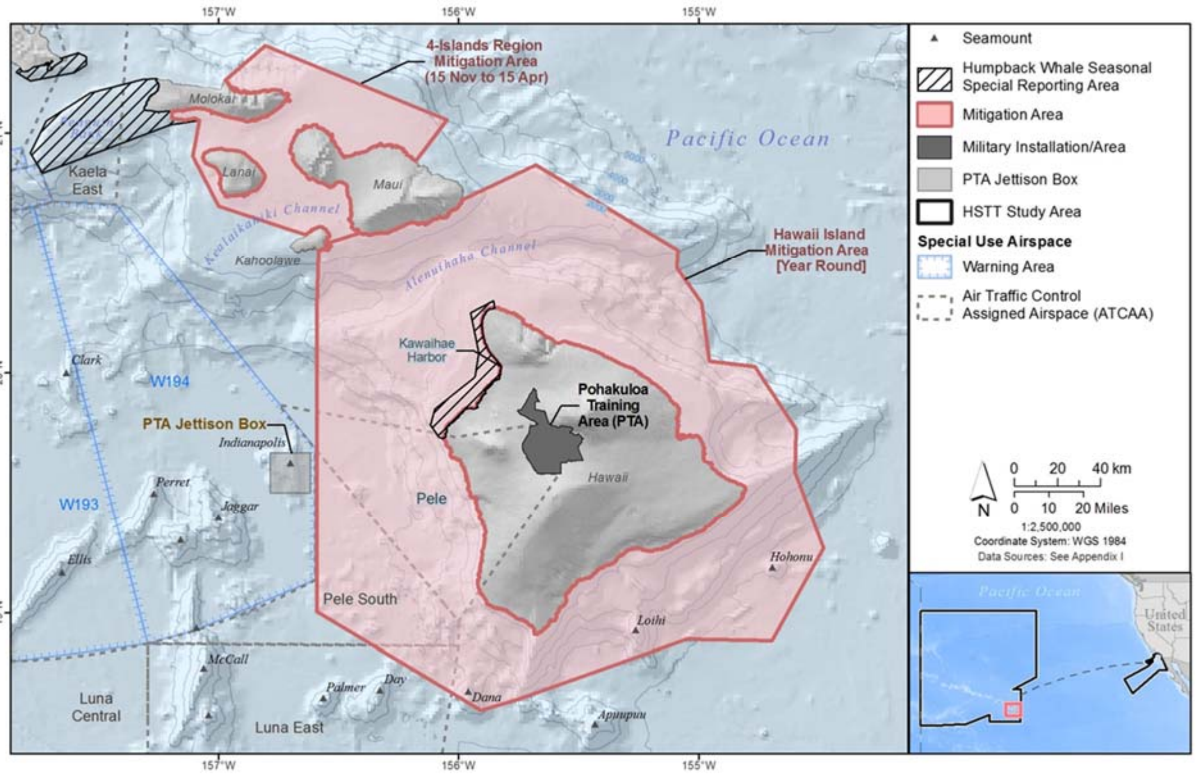
To aid in the implementation of seafloor resource mitigation, the Navy will include maps of the best available georeferenced data (i.e., where the available data accurately indicate the natural boundary of a seafloor resource and are not generalized within large geometric areas, such as large grid cells) in the Protective Measures Assessment Protocol (See Section 3.4.2) for shallow-water coral reefs, artificial reefs, live hard bottom, and shipwrecks.

3.4.2.2.2 Mitigation Areas for Marine Mammals in the Hawaii Range Complex

As described in Table 39 and shown in Figure 24, the Navy proposes to implement mitigation within mitigation areas to avoid or reduce impacts on marine mammals from acoustic and explosive stressors and vessel strikes from proposed training and testing activities in the HRC.

Table 39. Mitigation Areas for Marine Mammals in the Hawaii Range Complex (Navy 2018e).

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Vessel strikes
Resource Protection Focus • Marine mammals
Mitigation Area Requirements • **Hawaii Island Mitigation Area (year-round):** o The Navy will not conduct more than 300 hours of MF1 surface ship hull-mounted mid-frequency active sonar or 20 hours of MF4 dipping sonar, or use explosives that could potentially result in takes of marine mammals during training and testing. Should national security present a requirement to conduct more than 300 hours of MF1 surface ship hull-mounted mid-frequency active sonar or 20 hours of MF4 dipping sonar, or use explosives that could potentially result in the take of marine mammals during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., sonar hours or explosives usage) in its annual activity reports submitted to NMFS. • **4-Islands Region Mitigation Area (November 15 – April 15 for active sonar; year-round for explosives):** o The Navy will not use MF1 surface ship hull-mounted mid-frequency active sonar or explosives that could potentially result in takes of marine mammals during training and testing. Should national security present a requirement to use MF1 surface ship hull-mounted mid-frequency active sonar or explosives that could potentially result in the take of marine mammals during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., sonar hours or explosives usage) in its annual activity reports submitted to NMFS. • **Humpback Whale Special Reporting Areas (December 15 – April 15):** o The Navy will report the total hours of surface ship hull-mounted mid-frequency active sonar used in the special reporting areas in its annual training and testing activity reports submitted to NMFS. • **Humpback Whale Awareness Notification Message Area (November – April):** o The Navy will issue a seasonal awareness notification message to alert ships and aircraft operating in the area to the possible presence of concentrations of large whales, including humpback whales. o To maintain safety of navigation and to avoid interactions with large whales during transits, the Navy will instruct vessels to remain vigilant to the presence of large whale species (including humpback whales), that when concentrated seasonally, may become vulnerable to vessel strikes. o Platforms will use the information from the awareness notification message to assist their visual observation of applicable mitigation zones during training and testing activities and to aid in the implementation of procedural mitigation.



Notes: [1] Explosive restrictions for the Hawaii Island Mitigation Area apply only to those activities that are anticipated to result in harassment or injury under the MMPA (e.g., surface-to-surface or air-to-surface missile and gunnery events, BOMBEX, and mine neutralization).

Figure 24. Mitigation areas for marine mammals in the Hawaii Range Complex (Navy 2018e).

3.4.2.2.3 Mitigation Areas for Marine Mammals in the Southern California Portion of the Action Area

As described in Table 40 and shown in Figure 25, the Navy proposes to implement mitigation within mitigation areas to further avoid or reduce impacts on marine mammals from acoustic and explosive stressors and vessel strikes from proposed training and testing activities in the Southern California portion of the action area.

Table 40. Mitigation areas for marine mammals in the Southern California portion of the action area (Navy 2018e).

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Vessel strikes
Resource Protection Focus • Marine mammals

Mitigation Area Description
<u>Mitigation Area Requirements</u> • **San Diego Arc, San Nicolas Island, and Santa Monica/Long Beach Mitigation Areas (June 1 – October 31):** o The Navy will not conduct more than a total of 200 hours of MF1 surface ship hull-mounted mid-frequency active sonar in the combined areas, excluding normal maintenance and systems checks, during training and testing. Should national security present a requirement to conduct more than 200 hours of MF1 surface ship hull-mounted mid-frequency active sonar in the combined areas during training and testing (excluding normal maintenance and systems checks), naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., sonar hours) in its annual activity reports submitted to NMFS. o Within the San Diego Arc Mitigation Area, the Navy will not use explosives that could potentially result in the take of marine mammals during large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training and testing. Should national security present a requirement to use explosives that could potentially result in the take of marine mammals during large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., explosives usage) in its annual activity reports submitted to NMFS. o Within the San Nicolas Island Mitigation Area, the Navy will not use explosives that could potentially result in the take of marine mammals during mine warfare, large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training. Should national security present a requirement to use explosives that could potentially result in the take of marine mammals during mine warfare, large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., explosives usage) in its annual activity reports submitted to NMFS. o Within the Santa Monica/Long Beach Mitigation Area, the Navy will not use explosives that could potentially result in the take of marine mammals during mine warfare, large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training and testing. Should national security present a requirement to use explosives that could potentially result in the take of marine mammals during mine warfare, large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training or testing, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., explosives usage) in its annual activity reports submitted to NMFS. • **Santa Barbara Island Mitigation Area (year-round):** o The Navy will not use MF1 surface ship hull-mounted mid-frequency active sonar during training or testing, or explosives that could potentially result in the take of marine mammals during medium-caliber or large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training. Should national security present a requirement to use MF1 surface ship hull-mounted mid-frequency active sonar during training or testing, or explosives that could potentially result in the take of marine mammals during medium-caliber or large-caliber gunnery, torpedo, bombing, and missile (including 2.75" rockets) activities during training, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include the information (e.g., sonar hours or explosives usage) in its annual activity reports submitted to NMFS. • **Blue Whale (June – October), Gray Whale (November – March), and Fin Whale (November – May) Awareness Notification Message Areas:** o The Navy will issue a seasonal awareness notification message to alert ships and aircraft operating in the area to the possible presence of concentrations of large whales, including blue, gray, or fin whales.

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

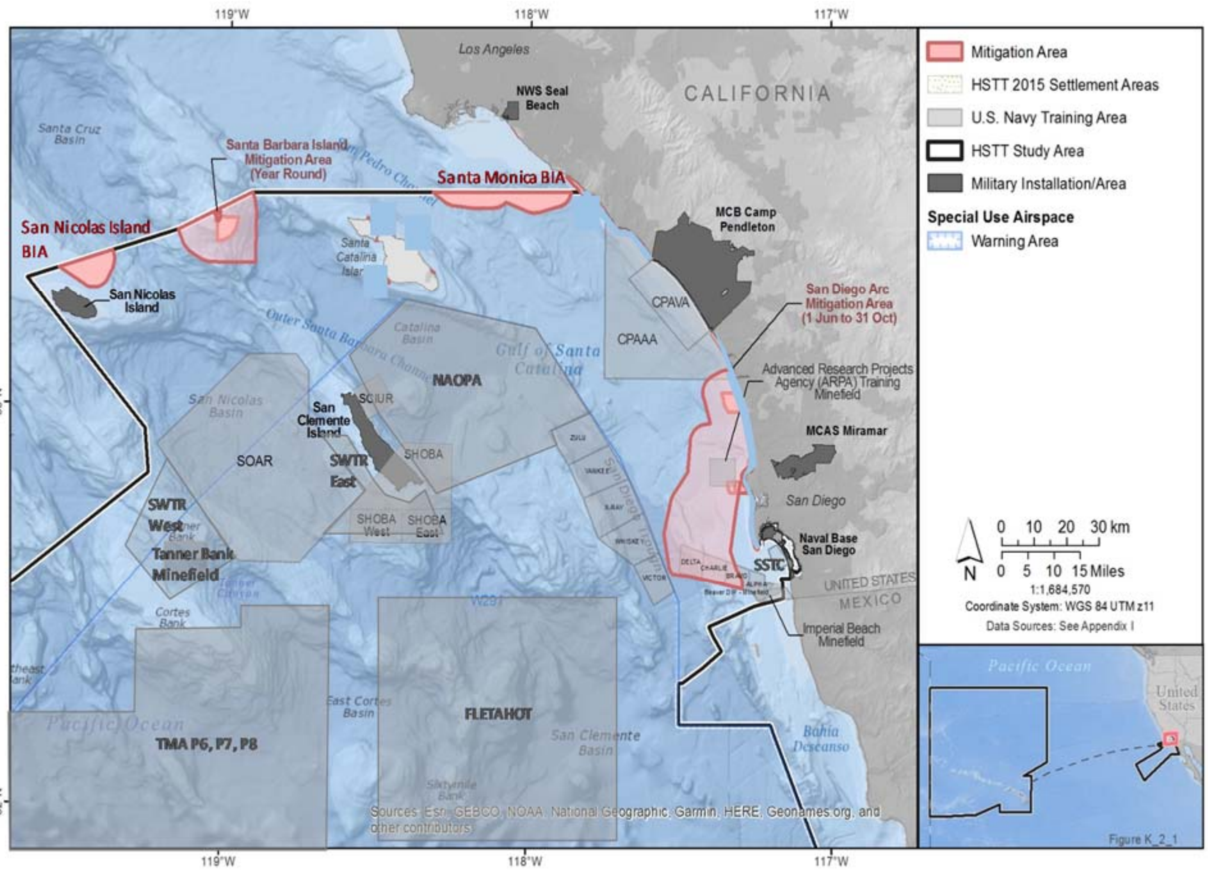


Figure 25. Mitigation areas for marine mammals in the Southern California portion of the action area (Navy 2018e).

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 action area for this consultation is the HSTT Study Area (Figure 9), described in further detail in Section 3.1 of this opinion. The Navy's activities will occur well within the boundaries depicted on Figure 9, so the effects of the action, including effects from sonar and explosives, would not extend beyond these boundaries.

5 Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility apart from the action under consideration. We determined that there are no interrelated or interdependent actions to the actions proposed by the Navy and NMFS Permits Division, as described in Section 2.3 of this opinion.

6 Potential Stressors

The potential stressors we expect to result from the proposed action are acoustic stressors, explosive stressors, energy stressors, physical disturbance and strike, entanglement, and ingestion. Further discussion of each of these stressors is below.

6.1 Acoustic Stressors

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars and air guns), as well as incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; pile driving and removal; 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.

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater sound deliberately employed by the Navy including sonars and other transducers (devices that convert energy from one form to another—in this case, to sound waves), air guns, and explosives, the Navy developed a series of source classifications, or source bins. The source classification bins do not include the broadband sounds produced incidental to pile driving; vessel and aircraft transits; and weapons firing.

6.1.1 Vessel Noise

Naval vessels (including ships and small craft) produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. Navy vessels represent a small amount of overall vessel traffic (Mintz 2016) and 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 2011). For example, Surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection. Table 41 presents information from Mintz (2016), describing the relative number of ship hours in the vicinity of the Southern California portion of the action area and the HRC for military versus non-military vessels. Navy ships make up only eight percent of total ship traffic in Hawaii, and only four percent of total ship traffic in Southern California (Mintz 2016). In terms of anthropogenic noise, Navy ships would contribute a correspondingly smaller amount of shipping noise compared to more common commercial shipping and boating (Mintz and Filadelfo 2011). Exposure of ESA-listed species to vessel noise would be greatest in the areas of highest vessel traffic. Within the action area, commercial traffic is heaviest along the coast of California and near the major Hawaiian Islands (Mintz 2016).

Table 41. Ship hours from 2011 to 2015 positional records in the action area.

Ship Category	HRC Vicinity	SOCAL Vicinity
U.S. Navy	358,000	1,076,000
U.S. Coast Guard	42,000	138,000
Foreign Military	68,000	56,000
Nonmilitary	3,903,000	27,223,000

Interpolated SeaLink data from 2011 through 2015 which represents an unknown fraction of actual vessel traffic. This data represents a relative traffic level, not absolute ship presence (Mintz, 2016)

Radiated noise from ships varies depending on the nature, size, and speed of the ship. 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 2011). McKenna et al. (2012b) determined that container ships produced broadband source levels around 188 dB re 1 μPa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 μPa (Mintz and Filadelfo 2011; Richardson et al. 1995c; Urick 1983b). 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 2011).

Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 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) (Mintz and Filadelfo 2011; Richardson et al. 1995c; 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. 2012b). Small craft types 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. During training and testing, speeds of most large naval vessels (greater than 60 ft) generally range from 10 to 15 knots. Ships will, on occasion, operate at higher speeds within their specific operational capabilities.

Anti-submarine warfare platforms (such as guided missile destroyers and cruisers) and submarines make up a large part of Navy traffic but are designed to be quiet to minimize detection. These platforms are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise than anti-submarine warfare platforms (Mintz and Filadelfo 2011).

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. Navy vessels do contribute to the overall increased ambient noise in inshore waters near Navy ports, although their contribution to the overall noise in these environments is a small percentage compared to the large amounts of commercial and recreational vessel traffic in these areas (Mintz and Filadelfo 2011).

6.1.2 Aircraft Noise

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. 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. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 42 provides source levels for some typical aircraft used during training and testing in the action area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

Table 42. Representative aircraft sound characteristics (Navy 2018e).

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*
Airborne Noise Level	
F/A-18C/D Under Military Power	143 dBA re 20 μPa at 13 m from source[3]
F/A-18C/D Under Afterburner	146 dBA re 20 μPa at 13 m from source[3]
F35-A Under Military Power	145 dBA re 20 μPa at 13 m from source[3]
F-35-A 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]
F-35A Takeoff Through 1,000 ft (300 m) Altitude	119 dBA re 20 $\mu Pa^2 s$[4]** (per second of duration)
EA-18G Takeoff Through 1,622 ft (500 m) Altitude	115 dBA re 20 $\mu Pa^2 s$ [5]** (per second of duration)

** Estimate based on in-air 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

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. Estimates of underwater SPL are provided for representative aircraft in Table 42.

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 dBs (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.

Helicopters

Noise generated from helicopters is transient in nature and variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft. 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 (m) below water surface for a UH-60 hovering 82 ft (25 m) altitude (Kufeld and M. 2005).

Helicopter unit level training typically entails single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about two to four hours. Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Most helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75-100 ft. Likewise, in some anti-submarine warfare events, a dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water.

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 more than 30 NM from inhabited coastal areas or islands, though 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 stronger 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 originated 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 1 mile 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 miles 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. 2000). 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 43.

Table 43. Sonic boom underwater sound levels modeled for supersonic flight from a representative aircraft.

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); km = kilometer.
[1] Equivalent to SEL for a plane wave.

6.1.3 Sonar and other Transducers

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

Propagation of sound produced underwater is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency sounds propagate. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its exposure analysis that consider sound source characteristics and varying ocean conditions across the action area. The Navy's acoustic modeling approach is described further in Section 2.2 of this opinion and in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g).

6.1.3.1 Anti-Submarine Warfare

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

Most anti-submarine warfare sonars are mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets with distance over which threats can be identified. However, some sources may use higher or lower frequencies. Duty cycles can vary widely, from rarely used to continuously active. For example, a submarine‘s mission revolves around its stealth; therefore, active sonar is used infrequently because its use would also reveal a submarine’s location. Anti submarine warfare sonars can be wide-angle in a search mode or highly directional in a track mode.

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

6.1.3.2 Mine Warfare, Small Object Detection, and Imaging

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

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

6.1.3.3 Navigation and Safety

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

6.1.3.4 Communication

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

6.1.3.5 Classification of Sonar and Other Transducers

For its acoustic exposure analysis, the Navy grouped sonars and other transducers into classes that share an attribute, such as frequency range or purpose of use. Classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used, as follows:

- frequency of the non-impulsive acoustic source
  - low-frequency sources operate below 1 kHz
  - mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - high-frequency sources operate above 10 kHz, up to and including 100 kHz
  - very high-frequency sources operate above 100 kHz but below 200 kHz
- sound pressure level
  - greater than 160 dB re 1 μPa, but less than 180 dB re 1 μPa
  - equal to 180 dB re 1 μPa and up to 200 dB re 1 μPa
  - greater than 200 dB re 1 μPa
- application in which the source would be used.
  - sources with similar functions that have similar characteristics, such as pulse length (duration of each pulse), beam pattern, and duty cycle

The bins used for classifying active sonars and transducers that are quantitatively analyzed in the action area are shown in Table 44. While general parameters or source characteristics are shown in the table, actual source parameters are classified. Table 44 shows the bin use that could occur in any year for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Section 3.3.

Table 44. Sonar and transducer sources quantitatively analyzed (Navy 2018d).

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total[4]	Annual[2]	5-year Total[4]
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	LF sources greater than 200 dB	H	0	0	195	975
	LF4	LF sources equal to 180 dB and up to 200 dB	H	0	0	589 – 777	3,131
			C	0	0	20	100
	LF5	LF sources less than 180 dB	H	0	0	1,814 – 2,694	9,950
	LF6	LF sources greater than 200 dB with long pulse lengths	H	121 – 167	668	40 – 80	240
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)	H	5,779 – 6,702	28,809	1,540	5,612
	MF1K	Kingfisher mode associated with MF1 sonars	H	100	500	14	70
	MF2[3]	Hull-mounted surface ship sonars (e.g., AN/SQS-56)	H	0	0	54	270
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	2,080 – 2,175	10,440	1,311	6,553
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22 and AN/AQS-13)	H	414 – 489	2,070	311 – 475	1,717
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	5,704 – 6,124	28,300	5,250 – 5,863	27,120
	MF6	Active underwater sound signal devices (e.g., MK 84)	C	9	45	1,141 – 1,226	5,835
	MF8	Active sources (greater than 200 dB) not otherwise binned	H	0	0	70	350

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total[4]	Annual[2]	5-year Total[4]
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	5,139 – 5,165	25,753
	MF10	Active sources(greater than 160 dB, but less than 180 dB) not otherwise binned	H	0	0	1,824– 1,992	9,288
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than80%	H	718 – 890	3,597	56	280
	MF12	Towed array surface ship sonars with an active duty cycle greater than80%	H	161 – 215	884	660	3,300
	MF13	MF sonarsource	H	0	0	300	1,500
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	1,795 – 1,816	8,939	772	3,859
	HF2	HF Marine Mammal Monitoring System	H	0	0	120	600
	HF3	Other hull-mounted submarine sonars (classified)	H	287	1,345	110	549
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	2,316	10,380	16,299 – 16,323	81,447
	HF5	Active sources(greater than200 dB) not otherwise binned	H	0	0	960	4,800
			C	0	0	40	200
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	1,000 – 1,009	5,007
	HF7	Active sources(greater than 160 dB, but less than 180 dB) not otherwise binned	H	0	0	1,380	6,900

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total[4]	Annual[2]	5-year Total[4]
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)	H	118	588	1,032	3,072
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB	H	194 – 261	1,048	470	2,350
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	C	688 – 790	3,346	4,334 – 5,191	23,375
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	5,005 – 6,425	25,955	2,741	13,705
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	1,284 – 1,332	6,407	2,244	10,910
	ASW5[3]	MF sonobuoys with high duty cycles	H	220 – 300	1,260	522 – 592	2,740
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK 46, MK 54, or Anti-Torpedo Torpedo)	C	231 – 237	1,137	923 – 971	4,560
	TORP2	Heavyweight torpedo (e.g., MK 48)	C	521 – 587	2,407	404	1,948
	TORP3		C	0	0	45	225
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	28	140	448 – 544	2,432
	FLS3	VHF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	0	0	2,640	13,200
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	61	153	518	2,588
Swimmer Detection Sonars (SD):	SD1–SD2	HF and VHF sources with short pulse lengths, used	H	0	0	10	50

Source Class Category	Bin	Description	Unit[1]	Training		Testing	
				Annual[2]	5-year Total[4]	Annual[2]	5-year Total[4]
Systems used to detect divers and submerged swimmers		for the detection of swimmers and other objects for the purpose of port security					
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems	H	0	0	1,960	9,800
	SAS2	HF SAS systems	H	900	4,498	8,584	42,920
	SAS3	VHF SAS systems	H	0	0	4,600	23,000
	SAS4	MF to HF broadband mine countermeasure sonar	H	42	210	0	0
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB4	LF to MF oceanographic source	H	0	0	810 – 1,170	4,434
	BB7	LF oceanographic source	C	0	0	28	140
	BB9	MF optoacoustic source	H	0	0	480	2,400

[1] H = hours; C = count (e.g., number of individual pings or individual sonobuoys).

[2] Expected annual use may vary per bin because the number of events may vary from year to year

[3] Formerly ASW2 (H) in Phase II.

[4] As noted previously, the Navy's proposed action includes the five year period of the proposed rule and subsequent five year periods into the reasonably foreseeable future.

Notes: dB = decibel(s), kHz = kilohertz

In addition to the sources described above that were quantitatively analyzed for potential exposure to ESA-listed marine mammals and sea turtles, the Navy utilizes in-water active acoustic sources with narrow beam widths, downward directed transmissions, short pulse lengths, frequencies above known hearing ranges, low source levels, or combinations of these factors. The Navy categorizes these sources as *de minimis* sources and did not quantitatively analyze them for potential exposure to marine mammals or sea turtles. When used during routine training and testing activities, and in a typical environment, *de minimis* sources fall into one or more of the following categories:

- Transmit primarily above 200 kHz: Sources above 200 kHz are above the hearing range of the most sensitive marine mammals and far above the hearing range of any other animals in the action area.
- Source levels of 160 dB re 1 μPa or less: Low-powered sources with source levels less than 160 dB re 1 μPa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 μPa source, the sound will attenuate to less than 140 dB within 10 m and less than 120 dB within 100 m of the source. Ranges would be even shorter for a source less than 160 dB re 1 μPa source level.
- Acoustic source classes listed in Table 45: Sources with operational characteristics, such as short pulse length, narrow beam width, downward-directed beam, and low energy release, or manner of system operation which minimize the possibility of impacting protected species (actual source parameters listed in the classified bin list).

Table 45. Sonars and transduces used, but not quantitatively analyzed for exposure to protected species (Navy 2018d).

Source Class Category	Bin	Characteristics
Broadband Sound Sources (BB): Sources with wide frequency spectra	BB3	• Very high frequency • Very short pulse length
	BB8	• Small imploding source (lightbulb)
Doppler Sonar/Speed Logs (DS): High-frequency/very high-frequency navigation transducers	DS2–DS4	*Required for safe navigation.* • downward focused • narrow beam width • very short pulse lengths
Fathometers (FA): High-frequency sources used to determine water depth	FA1–FA4	*Required for safe navigation.* • downward focused directly below the vessel • narrow beam width (typically much less than 30°) • short pulse lengths (less than 10 milliseconds)
Hand-Held Sonar (HHS): High-frequency sonar devices used by Navy divers for object location	HHS1	• very high frequency sound at low power levels • narrow beam width • short pulse lengths • under positive control of the diver (power and direction)

Source Class Category	Bin	Characteristics
Imaging Sonar (IMS): Sonars with high or very high frequencies used obtain images of objects underwater	IMS1-IMS3	• High-frequency or very high-frequency • downward directed • narrow beam width • very short pulse lengths (typically 20 milliseconds)
High-Frequency Acoustic Modems (M): Systems that send data underwater **Tracking Pingers (P):** Devices that send a ping to identify an object location	M2 P1-P4	• low duty cycles (single pings in some cases) • short pulse lengths (typically 20 milliseconds) • low source levels
Acoustic Releases (R): Systems that ping to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1-R3	• typically emit only several pings to send release order
Side-Scan Sonars (SSS): Sonars that use active acoustic signals to produce high-resolution images of the seafloor	SSS1-SSS2	• downward-directed beam • short pulse lengths (less than 20 milliseconds)

Notes: ° = degree(s), kHz = kilohertz, lb = pound(s)

6.1.4 Noise from Weapons

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. Other devices intentionally produce noise to serve as a non-lethal deterrent. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, are discussed in Section 6.1.5. Examples of some types of weapons noise are shown in Table 46.

Table 46. Examples of noise from weapons (Navy 2018d).

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]
Advanced Gun System Missile (115-millimeter)	133-143 dBA re 20 μPa between 12 and 22 m from the launcher on shore[3]
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]

Sources: [1]Yagla and Stiegler (2003a); [2]U.S. Department of the Army (1999); [3]U.S. Department of the Navy (2013).

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)

Muzzle Blast from Naval Gunfire

Firing a gun produces a muzzle blast in air that propagates away from the gun with strongest directivity in the direction of fire. 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. As explained in Appendix D (Acoustic and Explosive Concepts) in the HSTT DEIS/OEIS (Navy 2017b), 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-in 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 2003b). 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 μPa^2-s directly below the muzzle blast. 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.

Supersonic Projectile Bow Shock Wave

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 (for more explanation, see Appendix D [Acoustic and Explosive Concepts] in the HSTT DEIS/OEIS [(Navy 2017b)]). 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.

Launch Noise

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 46.

Impact Noise (Non-explosive)

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.

Long Range Acoustic Device

Although not a weapon, the Long Range Acoustic Device (and other hailing and deterrent sources) is considered along with in-air sounds produced by Navy sources. The Long Range Acoustic Device is a communication device that can be used to warn vessels from continuing towards a high value asset by emitting loud sounds in air. The system would typically be used in training activities near shore, and use would be intermittent during these activities. Source levels at 1 m range between 137 dBA re 1 μPa for small portable systems and 153 dBA re 1 μPa for large systems. Sound would be directed within a 30 to 60° wide zone and would be directed over open water.

6.1.5 Air Guns

Air guns are essentially stainless steel tubes charged with high-pressure air via a compressor. An impulsive sound is generated when the air is almost instantaneously released into the surrounding water. Small air guns with capacities up to 60 in^3 would be used during testing activities in various offshore areas of the SOCAL Range Complex and in the HRC. Table 47 shows the number of air guns shots proposed in the action area.

Table 47. Air gun sources proposed for use in the action area (Navy 2018d).

Source Class Category	Bin	Unit[1]	Training		Testing	
			Annual	5-year Total	Annual	5-year Total
Air Guns (AG): Small underwater air guns	AG	C	0	0	844	4,220

Notes: C = count. One count (C) of AG is equivalent to 100 air gun firings.

Generated impulses would have short durations, typically a few hundred milliseconds, with dominant frequencies below 1 kHz. The rms SPL and peak pressure (SPL peak) at a distance 1 m from the air gun would be approximately 215 dB rms re 1 μPa and 227 dBpeak re 1 μPa, respectively, if operated at the full capacity of 60 in^3. The size of the air gun chamber can be adjusted, which would result in a lower SPL and SEL per shot.

6.1.6 Pile Driving

Impact pile driving and vibratory pile removal would occur during construction of an Elevated Causeway System, a temporary pier that allows the offloading of ships in areas without a permanent port. Construction of the elevated causeway could occur in sandy shallow water coastal areas at Silver Strand Training Complex and at Camp Pendleton, both in the Southern California Portion of the action area (Figure 15).

Installing piles for elevated causeways would involve the use of an impact hammer mechanism with both it and the pile held in place by a crane. The hammer rests on the pile, and the assemblage is then placed in position vertically on the beach or, when offshore, positioned with the pile in the water and resting on the seafloor. When the pile driving starts, the hammer part of the mechanism is raised up and allowed to fall, transferring energy to the top of the pile. The pile is thereby driven into the sediment by a repeated series of these hammer blows. Each blow results in an impulsive sound emanating from the length of the pile radially and longitudinally, into the water column as well as from the bottom of the pile through the sediment. Because the impact wave travels through the steel pile at speeds faster than the speed of sound in water, a steep-fronted acoustic shock wave is formed in the water (Reinhall and Dahl 2011). An impact pile driver generally operates in the range of 35 to 50 strikes per minute.

Pile removal involves the use of vibratory extraction, during which the vibratory hammer is suspended from the crane and attached to the top of a pile. The pile is then vibrated by hydraulic motors rotating eccentric weights in the mechanism, causing a rapid up and down vibration in the pile. This vibration causes the sediment particles in contact with the pile to lose frictional grip on the pile. The crane slowly lifts up on the vibratory driver and pile until the pile is free of the sediment. Vibratory removal creates continuous non-impulsive noise at low source levels for a short duration.

Pile driving for elevated causeway system training would occur in shallower water, and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. Soft substrates such as sand bottom at the proposed elevated causeway system locations would absorb or attenuate the sound more readily than hard substrates (rock), which may reflect the acoustic wave. Most acoustic energy would be concentrated below 1,000 Hz (Caltrans 2012; Hildebrand 2009b).

The source levels of the noise produced by impact pile driving and vibratory pile removal from an actual elevated causeway installation pile driving and removal are shown in Table 48.

Table 48. Underwater sound levels for elevated causeway system pile driving and removal (Navy 2018d).

Pile Size and Type	Method	Average Sound Levels at 10 m (SEL per individual pile)
24-in. Steel Pipe Pile	Impact[1]	192 dB re 1 μPa SPL rms 182 dB re 1 μPa²s SEL (single strike) 211 dB re 1 μPa SPL peak[16]
24-in. Steel Pipe Pile	Vibratory[2]	146 dB re 1 μPa SPL rms 145 dB re 1 μPa²s SEL (per second of duration)

[1] Illingworth and Rodkin (2016), [2] Illingworth and Rodkin (2015)
Notes: in. = inch, SEL = Sound Exposure Level, SPL = Sound Pressure Level, rms = root mean squared, dB re 1 μPa = decibels referenced to 1 micropascal

During this training activity, the length of the pier, and therefore the number of piles required, would be determined by the distance from shore to the appropriate water depth for ship off-loading. For the purposes of training activities, a pier length of 1,500 ft (457 m) is typical, with approximately 119 supporting piles. Construction of the Elevated Causeway System would involve intermittent impact pile driving over approximately 20 days. Crews work 24 hours a day and would drive approximately six piles in that period. Each pile takes about 15 min to drive with time taken between piles to reposition the driver. When training events that use the Elevated Causeway System are complete, the structure would be removed using vibratory methods over approximately 10 days. Crews would remove about 12 piles per 24-hour period, each taking about six minutes to remove. Table 49 summarizes the pile driving and pile removal activities that would occur during a 24-hour period.

[16] The Navy reported the minimum range of rms values (192) incorrectly as the peak SPL in their BA and EIS. NMFS obtained a copy of the original monitoring report and took the average of the reported peak values (which is 211 dB re 1 μPa SPL peak) indicated in the table, but kept the lowest reported rms value as provided by the Navy which is similar to other rms values for the size and type of piles used here.

Table 49. Summary of pile driving and removal activities per 24-hour period (Navy 2018d).

Method	Piles Per 24-Hour Period	Time Per Pile	Total Estimated Time of Noise Per 24-Hour Period
Pile Driving (Impact)	6	15 minutes	90 minutes
Pile Removal (Vibratory)	12	6 minutes	72 minutes

6.2 Explosive Stressors

This section describes the characteristics of explosions during naval training and testing. The activities analyzed in this opinion that use explosives are described in Section 3 of this opinion and in Appendix A (Navy Activity Descriptions) in the HSTT DEIS/OEIS (Navy 2017b). The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive warhead, the type of explosive material, the boundaries and characteristics of the propagation medium, and, in water, the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of trinitrotoluene, accounts for the first two parameters.

6.2.1 Explosions in Water

Explosive detonations during training and testing activities are associated with high-explosive munitions, including, but not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations during training and testing involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than 200 ft in depth, and greater than 3 NM from shore, with exceptions for Mine Warfare ranges at Silver Strand Training Complex, San Clemente Island, and Puuloa Underwater Range proximate to Pearl Harbor.

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the action area are shown in Table 50. This table shows the number of in-water explosive items that could be used in any year for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Section 3.3 of this opinion. The five-year total takes any annual variability into account.

Table 50. Explosive sources quantitatively analyzed that could be used underwater or at the water surface (Navy 2018d).

Bin	Net Explosive Weight[1] (lb)	Example Explosive Source	Training		Testing	
			Annual[2]	5-year Total	Annual[2]	5-year Total
E1	0.1–0.25	Medium-caliber projectiles	2,940	14,700	8,916 – 15,216	62,880
E2	> 0.25–0.5	Medium-caliber projectiles	1,746	8,730	0	0
E3	> 0.5–2.5	Large-caliber projectiles	2,797	13,985	2,880 – 3,124	14,844
E4	> 2.5–5	Mine neutralization charge	38	190	634 – 674	3,065
E5	> 5–10	5 inch projectile	4,730 – 4,830	23,750	1,400	7,000
E6	> 10–20	Hellfire missile	592	2,872	26–38	166
E7	> 20–60	Demo block/shaped charge	13	65	0	0
E8	> 60–100	Lightweight torpedo	33 – 38	170	57	285
E9	> 100–250	500 lb bomb	410 – 450	2,090	4	20
E10	> 250–500	Harpoon missile	219 – 224	1,100	30	150
E11	> 500–650	650 lb mine	7 – 17	45	12	60
E12	> 650–1,000	2,000 lb bomb	16 – 21	77	0	0
E13	> 1,000–1,740	Multiple Mat Weave charges	9	45	0	0

[1] Net Explosive Weight refers to the amount of explosives; the actual weight of a munition may be larger due to other components.

[2] Expected annual use may vary per bin because the number of events may vary from year to year

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species shown in Table 50, the Navy uses some very small impulsive sources (less than 0.1 lb net explosive weight), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to protected species. Quantitative modeling in multiple locations has indicated that these sources have a very small zone of influence. For this reason, they are excluded from further consideration in this opinion.

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. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its exposure analysis that consider sound source characteristics and varying ocean conditions across the action area. The Navy's acoustic modeling approach is described further in Section 2.2 of this opinion and in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g).

6.2.2 Explosions in Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface. Various missiles, rockets, and medium and large projectiles may be explosive or non-explosive, depending on the objective of the training or testing activity in which they are used. 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.

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 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 ESA-listed species could occur.

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.

6.3 Energy Stressors

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

6.3.1 In-Water Electromagnetic Devices

In-water electromagnetic energy devices include towed or unmanned mine warfare systems that simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic "pulse." A mine neutralization device could be towed through the water by a surface vessel or remotely operated vehicle, emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to detonate.

Generally, voltage used to power these systems is around 30 volts. Since saltwater is an excellent conductor, just 35 volts (capped at 55 volts) is required to generate the current needed to power the systems. These are considered safe levels for marine species due to the low electric charge relative to salt water (Navy 2018d).

The static magnetic field generated by the mine neutralization devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 2,300 microteslas[17]. This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items (e.g., the magnetic field generated is between the levels of a refrigerator magnet, which is 15,000 to 20,000 microteslas).

6.3.2 In-Air Electromagnetic Devices

Sources of electromagnetic energy in the air include kinetic energy weapons, communications transmitters, radars, and electronic countermeasure 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 1,280,00 watts.

A radar system is an electromagnetic device that emits radio waves to detect and locate objects. In most cases, basic radar systems operate by generating pulses of radio frequency energy and transmitting these pulses via directional antennae into space (Courbis and Timmel 2008). Some of this energy is reflected by the target back to the antenna, and the signal is processed to provide useful information to the operator.

Radars come in a variety of sizes and power, ranging from wide-band milliwatt systems to very high-power systems that are used primarily for long-range search and surveillance (Courbis and Timmel 2008). In general, radars operate at radio frequencies that range between 300 MHz and 300 gigahertz, and are often classified according to their frequency range. Navy vessels commonly operate radar systems which include S-band and X-band electronically steered radar. S-band radar serves as the primary search and acquisition sensor capable of tracking and collecting data on a large number of objects while X-band radar can provide high resolution data on particular objects of interest and discrimination for weapons systems. Both systems employ a variety of waveforms and bandwidths to provide high quality data collection and operational flexibility (Baird et al. 2016a).

The Navy assumes that most platforms (e.g., vessels) associated with proposed training and testing activities will be transmitting from a variety of in-air electromagnetic devices at all times while they are underway, with very limited exceptions (Navy 2018d). 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.

[17] The microtesla is a unit of measurement of magnetic flux density, or “magnetic induction.”

6.3.3 Lasers

Low-energy lasers are used to illuminate or designate targets, to measure the distance to a target, to guide weapons, to aid in communication, and to detect or classify mines. High-energy lasers are used as weapons to create critical failures of air and surface targets.

6.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors include vessels and other in-water devices, military expended materials, seafloor devices, and aircraft, each of which is described further in the sections below.

6.4.1 Vessels

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 to over 1,000 ft. Table 51 provides examples of the types of vessels, length, and speeds used in both testing and training activities.

Table 51. Representative vessel types, lengths, and speeds (Navy 2018d).

Type	Example(s)	Length	Typical Operating Speed
Aircraft Carrier	Aircraft Carrier (CVN)	>1000 ft	10–15 knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), Frigates (FF), Littoral Combat Ships (LCS)	300–700 ft	10–15 knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	300–900 ft	10–15 knots
Combat Logistics Force Ships	Fast Combat Support Ship (T-AOE), Dry Cargo/Ammunition Ship (T-AKE), Fleet Replenishment Oilers (T-AO)	600–750 ft	8–12 knots
Support Craft/Other	Amphibious Assault Vehicle (AAV); Combat Rubber Raiding Craft (CRRC); Landing Craft, Mechanized (LCM); Landing Craft, Utility (LCU); Submarine Tenders (AS); Yard Patrol Craft (YP)	15–140 ft	0–20 knots
Support Craft/Other—Specialized High Speed	High Speed Ferry/Catamaran; Patrol Combatants (PC); Rigid Hull Inflatable Boat (RHIB); Expeditionary Fast Transport (EPF); Landing Craft, Air Cushion (LCAC)	33–320 ft	0–50+ knots
Submarines	Fleet Ballistic Missile Submarines (SSBN), Attack Submarines (SSN), Guided Missile Submarines (SSGN)	300–600 ft	8–13 knots

Notes: > = greater than, ft = feet

Navy ships transit at speeds that are optimal for fuel conservation or to meet operational requirements. Large Navy ships (greater than 18 m in length) generally operate at average speeds of between 10 and 15 knots, and submarines generally operate at speeds in the range of 8–13 knots. Small craft (for purposes of this discussion, less than 18 m in length), which are all support craft, have much more variable speeds (0–50+ knots, dependent on the mission). While these speeds are considered averages and 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. Also, there are other instances such as launch and recovery of a small rigid hull inflatable boat; vessel boarding, search, and seizure training events; or retrieval of a target when vessels would be dead in the water or moving slowly ahead to maintain steerage. There are a few specific events, including high-speed tests of newly constructed vessels, where vessels would operate at higher speeds.

The number of Navy vessels in the action area at any given time varies and is dependent on local training or testing requirements. Activities range from involving one or two vessels to several vessels operating over various time frames and locations. Vessel movements in the action area fall into one of two categories; (1) those activities that occur in the offshore component of the action area and (2) those activities that occur in inshore waters.

Activities that occur in the offshore component of the action area may last from a few hours to a few weeks. Vessels associated with those activities would be widely dispersed in the offshore waters, but more concentrated in portions of the action area in close proximity to ports, naval installations, range complexes, and testing ranges. In contrast, activities that occur in inshore waters can last from a few hours to up to 12 hours of daily movement per vessel per activity. The vessels operating within the inshore waters are generally smaller than those in the offshore waters.

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis conducted a review of historic data for commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 20 m in length), was heaviest along the U.S. west coast between San Diego and Seattle (Puget Sound) and between the Hawaiian Islands (Mintz and Parker 2006). Well-defined International shipping lanes within the action area are also heavily traveled. Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the action area (Mintz and Parker 2006). Navy traffic in the action area was heaviest offshore of the naval ports at San Diego and Pearl Harbor. As described further in Section 6.1.1, Navy vessel traffic is a relatively small component of overall vessel traffic in the action area.

Figure 26 displays locations within the HSTT action area where the Navy concentrates the majority of their effort. Data in Figure 26 is based on totaled ship-hours for each 15-minute geographical box (i.e., 0.25 degrees latitude by 0.25 degrees longitude) and each box shaded according to the total number of ship-hours it contained (i.e., its "density"). Almost all underway time will be farther than 12 nm from shore and a majority would likely be greater than 25 nm from shore. Transit in and out of ports to access operational areas or the transit lane makes up a small percentage of this overall time.

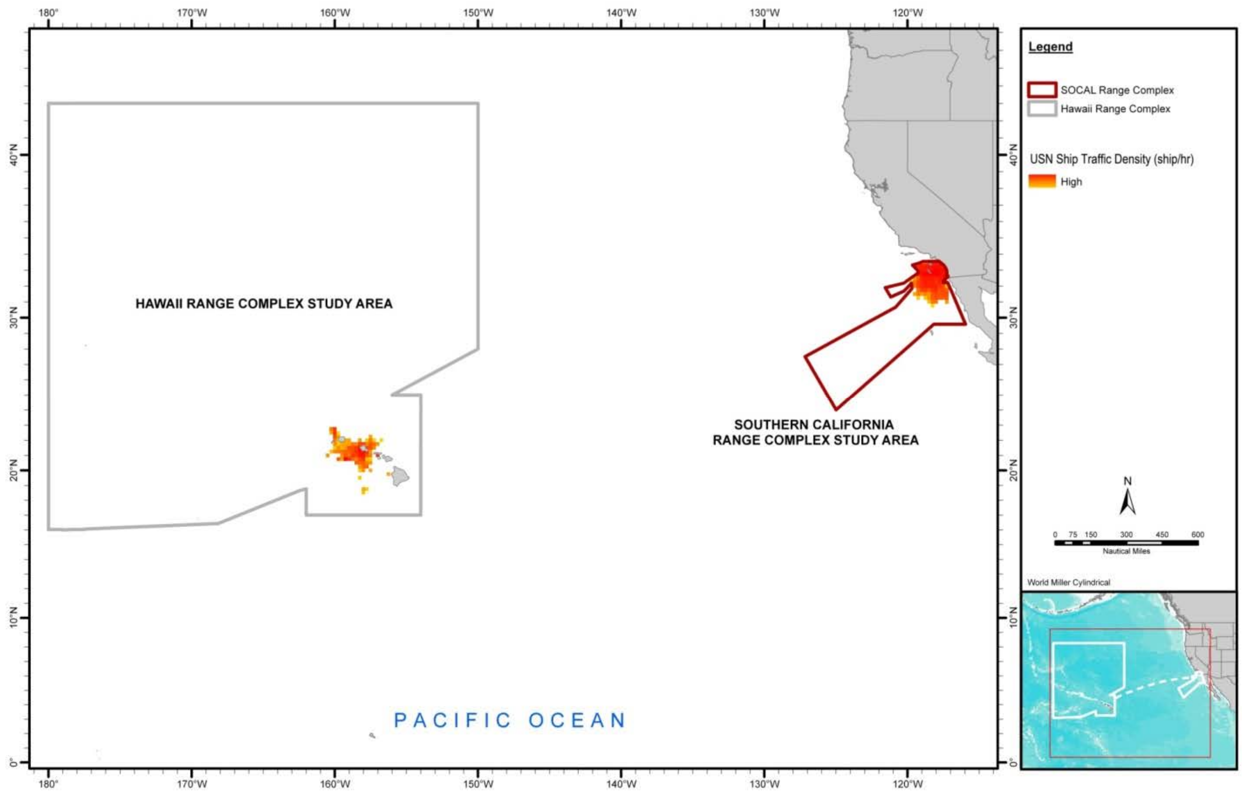


Figure 26. High density Navy Surface Ship transit and movement within the action area (Mintz, 2012).

6.4.2 In-Water Devices

In-water devices include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned underwater vehicles, motorized autonomous targets, and towed devices. 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. See Table 52 for information regarding the range of in-water devices to be used. These devices can operate anywhere from the water surface to the benthic zone. Most devices do not have a realistic potential to strike living marine resources 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.

Table 52. Representative types, sizes, and speeds of in-water devices (Navy 2018d).

Type	Example(s)	Length	Typical Operating Speed
Towed Device	Minehunting Sonar Systems; Improved Surface Tow Target; Towed Sonar System; MK-103, MK-104 and MK-105 Minesweeping Systems; Organic Airborne and Surface Influence Sweep	< 33 ft	10–40 knots
Unmanned Surface Vehicle	MK-33 Seaborne Power Target Drone Boat, QST-35A Seaborne Powered Target, Ship Deployable Seaborne Target, Small Waterplane Area Twin Hull, Unmanned Influence Sweep System	< 50 ft	Variable, up to 50+ knots
Large Unmanned Surface Vehicle	Research and Development Surface Vessels, Patrol Boats	< 200 ft	Typical 1-15 knots, sprint 25-50 knots
Unmanned Underwater Vehicle	Acoustic Mine Targeting System, Airborne Mine Neutralization System, AN/AQS Systems, Archerfish Common Neutralizer, Crawlers, CURV 21, Deep Drone 8000, Deep Submergence Rescue Vehicle, Gliders, Expendable Mobile Anti-Submarine Warfare Training Targets, Magnum Remotely Operated Vehicle, Manned Portables, MK 30 Anti-Submarine Warfare Targets, Remote Multi-Mission Vehicle, Remote Minehunting System, Large Displacement Unmanned Underwater Vehicle	< 60 ft	1–15 knots
Torpedoes	Light-weight and Heavy-weight Torpedoes	< 33 ft	20-30 knots

6.4.3 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 (4) expended materials other than munitions, such as sonobuoys or torpedo accessories.

6.4.4 Seafloor Devices

Seafloor devices represent items used during training or testing activities that are deployed onto the seafloor and typically recovered. These items include moored mine shapes, anchors that may or may not be recovered, bottom-placed instruments, temporary bottom cable arrays, energy harvesting devices, and robotic vehicles referred to as "crawlers." Seafloor devices are either stationary or move very slowly along the bottom.

6.5 Entanglement Stressors

The Navy proposes to utilize a variety of materials that could pose an entanglement risk to ESA-listed species including wires and cables, decelerators and parachutes, and biodegradable polymer.

6.5.1 Wires and Cables

Fiber optic cables are expended during Navy training and testing associated with remotely operated mine neutralization activities. Although a portion may be recovered, some fiber optic cables used during Navy training and testing associated with remotely operated mine neutralization activities would be expended. The length of the expended tactical fiber would vary (up to about 3,000 m) depending on the activity. Tactical fiber has an 8-micrometer (µm) (0.008 mm) silica core and acylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 242-µm (0.24 mm) diameter, 12-lb tensile strength, and 3.4-mm bend radius (Navy 2017b). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. Deployed tactical fiber will break if looped beyond its bend radius (3.4 mm), or exceeds its tensile strength (12 lb). If the fiber becomes looped around an underwater object or marine animal, it will not tighten unless it is under tension. Such an event would be unlikely based on its method of deployment and its resistance to looping after it is expended. The tactical fibers are often designed with controlled buoyancy to minimize the fiber's effect on vehicle movement. The tactical fiber would be suspended within the water column during the activity, and then be expended and sink to the seafloor (effective sink rate of 1.45 centimeters (cm) per second (Navy 2017b)) where it would be susceptible to abrasion and burial by sedimentation.

In addition to expended fiber optic cables, the Navy proposes to temporarily deploy slightly negatively buoyant fiber optic cables at depths of approximately 600 to 850 ft up to approximately 60 miles in length. These cables are designed to resist coiling when unspooled, and breaking strength would be approximately 50 to 90 lb. These fiber optic cables would be recovered following their use.

Guidance wires are used during heavy-weight torpedo firings to help the firing platform control and steer the torpedo. They trail behind the torpedo as it moves through the water. The guidance wire is then released from both the firing platform and the torpedo, and sinks to the ocean floor. The torpedo guidance wire is a single-strand, thin gauge, coated copper alloy. The tensile breaking strength of the wire is a maximum of 40.4 lb (Swope and McDonald 2013), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that use ropes with substantially higher (up to 500 to 2,000 lb) breaking strength as their "weak links." However, the guidance wire has a somewhat higher breaking strength than the monofilament used in the body of most commercial gillnets (typically 31 lb or less). The resistance to looping and coiling suggest that torpedo guidance wire does not have a high entanglement potential compared to other entanglement hazards (Swope and McDonald 2013). Torpedo guidance wire sinks at a rate of 0.24 m per second (Swope and McDonald 2013).

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin-gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by hollow rubber tubing or a bungee in a spiral configuration.

The tensile breaking strength of the wire and rubber tubing is no more than 40 lb The length of the wire is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. The nylon fabric is very thin and can be broken by hand. The wire runs through the stabilizing system and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on the type of sonobuoy, but pose no entanglement risk. Each sonobuoy has a saltwater-activated polyurethane float that inflates when the sonobuoy is submerged and keeps the sonobuoy components floating vertically in the water column below it. Sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor.

Bathythermographs are similar to sonobuoys in that they consist of an antenna, a float unit, and a subsurface unit (to measure temperature of the water column in the case of the bathythermograph) that is connected to the float unit by a wire. The bathythermograph wire is similar to the sonobuoy wire described above.

6.5.2 Decelerators and Parachutes

Decelerators/parachutes used during training and testing activities are classified into four different categories based on size: small, medium, large, and extra-large (Table 53). Aircraft-launched sonobuoys and lightweight torpedoes use nylon decelerators/parachutes ranging in size from 18 to 48 inches in diameter (small). The majority of the decelerators/parachutes in the small size category are smaller (18 inches) cruciform shape decelerators/parachutes associated with sonobuoys. Illumination flares use medium-sized decelerators/parachutes, up to approximately 19 ft in diameter. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon, many with weights on their short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Group 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Table 53. Size categories for decelerators/parachutes expended during training and testing activities (Navy 2018d).

Size Category	Diameter (feet)	Associated Activity
Small	1.5 to 6	Air-launched sonobuoys, lightweight torpedoes, and drones (drag parachute)
Medium	19	Illumination flares
Large	30 to 50	Drones (main parachute)
Extra-large	82	Drones (main parachute)

Aerial targets (drones) 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]; and extra-large: 82 ft in length [with up to 64 lines per decelerator/parachute]). Some aerial targets also use a small drag parachute (6 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 some time prior to eventual settlement on the seafloor.

6.5.3 Biodegradable Polymer

Marine vessel stopping payloads are systems designed to deliver the appropriate measure(s) to affect a vessel's propulsion and associated control surfaces to significantly slow and potentially stop the advance of the vessel. Marine vessel stopping proposed activities include the use of biodegradable polymers designed to slow down or occlude the propellers of in-water vessels. A biodegradable polymer is a polymer that degrades to smaller compounds as a result of microorganisms and enzymes present in the environment.

The biodegradable polymers that the Navy uses are designed to temporarily interact with the propeller(s) of a target craft rendering it ineffective. Some of the polymer constituents would dissolve within two hours of immersion. Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will breakdown into small pieces within a few days to weeks. This will breakdown further and dissolve into the water column within weeks to a few months. Degradation and dispersal timelines are influenced by water temperature, currents, and other oceanographic features. Overall, the longer the polymer remains in the water, the weaker it becomes making it more brittle and likely to break. At the end of dispersion, the remaining materials are generally separated fibers with lengths on the order of 54 μm.

6.6 Ingestion Stressors

The Navy expends the following types of materials that could become ingestion stressors during training and testing: 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. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine organisms to consume and are eliminated from further discussion regarding ingestion.

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 vegetation 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]).

6.6.1 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. This is discussed in more detail within each section for ESA-listed species. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 in in diameter. Flechettes from some non-explosive rockets are approximately 2 in 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.

6.6.2 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 net explosive weight and munition type. These solid metal materials would quickly sink through the water column and settle to the seafloor.

6.6.3 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 some time.

6.6.4 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 miles from the point of release, with the plume covering more than 400 miles (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.

6.6.5 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 in in diameter and 5.8 in 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 g depending on flare type). The flare pads and pistons float in sea water.

6.7 Potential Effects on Endangered Species Act (ESA) Protected Resources

The stressors described above have the potential to affect ESA-protected resources in the action area in a variety of ways. For example, exposure to acoustic stressors (including explosives) may lead to lethal and non-lethal injury, hearing impairment, behavioral disturbance, physiological stress, and masking. Vessels may collide with ESA-listed marine mammals, sea turtles, or fish resulting in injuries or death. Military expended materials have the potential to result in entanglement of some ESA-listed animals. Additional detail on these potential effects are discussed in later sections of this opinion.

7 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 54). Section 7.1 then identifies those species 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, or fully beneficial. In Section 7.2, we provide a summary of the biology and ecology of those species that may 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.

Table 54. ESA-Listed Species and DPSs and Designated Critical Habitat That May Be Affected by the Proposed Action.

Species or Critical Habitat	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E – 81 FR 62259	-- --	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	-- --	11/1991
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584
False Killer Whale (*Pseudorca crassidens*) – Main Hawaiian Islands Insular DPS	E – 77 FR 70915	83 FR 35062	-- --
Marine Mammals – Pinnipeds			
Guadalupe Fur Seal (*Arctocephalus townsendi*)	T – 50 FR 51252	-- --	-- --
Hawaiian Monk Seal (*Neomonachus schauinslandi*)	E – 41 FR 51611	80 FR 50925	72 FR 46966 2007
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – Central North Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359
Green Turtle (*Chelonia mydas*) – Central West Pacific DPS	E – 81 FR 20057	-- --	63 FR 28359
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	-- --	63 FR 28359 and 05/1998 – U.S. Pacific
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	-- --	05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) All Other Areas	T – 43 FR 32800	-- --	-- --
Olive Ridley Turtle (*Lepidochelys olivacea*) Mexico's Pacific Coast Breeding Colonies	E – 43 FR 32800	-- --	63 FR 28359
Fishes			
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	-- --
Scalloped Hammerhead Shark (*Sphyrna lewini*) – Eastern Pacific DPS	E – 79 FR 38213	-- --	-- --
Steelhead Trout (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	-- --	77 FR 1669
Marine Invertebrates			
Black Abalone (*Haliotis cracherodii*)	E – 74 FR 1937	76 FR 66805	-- --
White Abalone (*Haliotis sorenseni*)	E – 66 FR 29046	-- --	73 FR 62257

7.1 Species Not Likely to be Adversely Affected

NMFS uses two criteria to identify the ESA-listed species or 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 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 is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action.

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. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs, and consultation is required because the species may be affected.

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. That means the ESA-listed species may be expected to be affected, but the intensity of the impacts would not reach a scale where take would occur (e.g. harm, harassment).

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible 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.

We applied these criteria to the ESA-listed species and designated critical habitat in Table 54. We summarize our results below for ESA-listed species that are not likely to be adversely affected by any stressor created by the proposed action.

7.1.1 Black Abalone

The black abalone (*Haliotis cracherodii*) is a large (up to eight inches), long-lived (up to 30 years) marine gastropod found in rocky intertidal and subtidal habitats. Both their "mantle" and "foot" are black. They have five to nine open respiratory pores along the left sides of their shell and spiral growth lines on the rear. Black abalone are herbivores. Adults eat different types of algae, including kelp which they can catch drifting along the seabed or attached to rocks. Abalone are slow-moving bottom dwellers. They attach to rocks and other hard surfaces using their muscular foot and when disturbed, they become difficult or impossible to remove. During low tides, they can typically be found wedged into crevices, cracks, and holes of intertidal and shallow subtidal rocks, where they are fairly concealed (Leighton 2005). They generally occur in areas of moderate to high surf and range vertically from the high intertidal zone to a depth of about 20 ft (6 m) and are typically found in middle intertidal zones. However, variation in wave exposure and where drift kelp (an important food item for black abalone) accumulates may result in animals being distributed primarily in high or low intertidal zones depending on the local conditions at particular locations. Black abalone can withstand extreme variation in temperature, salinity, moisture, and wave action. The species was listed as endangered on February 14, 2009 (74 FR 1937).

Black abalone historically occurred from Crescent City, California to southern Baja California, Mexico (Butler et al. 2009a), but today the species' constricted range occurs from Point Arena, California to Bahia Tortugas, Mexico, and it is rare north of San Francisco, California (Butler et al. 2009a), and south of Punta Eugenia, Mexico (76 FR 66805).

An important source of black abalone mortality is the disease known as withering syndrome caused by the bacterium *Candidatus Xenohaliotis californiensis*. Disease transmission and manifestation is intensified when local sea surface temperatures increase by as little as 2.5 °C above ambient sea surface temperatures and remain elevated over a prolonged period of time (i.e., a few months or more) (Ben-Horin et al. 2013; Friedman et al. 1997; Raimondi et al. 2002; Vilchis et al. 2005). Although there is no explicitly documented causal link between the persistence of withering syndrome and long-term climate change, patterns observed over the past three decades suggest that progression of ocean warming associated with large-scale climate change may facilitate further and more prolonged vulnerability of black abalone to the effects of withering syndrome.

Factors such as poaching, reduced genetic diversity, ocean acidification, non-anthropogenic predation (e.g., by octopuses, lobsters, sea stars, fishes, sea otters, and shorebirds) and competition (e.g., with sea urchins), food limitation, environmental pollutants and toxins, and substrate destruction may all represent threats to black abalone survival. However, predicting the relative impacts of each of these factors on the long-term viability of black abalone is difficult without further study. In addition to the aforementioned present-day threats, commercial and recreational fisheries operating in California until 1993 likely contributed to the species' decline. For more information on historic and present-day factors leading to the decline of black abalone populations see Butler et al. (2009b).

Massive declines in black abalone began in 1986 that resulted in significant large-scale population reductions by the early 1990s (Lafferty and Kuris 1993). Evidence of population declines has also been observed in central California (Raimondi et al. 2002). The Black Abalone Status Review Team estimated that, unless effective measures are put in place to counter the population decline caused by withering syndrome and overfishing, the species would become extinct within 30 years (Butler et al. 2009b).

The black abalone population at one known location at San Nicolas Island may remain above a critical density threshold and is experiencing ongoing successful recruitment (VanBlaricom et al. 2015). The San Nicolas Island location is known to be characterized by small local sea surface temperature anomalies, with typical temperatures slightly lower (less than 1° C on average) than at other monitored sites at the Island (Butler et al. 2009b; VanBlaricom et al. 2015). The San Nicolas Island black abalone population sustained significant declines between the late 1980s and early 1990s, though to a lesser degree than other geographical locations. The current status of San Nicolas Island black abalone shows continuous increases in population since 2007 (VanBlaricom et al. 2015). The total number of black abalone counted across nine sites in 2014 was 1,712, an increase of 10.3 percent over 2013. The 2014 count is approximately 7.4 percent of the mean count for the seven surveys conducted from 1981 through 1991, prior to the first observation of withering syndrome impacts at San Nicolas Island in spring 1992 (VanBlaricom et al. 2015).

An intensive survey aimed at recording black abalone distribution at San Clemente Island was conducted in January 2008 (Tierra Data 2008). The survey was performed at 61 locations between Northwest Harbor and Pyramid Head along the west shore, within primary abalone habitat. Ten abalone were recorded, with most occurring at locations previously documented to support abundant populations (e.g.,West Cove, Eel Point, Mail Point; See Figure 27). Black abalone recorded all ranged from four to five inches (100 to 130 mm) long. There were no signs of recruitment (fresh shells). Based on the area surveyed, approximate black abalone density at San Clemente Island is one abalone per 2.3 acres (0.9 ha). In 2011 and 2012, researchers from the University of California Santa Cruz surveyed between 13.6 percent and 20.7 percent of the rocky coastline on San Clemente Island, with sites located on all sides of the island (Tierra Data 2013). A total of 47 black abalone were found. From this study, Raimondi (2012) estimated the black abalone population size in the nearshore waters of San Clemente Island was 187, with a 90% confidence interval between 91 and 344 individuals. The average size in 2011-2012 was about 4.7 inches (119.5 mm), which is similar to the average size of black abalone measured in the 2008 surveys. There were no individuals smaller than 3.1 inches (80 mm) found, and individuals were significantly larger in moderate habitat than in good habitat (Tierra Data 2013). Black abalone inhabited good habitat disproportionately more than moderate habitat, and no abalone were found in poor habitat. The quality of habitat is measured by the amount of fouling organisms located on potential black abalone habitat, such as algae, sponges, tunicates, and barnacles. Extensive colonization by these organisms may dramatically decreases the utility of the rock surfaces for recruitment of black abalone (Tierra Data 2013). Rocky intertidal areas surveyed around San Clemente Island contained more poor abalone habitat than good and moderate habitat combined (Tierra Data 2013).

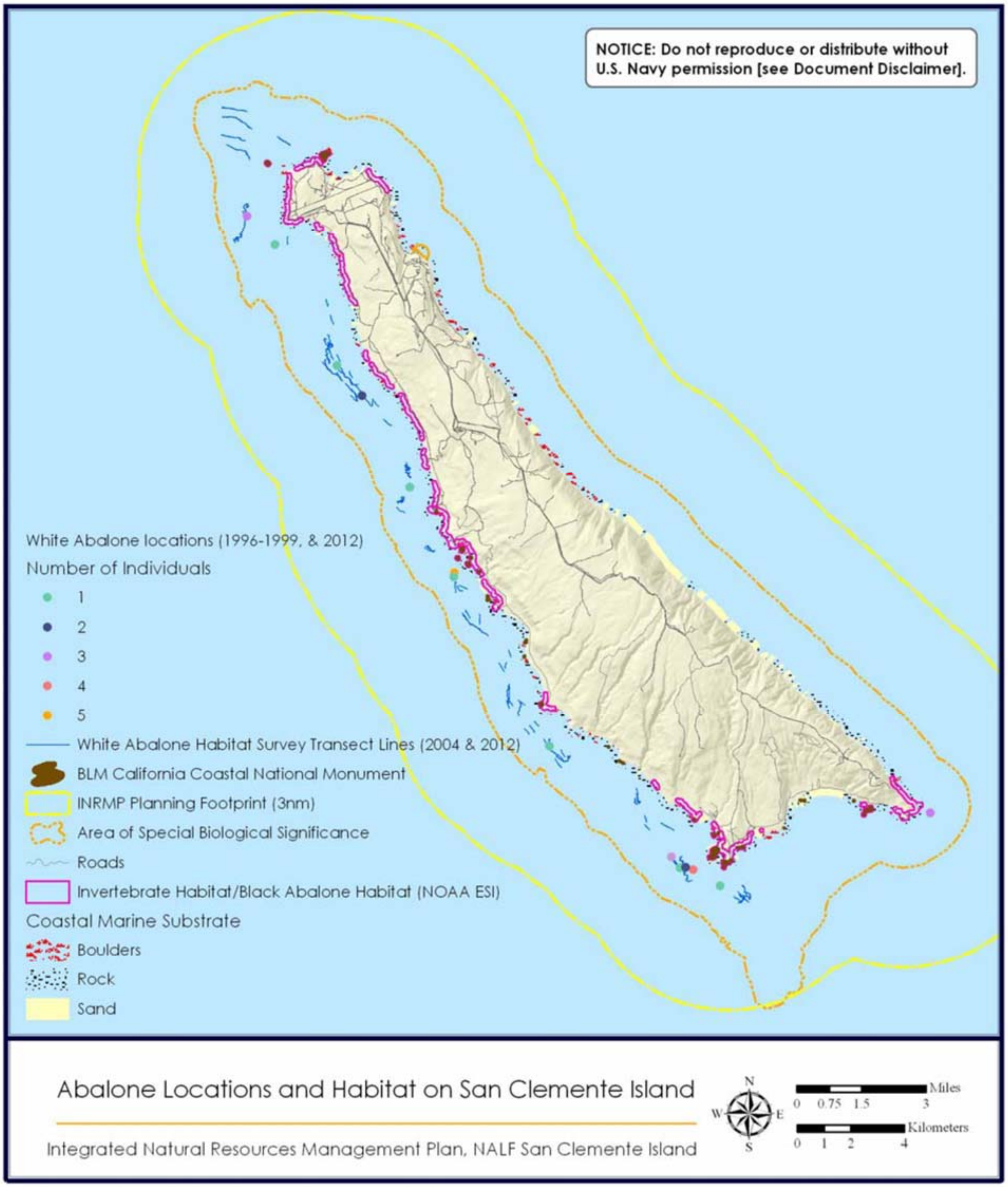


Figure 27. White and black abalone habitat in the nearshore waters of San Clemente Island (Tierra Data 2013).

7.1.1.1 Explosive Stressors

Under the proposed action, black abalone could be exposed to surface and underwater explosions and associated underwater impulsive sounds. The majority of explosions would occur in the air or at the surface, with relatively few at the bottom, which would decrease the potential for impacts to benthic species such as abalone (Navy 2018d). While explosives would be used throughout the action area, black abalone are generally not found in areas where the Navy trains or tests with explosives (Navy 2018d). Black abalone are found wedged into crevices, cracks, and holes of intertidal and shallow subtidal rocks and generally occur in areas of moderate to high surf and range vertically from the high intertidal zone to a depth of about 20 ft (6 m) and are typically found in middle intertidal zones (Butler et al. 2009a).

Based on information from HSTT activities conducted in 2017 provided by the Navy (Navy 2018a), we anticipate the large majority of annual underwater detonations would occur at designated areas within the Silver Strand Training Complex, where black abalone are not known to occur. While explosives could be used throughout the SOCAL Range Complex, in practice large explosive activities are conducted mainly at designated deep water offshore subareas where black abalone do not occur. Therefore, there would be no exposures to black abalone along the California mainland, San Clemente Island, and San Nicolas intertidal zones from large explosives. A relatively small number of underwater detonations associated with Mine Warfare training are expected to occur in the Northwest Harbor of San Clemente Island (Navy 2018a). The shallow water areas of Northwest Harbor are primarily sandy bottom habitat that is not suitable for black abalone. The Navy has commited to avoiding conducting underwater detonations in shallow, rocky bottom habitats around San Clemente Island where suitable black abalone habitat could occur.

Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for black abalone to be exposed to explosions as part of the proposed action. Therefore, potential effects on black abalone from explosive stressors are considered discountable.

7.1.1.2 Acoustic Stressors

Abalone are likely only sensitive to water particle motion caused by nearby low-frequency sources, and likely do not sense distant or mid- and high-frequency sounds (Navy 2018d). Abalone hearing is expected to be similar to other marine invertebrates, which are generally thought to perceive sound via either external sensory hairs or internal statocysts. Many aquatic invertebrates have ciliated “hair” cells that may be sensitive to water movements, such as those caused by currents or water particle motion very close to a sound source (Budelmann 1992a; Budelmann 1992b; Mackie and Singla 2003). This may allow sensing of nearby prey or predators, or help with local navigation. Detection of particle motion is thought to occur in mechanical receptors found on various body parts (Roberts et al. 2016). Aquatic invertebrates that are able to sense local water movements with ciliated cells include molluscs such as abalone (Budelmann 1992a; Budelmann 1992b; Popper et al. 2001).

The effects of acoustic stressors associated with HSTT activities on ESA-listed abalone species are not known. Compared to some other taxa of marine animals (e.g., fishes, marine mammals), little information is available on the potential impacts on abalone from exposure to sonar and other sound-producing activities (Hawkins et al. 2015). Historically, many studies focused on squid or crustaceans and the consequences of exposures to broadband impulsive air guns typically used for oil and gas exploration. More recent investigations have included additional taxa (e.g., molluscs) and sources, although extensive information is not available for all potential stressors and impact categories. Furthermore, the shallow water, inter-tidal zones at San Clemente Island that serve as black abalone habitat are not areas the Navy would train or test with acoustic sources, although some limited testing with high frequency sources could occur in open waters adjacent to San Clemente Island. In summary, based on the best available information there is no indication that black abalone may be affected by acoustic stressors resulting from HSTT activities.

7.1.1.3 Physical Disturbance and Strike Impact Stressors

Species that do not occur near the surface within the action area, including ESA-listed black abalone and white abalone, would not be exposed to vessel strikes. In addition, these species would not be affected by amphibious landings (amphibious assault, insertion, and extraction) since abalone inhabit rocky shores and hard bottom, which are not used for amphibious landings (Navy 2018d). The U.S. Navy has committed to restrict activities such as amphibious assaults, insertion and extraction, and Naval Fire Support to areas that would not support black abalone (Navy 2013c), so this species is not likely to be exposed to stressors associated with these activities.

Physical disturbance or strikes by military expended materials on abalone is possible at the seafloor. However, disturbance or strike impacts by military expended materials falling through the water column are not very likely because such materials do not generally sink rapidly enough to cause strike injury (Navy 2018d). In addition, physical disturbance or strikes by military expended materials would likely not be applicable to black abalone since the Navy does not conduct training and testing activities that use military expended material in the shallow water, rocky inter-tidal areas that serve as black abalone habitat. In-water devices do not contact the bottom and would therefore not impact black abalone or white abalone. Potential impacts from sea floor devises on black abalone and black abalone habitat would be discountable. Navy practice is to place these kind of devices on soft bottom areas. Furthermore, most black abalone roecky habitat at San Clemente and along the California is too shallow to meeting training and testing requirements that would use seafloor devices. Some shallow water seafloor devices are used by the Navy along the coast at Silver Strand, but only at designated sandy, soft bottom areas not associated with black abalone habitat (Navy 2018d). Inert (non-explosive) mine laying would not affect black abalone since the Navy has committed to conducting this activity at depths greater than 60 m and in sandy areas (away from kelp and rocky bottom) where black abalone are not found.

The Navy anticipates 75 precision anchorages per year near San Diego (Navy 2018b). Precision anchoring could affect black abalone and abalone habitat if conducted in shallow, rocky habitats where this pecies occurs. However, under the proposed action, precision anchoring would only be conducted at U.S. Coast Guard designated anchorages at the mouth of San Diego where black abalone do not occur. The Navy has committed to conducting precision anchoring at depths from 18-60 ft and over sandy or loose fragmented shell bottom where black abalone are not found (Navy 2018b). Precision anchoring would not be conducted around San Clemente Island or other parts of the HSTT action area where black abalone are known to occur (Navy 2018b). Pile driving activities also have the potential to impact some marine invertebrates, but would not be conducted in areas that support ESA-listed abalone species (Navy 2018d).

Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for black abalone to be exposed to physical disturbance and strike impact as part of the proposed action. Therefore, potential effects on black abalone from physical disturbance and strike impact are considered discountable.

7.1.1.4 Entanglement Stressors

Benthic invertebrates such as abalone could be susceptible to entanglement in decelerators/parachutes, with the principal mechanisms of impact being burial, smothering, or abrasion. However, because they are in the air and water column for a time span of minutes, it is unlikely that a decelerator/parachute deployed in areas greater than three NM from the shore and in water depths greater than 200 m could travel far enough to affect black abalone located in shallower nearshore areas (Navy 2018d). In addition, the materials found in decelerators/parachutes generally do not have the characteristics required to entangle marine species. Decelerators/parachutes have large openings between the cords separating the decelerator/parachute fabric from the release mechanism thus reducing the risk of entanglement (Navy 2018d). Although some invertebrates can become entangled in mesh nets, we would not expect abalone to be particularly susceptible to such entanglement. Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for black abalone to be exposed to entanglement in decelerators/parachutes as part of the proposed action. Therefore, potential effects on black abalone from entanglement in decelerators/parachutes are considered discountable.

7.1.1.5 Indirect Effects

In addition to the potential direct effects discussed above, HSTT activities may affect ESA-listed abalone indirectly through impacts on their habitat (sediment or water quality) or prey. Stressors from Navy training and testing activities that could pose indirect impacts to marine invertebrates via habitat or prey include: (1) explosives, (2) explosives byproducts and unexploded munitions, (3) metals, and (4) chemicals.

Most explosions on the bottom would occur in soft bottom habitat and would displace some amount of sediment (Navy 2018d). Any effects from soft bottom sediment displacement or redistribution would likely by short-term and minor. Activities that inadvertently result in explosions on or near hard bottom habitat could break hard structures and reduce the amount of habitat available for abalone recruitment. Since Navy explosive use would not occur on known hard bottom areas, impacts on abalone habitat resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would be minor overall (Navy 2018d). Explosions would temporarily disturb soft bottom sediments and could potentially damage some hard structures, but such effects would likely be localized and undetectable at the ecosystem level. Similarly, impacts on invertebrate food availability (including vegetation and phytoplankton) resulting from explosives, explosives byproducts, unexploded munitions, metals, and chemicals would likely be localized and temporary. Since the effects to algae would predominantly occur in habitats not typically utilized by black abalone (i.e., deeper waters and soft bottom areas), we do not anticipate such effects on abalone food would translate into adverse effects on these species.

Therefore, any indirect effects to habitat or prey supporting black abalone are expected to be minor and result in only insignificant effects on abalone fitness or survival.

7.1.1.6 Black Abalone Effects Determination

As discussed above, any effects to black abalone from the proposed action are expected to be either discountable or insignificant. Overall, we find that black abalone may be affected by the proposed Navy training exercises and testing activities in the HSTT action area, but black abalone are not likely to be adversely affected by those activities. In the absence of adverse effects, take will not occur and there will thus be no potential for adverse consequences at a population level and for the survivial and recovery of the species. Therefore, black abalone will not be considered further in this opinion.

7.1.2 White Abalone

White abalone are herbivorous gastropods that live in rocky ocean waters. They are generally 5-8 inches (13-20 cm) long, but can grow to as big as 10 inches (25 cm), and weigh about 1.7 lbs (0.8 kg) on average. White abalone are the deepest occurring abalone species on the U.S. West Coast. They are found in greatest abundance at depths of 80-100 ft (25-30 m), but have been reported at depths up to 200 ft (Cox 1960; Tutschulte 1976). White abalone occupy open low relief rock or boulder habitat surrounded by sand (Davis et al. 1996; Tutschulte 1976). Sand channels may be important for the movement and concentration of drift macroalgae and red algae, upon which white abalone are known to feed.

Historically, white abalone were found in the Pacific Ocean from Point Conception, California, to Punta Abreojos, Mexico (Hobday and Tegner 2000). In the northern part of the California range, white abalone were reported as being more common along the mainland coast. However, in the middle portion of the California range, they were noted to occur more frequently at the offshore islands, especially San Clemente and Santa Catalina Islands (Hobday and Tegner 2000). White abalone populations throughout southern California are severely depleted. Densities of white abalone were estimated to be as high as 2,300 ha-1 (Tutschulte 1976) and the total population was estimated to be between 700,000 and 4.2 million individuals across their entire range (Hobday et al. 2000). A more conservative density estimate, based solely on fishery-dependent information in California, is 479 ha-1, which translates to a population size of 360,476 individuals for California alone (Rogers-Bennett et al. 2002). Over the past several decades, the white abalone populations have declined precipitously in abundance primarily as a result of exploitation.

At Tanner Bank, the white abalone population has declined by nearly 73 percent between 2002 and 2010 (Stierhoff et al. 2012). In 2014, Stierhoff et al. (2015) optically surveyed white abalone by conducting 28 transects at Tanner Bank and 16 transects at Cortes Bank during five days at sea. At Tanner Bank, 19 white abalone were observed, all in 40-50 m depths; no white abalone were observed at Cortes Bank. Based on this survey, Stierhoff et al. (2015) estimated the white abalone population at Tanner Bank was 3,745 animals, which was not significantly greater than the 2010 estimate of 3,375 animals. Within the 40-50m depth range, the estimated density was 8.8 white abalone per hectare. The authors concluded that these results indicate that the white abalone population at Tanner Bank has not recovered from severe depletion (Stierhoff et al. 2015). The high coefficient of variation (87 to 303 percent) from white abalone estimates (i.e., population and density) reflects the low numbers and patchiness of white abalone at Tanner Bank and Cortes Bank. For example, of the 44 transects surveyed in 2014, zero white abalone were observed on 35 transects; one was observed on six transects; and more than one (two, five, and six individuals) were observed on three transects.

At one time, San Clemente Island served as an important commercial and recreational source of white, green, pink, and black abalone and the island has been highlighted as an important area for current monitoring and future abalone restoration efforts. In October 1999, surveys were conducted in potential white abalone habitat areas on San Clemente Island (Figure 27). This survey was limited to the northern, western, and southern sides of the island. Most of the individuals observed were found offshore of the center of the island on the west side of San Clemente Island (Tierra Data 2013). Individuals and groups of two or more individuals were most abundant offshore from Seal Cove and Seal Point. A total of 24 white abalone were found, ranging from one to six individuals per site, at ten of the 26 sites surveyed. Abalone were found in 100 to 200 ft (30–60 m) of water, with most at approximately 157 ft (48 m) (Tierra Data 2013).

In 2004, underwater surveys using a remotely operated vehicle identified several remnant populations of white abalone, including one along the west and south shores of San Clemente Island. The surveys were conducted over a ten-day period off the west shore of San Clemente Island from Castle Rock south to China Point and consisted of multibeam and sidescan sonar from the seaward edge of the kelp beds at 82 ft (25 m) out to approximately 245 ft (75 m) (Butler et al. 2006). Extensive remotely operated vehicle surveys were conducted where suitable habitat was found to measure abalone densities. Butler et al. (2006) found all abalone at 100 to 130 ft (30–40 m) and 130 to 165 ft (40–50 m) depth ranges with none sighted at 165 to 200 ft (50–60 m). Suitable habitat on San Clemente Island was measured at 2,220 acres (889 ha) (Butler et al. 2006). In 2012, another survey of white abalone habitats was conducted at San Clemente Island to examine potential changes in that population. A total of 48 remotely-operated vehicle transects were conducted along the west and south edges of San Clemente Island using methods from the 2004 surveys. Both surveys (2004 and 2012) found that white abalone are sparse at San Clemente Island; only five white abalone (mean shell length of 17.2 cm [standard deviation = 2.2 cm] and 17.7 cm [standard deviation = 1.8 cm] in 2004 and 2012, respectively) were observed in each of the two surveys (Stierhoff et al. 2014). Average densities were 0-1.24 abalone per hectare (ha-1) in 2004 and 0.27-1.44 abalone ha-1 in 2012, which resulted in a slight increase in the population from 353 (standard error = 62) to 565 (standard error = 136) white abalone during that time (Stierhoff et al. 2014). However, the low density and patchy distribution of white abalone at San Clemente Island resulted in high coefficients of variation for population estimates in all years and depths (coefficient of variation = 0.70-0.96). In 2016, a remotely operated vehicle was used to conduct another visual transect surveys of white abalone from 30 to 60 m depths at San Clemente Island (Neuman et al. 2017). Two white abalone were observed in 36 visual transects. The low numbers of observations resulted in estimates of population size that were too imprecise for statistical comparisons to results from the 2004 or 2012 survey.

These surveys located only adult white abalone, suggesting that recruitment may not be occurring at the surveyed locations within the action area (Stierhoff et al. 2014). White abalone, like other abalone species, are cryptic and often difficult to detect during visual surveys (Stierhoff et al. 2014). They preferentially inhabit rocky substrates and are often covered in the same encrusting algae and kelp that cover their habitat, which provides effective camouflage and makes detection and positive identification challenging. The challenges associated with detection become even greater as shell size decreases, making the ability to monitor any recent recruitment or gauge recovery more difficult (Stierhoff et al. 2014).

There is little information available regarding the white abalone population around San Nicholas Island. Considering the historical abalone landings and requirements for suitable habitat and growth, white abalone are thought to be more rare around San Nicolas Island than San Clemente Island or other parts of the species' range.

7.1.2.1 *Explosive Stressors*

As part of the proposed action, white abalone could be exposed to surface and underwater explosions and associated underwater impulsive sounds from high-explosive munitions (including bombs, missiles, torpedoes, and naval gun shells), mines, and demolition charges. White abalone are the deepest living abalone species on the west coast and occur at depths up to almost 200 ft. This species would potentially be exposed to noise from surface explosions, but the likelihood of surface explosions affecting this white abalone is low. Surface explosions typically occur during the day at offshore locations more than 12 NM from shore and in locations with no white abalone habitat (i.e., too deep; Navy 2018d). Locations of known white abalone habitat or habitat capable of supporting white abalone (Figure 27) based on substrate and depth are not areas where Navy ordnance would be used (Navy 2018d). Based on information from HSTT activities conducted in 2017 provided by the Navy (Navy 2018a), we anticipate the large majority of annual underwater detonations would occur at designated areas within the Silver Strand Training Complex, where white abalone are not known to occur. A relatively small number of underwater detonations associated with Mine Warfare training are expected to occur in the Northwest Harbor of San Clemente Island (Navy 2018a). The shallow water areas of Northwest Harbor are primarily sandy bottom habitat that is not suitable for white abalone. The Navy has commited to avoiding conducting underwater detonations in rocky bottom habitats around San Clemente Island where suitable white abalone habitat could occur.

The only possible exposure to explosive impacts white abalone would likely experience would be sound from distant explosions. Operations involving underwater detonations are not likely to adversely affect white abalone because the number of bottom-placed charges are few, these charges are not likely to adversely affect rocky habitat, and sinking exercises occur in at least 3,000 m of water, where white abalone are not found (Navy 2018d).

Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for white abalone to be exposed to explosions as part of the proposed action. Therefore, potential effects on white abalone from explosive stressors are considered discountable.

7.1.2.2 *Other Stressors*

We anticipate that the effects of other stressors resulting from the proposed action (i.e., acoustic, physical disturbance and strike, and entanglement) on white abalone would be similar to the effects on black abalone described above (See Sections 7.1.1.1 through 7.1.1.4).

7.1.2.3 *Indirect Effects*

We anticipate that any indirect effects of stressors resulting from the proposed action on white abalone would be similar to the indirect effects on black abalone described above (See Section 7.1.1.5. For a discussion of the indirect effects on white abalone, see black abalone effects Section 7.1.1.5 above.

7.1.2.4 White Abalone Effects Determination

Any effects to white abalone from the proposed action are expected to be either discountable or insignificant. Overall, we find that white abalone may be affected by the proposed Navy training exercises and testing activities in the HSTT action area, but are not likely to be adversely affected by those activities. In the absence of adverse effects, take will not occur and there will thus be no potential for adverse consequences at a population level and for the survivial and recovery of the species. Therefore, white abalone will not be considered further in this opinion.

7.2 Species Likely to be Adversely Affected

This section examines the status of each species that are likely to be adversely affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which 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), among others.

7.2.1 Blue Whale

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

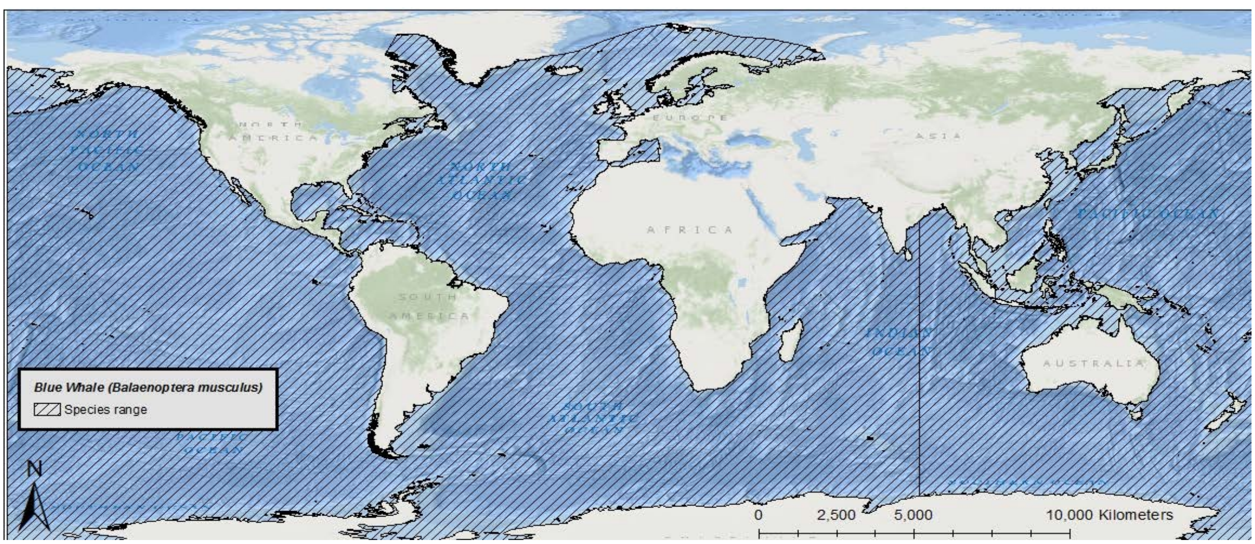


Figure 28. Map identifying the range of the endangered blue whale.

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. 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. The blue whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta et al. 2017b; Hayes et al. 2017; Muto et al. 2017), the status review (COSEWIC 2002), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of 10 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 daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 m.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the blue whale.

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. There are three stocks of blue whales designated in U.S. waters: the Eastern North Pacific Ocean [current best estimate N = 1,647 Nmin = 1,551; (Calambokidis and Barlow 2013)], Central North Pacific Ocean (N = 81 Nmin = 38), and Western North Atlantic Ocean (N = 400 to 600 Nmin = 440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 [95 percent confidence intervals 1,160 to 4,500 (Branch 2007)].

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis et al. 2009). 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).

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 of 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.

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. 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°S and 61°S latitude) and close to the ice edge. The subspecies B. m. brevicauda is typically distributed north of the Antarctic Convergence.

Vocalizations and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson and Richardson 1995a), 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 dB re: 1 μPa at 1 m (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971c; 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 et al. (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 (less than 30 m whales), while deeper diving whales (greater than 50 m) 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. 2006b) 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 1971c; 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. 2006b). 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 10 known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have 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. 1992). 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; Richardson et al. 1995d). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001; 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 Hz to 35 kHz (NOAA 2016).

Status

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 nineteenth to mid-twentieth 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.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 1998 Final Recovery Plan for the Blue whale for complete down listing/delisting criteria for each of the following recovery goals.

- Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere
- Estimate the size and monitor trends in abundance of blue whale populations
- Identify and protect habitat essential to the survival and recovery of blue whale populations
- Reduce or eliminate human-caused injury and mortality of blue whales
- Minimize detrimental effects of directed vessel interactions with blue whales
- Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales

- Coordinate state, federal, and international efforts to implement recovery actions for blue whales
- Establish criteria for deciding whether to delist or downlist blue whales

7.2.2 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 29).

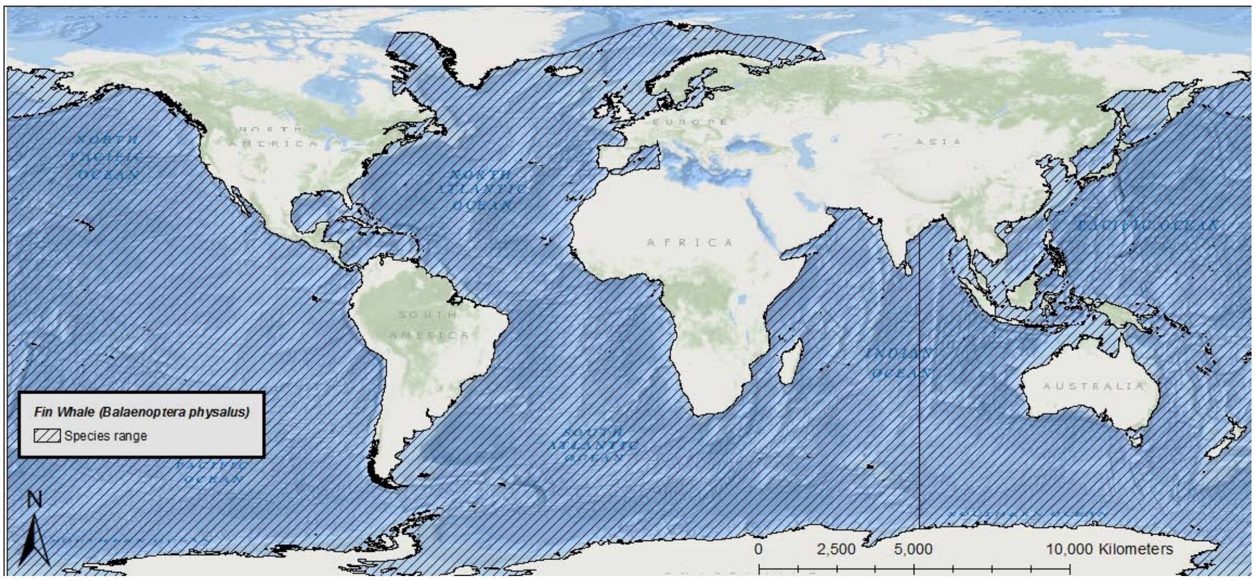


Figure 29. Map identifying the range of the endangered fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta et al. 2017b; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 2011a), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

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. Sexual maturity is reached between six and 10 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. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lance.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals (Nmin=1,234); however, this may be an underrepresentation as the entire range of the stock was not surveyed (Palka 2012). There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific (minimum 1,368 individuals), Hawaii (approximately 58 individuals, Nmin=27) and California/Oregon/Washington (approximately 9,029 individuals, Nmin=8,127) (Nadeem et al. 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently 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 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. Generally speaking, haplotype diversity was found to be high both within ocean basins, and across. 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.

There are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere where they appear to be reproductively isolated. The availability of prey, sand lance in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981b; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 μPa at 1 m (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson et al. 1995d; Sirovic et al. 2007; Watkins 1981b; 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 (Clark and Charif 1998). Richardson et al. (1995d) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981b; Watkins et al. 1987); a notion further supported by 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 (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981b), 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 Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hz calls has been reported as 189 ± 5.8 dB re: 1 μPa at 1 m (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981b). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 μPa at 1 m (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987). 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. 1992; 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 humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). Also, it has been suggested that some fin whale 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).

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. 1995d). 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 mid- to high-frequencies (Ketten 1997). 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 (NOAA 2016).

Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals.

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

7.2.3 Gray Whale – Western North Pacific Distinct Population Segment (DPS)

The gray whale is a baleen whale and the only species in the family Eschrichtiidae. There are two isolated geographic distributions of gray whales in the North Pacific Ocean: the Eastern North Pacific stock, found along the west coast of North America, and the Western North Pacific or "Korean" stock, found along the coast of eastern Asia (Figure 30).

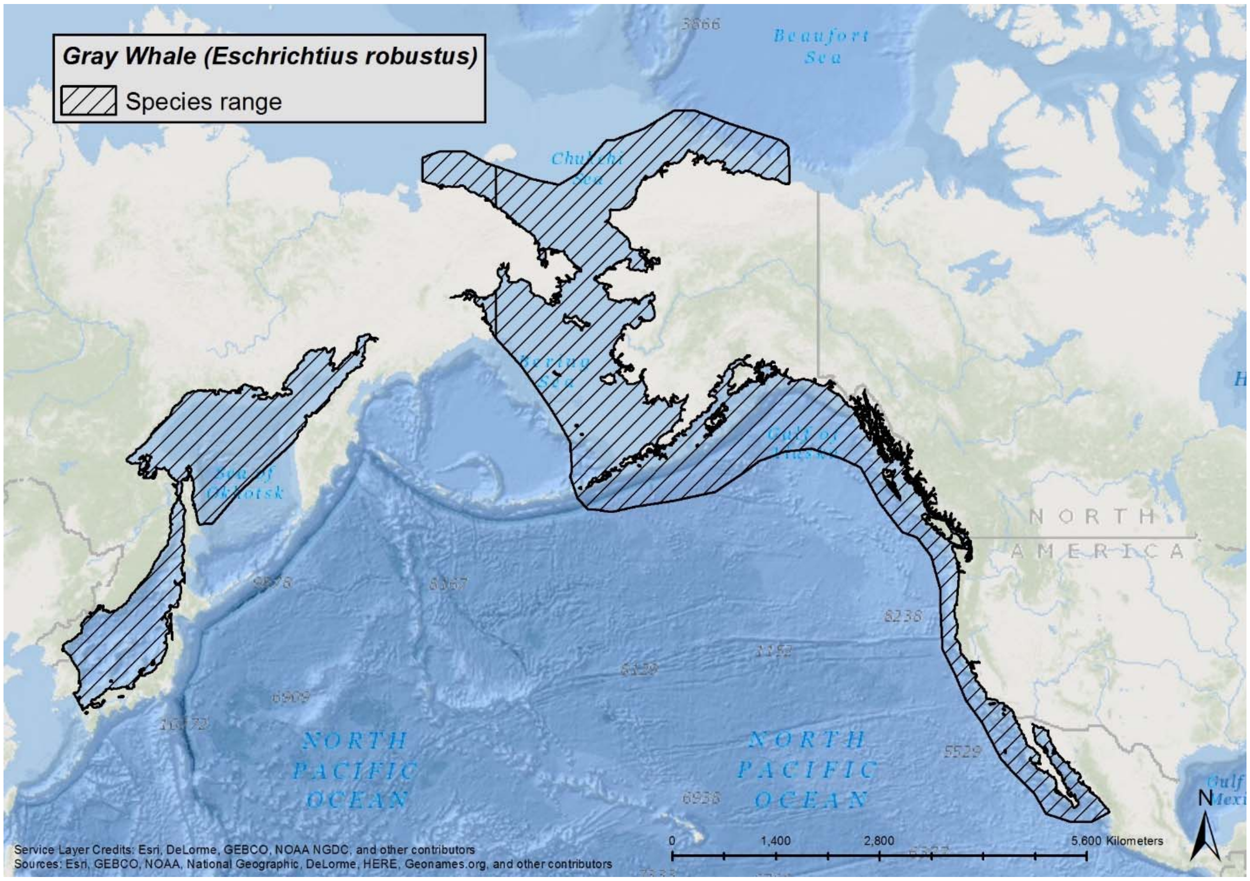


Figure 30. Map identifying the range of gray whales.

Gray whales are distinguishable from other whales by a mottled gray body, small eyes located near the corners of their mouth, no dorsal fin, broad, paddle-shaped pectoral fins and a dorsal hump with a series of eight to fourteen small bumps known as "knuckles". The gray whale was originally listed as endangered on December 2, 1970 (35 FR 18319). The Eastern North Pacific stock was officially delisted on June 16, 1994 (58 FR 3121) when it reached pre-exploitation numbers. The Western North Pacific population of gray whales remained listed as endangered. Information available from the recent stock assessment reports (Carretta et al. 2016c; Muto et al. 2016; Waring et al. 2016b) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

The average life span of gray whales is unknown but it is thought to be as long as eighty years. They have a gestation period of twelve to thirteen months, and calves nurse for seven to eight months. Sexual maturity is reached between six and twelve years of age with an average calving interval of two to four years (Weller et al. 2009). Gray whales mostly inhabit shallow coastal waters in the North Pacific Ocean. Some Western North Pacific gray whales winter on the west coast of North America while others migrate south to winter in waters off Japan and China, and summer in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern

Kamchatka in the Bering Sea (Burdin et al. 2013). Gray whales travel alone or in small, unstable groups and are known as bottom feeders that eat "benthic" amphipods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the gray whale.

Photo-identification data collected between 1994 and 2011 on the Western North Pacific gray whale summer feeding ground off Sakhalin Island were used to calculate an abundance estimate of 140 whales for the non-calf population size in 2012 (Cooke et al. 2013). The minimum population estimate for the Western North Pacific stock is 135 individual gray whales on the summer feeding ground off Sakhalin Island.

The current best growth rate estimate for the Western North Pacific gray whale stock is 3.3 percent annually.

There are often observed movements between individuals from the Eastern North Pacific stock and Western North Pacific stock; however, genetic comparisons show significant mitochondrial and nuclear genetic differences between whales sampled from each stock indicating genetically distinct populations (Leduc et al. 2002). A study conducted between 1995 and 1999 using biopsy samples found that Western North Pacific gray whales have retained a relatively high number of mitochondrial DNA haplotypes for such a small population. Although the number of haplotypes currently found in the Western North Pacific stock is higher than might be expected, this pattern may not persist into the future. Populations reduced to small sizes, such as the Western North Pacific stock, can suffer from a loss of genetic diversity, which in turn may compromise their ability to respond to changing environmental conditions (Willi et al. 2006) and negatively influence long-term viability (Frankham 2005; Spielman et al. 2004).

Gray whales in the Western North Pacific population are thought to feed in the summer and fall in the Okhotsk Sea, primarily off Sakhalin Island, Russia and the Kamchatka peninsula in the Bering Sea, and winter in the South China Sea (Figure 30). However, tagging, photo-identification, and genetic studies have shown that some whales identified as members of the Western North Pacific stock have been observed in the Eastern North Pacific, which may indicate that not all gray whales share the same migratory patterns.

Vocalizations and Hearing

No data are available regarding western North Pacific gray whale hearing or communication. We assume that eastern North Pacific gray whale communication is representative of the western population and present information stemming from this population. Individuals produce broadband sounds within the 100 Hz to 12 kHz range (Dahlheim et al. 1984; Jones and Swartz 2002; Thompson et al. 1979). The most common sounds encountered are on feeding and breeding grounds, where "knocks" of roughly 142 dB re: 1 µPa at 1 m (source level) have been recorded (Cummings et al. 1968; Jones and Swartz 2002; Thomson and Richardson 1995b). However, other sounds have also been recorded in Russian foraging areas, including rattles, clicks, chirps, squeaks, snorts, thumps, knocks, bellows, and sharp blasts at frequencies of 400 Hz to 5 kHz (Petrochenko et al. 1991). Estimated source levels for these sounds ranged from 167-188 dB re: 1 μPa at 1 m (Petrochenko et al. 1991). Low frequency (less than 1.5 kHz) “bangs” and “moans” are most often recorded during migration and during ice-entrapment (Carroll et al. 1989; Crane and Lashkari. 1996). Sounds vary by social context and may be associated with startle responses (Rohrkasse-Charles et al. 2011). Calves exhibit the greatest variation in frequency range used, while adults are narrowest; groups with calves were never silent while in calving grounds (Rohrkasse-Charles et al. 2011). Based upon a single captive calf, moans were more frequent when the calf was less than a year old, but after a year, croaks were the predominant call type (Wisdom et al. 1999).

Auditory structure suggests hearing is attuned to low frequencies (Ketten 1992a; Ketten 1992b). Responses of free-ranging and captive individuals to playbacks in the 160 Hz to 2 kHz range demonstrate the ability of individuals to hear within this range (Buck and Tyack 2000; Cummings and Thompson 1971b; Dahlheim and Ljungblad 1990; Moore and Clark 2002; Wisdom et al. 2001). Responses to low-frequency sounds stemming from oil and gas activities also support low-frequency hearing (Malme et al. 1986b; Moore and Clark 2002).

Status

The Western North Pacific gray whale is endangered as a result of past commercial whaling and may still be hunted under “aboriginal subsistence whaling” provisions of the International Whaling Commission. Current threats include ship strikes, fisheries interactions (including entanglement), habitat degradation, harassment from whale watching, illegal whaling or resumed legal whaling, and noise.

Critical Habitat

No critical habitat has been designated for the Western North Pacific gray whale. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

There is currently no Recovery Plan for the Western North Pacific gray whale. In general, listed species which occur entirely outside U.S. jurisdiction are not likely to benefit from recovery plans (55 FR 24296; June 15, 1990).

7.2.4 Humpback Whale – Central America and Mexico DPSs

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 31).

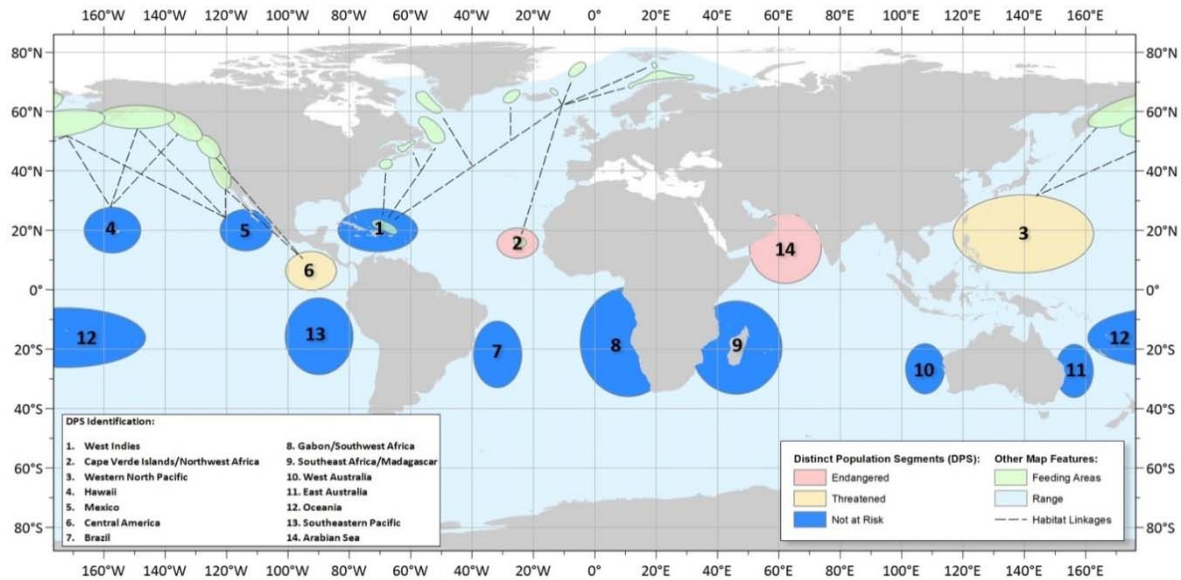


Figure 31. Map identifying 14 DPSs with one threatened and four endangered, based on primary breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015).

Humpbacks are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated fourteen DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico) (81 FR 62259). Information available from the recovery plan (NMFS 1991), recent stock assessment reports (Carretta et al. 2016c; Muto et al. 2016; Waring et al. 2016a), the status review (Bettridge et al. 2015), and the final listing (81 FR 62259) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpbacks can live, on average, fifty years. They have a gestation period of eleven to twelve months, and calves nurse for one year. Sexual maturity is reached between five to eleven years of age with an average calving interval of two to three years. Humpbacks mostly inhabit coastal and continental shelf waters. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpbacks 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. 2015).

Population Dynamics – Central America DPS

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Central America humpback whale DPS. The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Central America DPS is 411 (81 FR 62259). A population growth rate is currently unavailable for the Central America humpback whale DPS.

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. DPSs that have a total population five hundred 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. The Central America has just below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance (81 FR 62259, Bettridge et al. 2015).

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, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds (81 FR 62259).

Population Dynamics – Mexico DPS

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Mexico humpback whale DPS.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Mexico humpback whale DPS is 3,264 (81 FR 62259).

A population growth rate is currently unavailable for the Mexico humpback whale DPS.

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. DPSs that have a total population five hundred 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. The Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes (81 FR 62259, Bettridge et al. 2015).

The Mexico DPS consists of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands and transit through the Baja California Peninsula coast. The 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 (Figure 31) (81 FR 62259).

Vocalizations and Hearing

Humpback whale vocalization is much better understood than is 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 144-174 dB (Au et al. 2006; Au et al. 2000b; Frazer and Mercado III 2000; Richardson et al. 1995g; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 kilometers (km) 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. 1995g; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m) (Au et al. 2000b; Erbe 2002a; Payne 1985; Richardson et al. 1995g; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995g).

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 (Thomson and Richardson 1995b). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds only by adult males (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008). 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. (Au et al. 2000a) noted that humpbacks off Hawaii tended to sing louder at night compared to the day. There is 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. 2006; Winn et al. 1970).

Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986; Simao and Moreira 2005). Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity.

"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 1 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) (D'Vincent et al., 1985; Thompson et al., 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic has been documented with Digital Acoustic Recording Tags (DTAGs[18]) (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple bouts of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (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.

Houser et al. (Houser et al. 2001b) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear: estimated sensitivity was from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Previously mentioned research by Au et al. (2001, 2006) 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 humpbacks can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpbacks to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (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 1μPa-m or frequency sweep of 3.1to 3.6 kHz (although it should be noted that this system is significantly different from the Navy's hull mounted sonar). 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.

In terms of functional hearing capability humpback whales belong to low-frequency cetaceans which have the best hearing ranging from 7 to 22 kHz (Southall et al. 2007e).

Humpback whales are the most abundant ESA-listed species observed during Navy visual surveys and monitoring projects using Pacific Missile Range Facility range hydrophones (Navy 2012). Analysis of visual sightings correlated with acoustic detections from the hydrophones was conducted on twelve humpback whales observed during a Navy training event in the HRC. A

[18] DTAG is a novel archival tag, developed to monitor the behavior of marine mammals, and their response to sound, continuously throughout the dive cycle. The tag contains a large array of solid-state memory and records continuously from a built-in hydrophone and suite of sensors. The sensors sample the orientation of the animal in three dimensions with sufficient speed and resolution to capture individual fluke strokes. Audio and sensor recording is synchronous so the relative timing of sounds and motion can be determined precisely (Johnson & Tyack 2003).

group of five animals were estimated to have received SPLs of 183dB; visual observations showed that while the animals initially continued their initial course towards the destroyer allowing them to receive higher levels on sonar, they ultimately reversed their course, dove and resurfaced behind the destroyer in two groups (Martin and Manzano-Roth 2012). Audiograms of humpback whales are unavailable; however, it is reasonable to assume that humpback whales can hear mid-frequency active sonar. It is unknown whether the animals' course change was as a result of the approaching vessel or sonar transmissions.

Status

Humpback whales were originally listed as endangered as a result of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central American, Arabian Sea, and Mexico) have likely not yet recovered from this. 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 (e.g., Rockwood et al. (2017)), fisheries interactions (including entanglement), energy development, harassment from whale watching, noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Central America DPS still faces a risk of extinction.

Critical Habitat

No critical habitat has been designated for humpback whales.

Recovery Goals

See the 1991 Final Recovery Plan 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.

7.2.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 32).

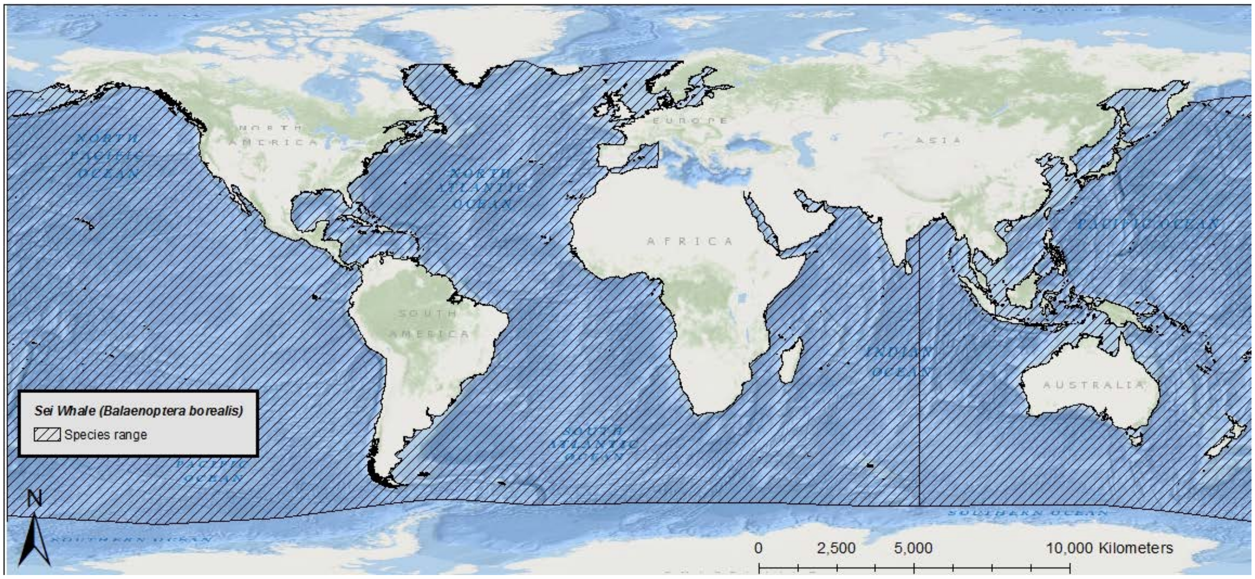


Figure 32. Map identifying the range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Carretta et al. 2017b; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 2012b), and the scientific literature were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of 10 to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill), small schooling fishes, and cephalopods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sei whale.

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=178, N_{min}=93), and Eastern North Pacific (N=519, N_{min}=374). There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Outside of U.S. waters, a shipboard sighting survey of Icelandic and Faroese waters produced an estimate of about 10,300 sei whales (Cattanach et al. 1993). Additionally in the North Atlantic, Macleod et al. (2005) reported an estimated 1,011 sei whales in waters off Scotland. Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

While some genetic data exist for sei whales, current samples sizes are small limiting our confidence in their estimates of genetic diversity (NMFS 2011b). 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. All stocks of sei whales within U.S. waters are estimated to be below 500 individuals indicating they may be at risk of extinction due to inbreeding.

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere.

Vocalizations and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson and Richardson 1995a). Source levels of 189 ±5.8 dB re: 1 μPa at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995d). This suggests sei 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 mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2016).

Status

The sei whale is endangered as a result of past commercial whaling. Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals (NMFS 2011b).

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

7.2.6 Sperm Whales

The sperm whale is widely distributed and found in all major oceans (Figure 33).

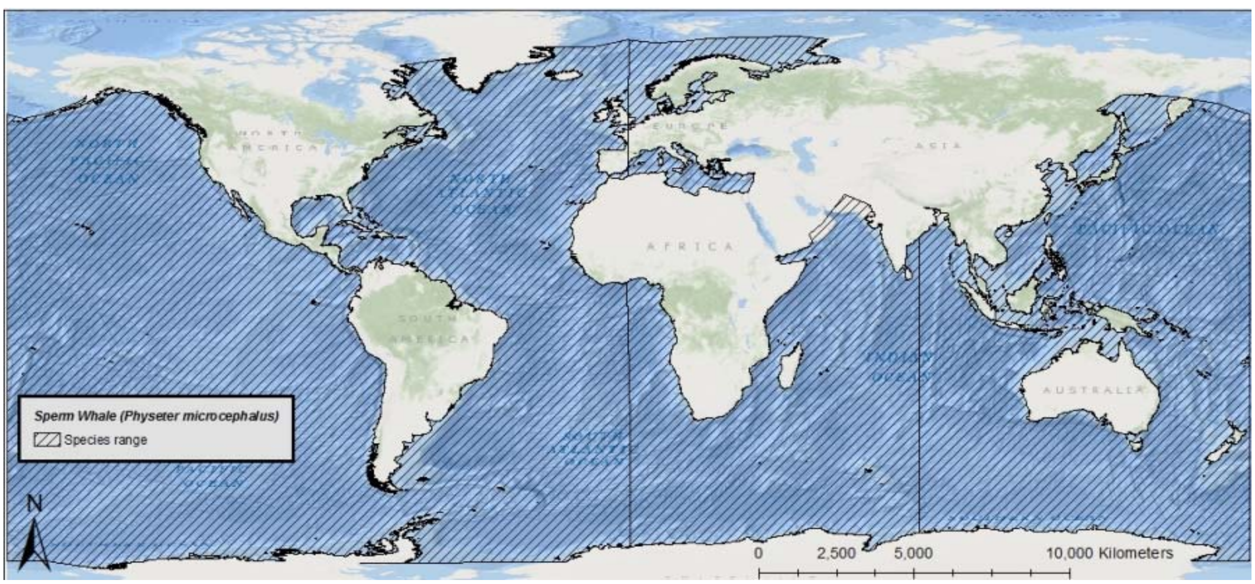


Figure 33. Map identifying the range of the endangered sperm whale.

The sperm whale is the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up 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. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta et al. 2017b; Hayes et al. 2017; Muto et al. 2017), the status review (NMFS 2015c), and the scientific literature 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 is reached between seven and 13 years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales mostly inhabit areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep. 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).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the sperm whale.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated 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, the reason for ESA listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two of three U.S. stocks that occur in the Pacific, the California/Oregon/ Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 3,354 individuals (N_{min}=2,539). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time.

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). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). 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°, only adult males venture into the higher latitudes near the poles.

Vocalizations 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 at 1 m, although lower source level energy has been suggested at around 171 dB re: 1 μPa at 1 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 at 1 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 (Cranford 1992; 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 1992a). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992a). 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 (André et al. 1997). 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 one 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. 1999). 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 (NOAA 2016).

Status

The sperm whale is endangered as a result of past commercial whaling. 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; however, illegal hunting may occur. Continued threats to sperm whale populations include vessel strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and sound. The species' large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the environmental baseline section of this opinion. See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals.

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

7.2.7 False Killer Whales – Main Hawaiian Islands Insular DPS

False killer whales are distributed worldwide in tropical and temperate waters more than 1,000 m deep. MHI IFKWs are found in waters around the Main Hawaiian Islands (Figure 34).

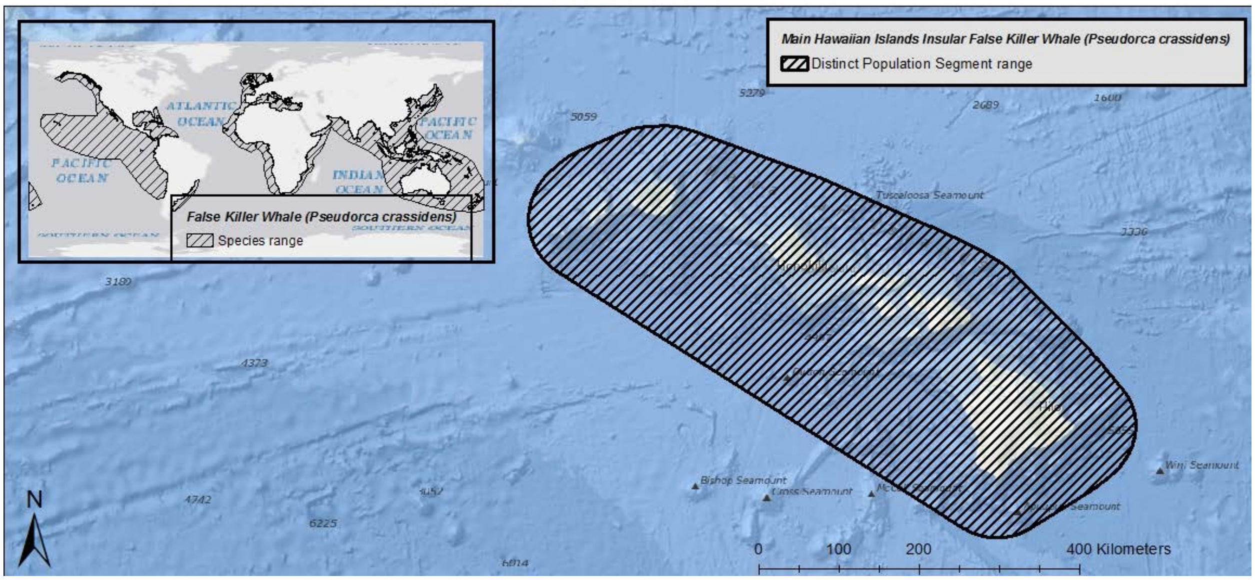


Figure 34. Map identifying the range of false killer whales and the Main Hawaiian Islands Insular DPS.

The false killer whale is a toothed whale and large member of the dolphin family. False killer whales are distinguishable from other whales by having a small conical head without a beak, tall dorsal fin, and a distinctive bulge in the middle of the front edge of their pectoral fins. MHI IFKWs were originally listed as endangered on November 28, 2012 (77 FR 70915).

Information available from the most recent status review (NMFS 2010c) and recent stock assessment (Carretta et al. 2018b) were used to summarize the status of the species as follows.

Life History

False killer whales can live, on average, for 60 years. They have a gestation period of 14 to 16 months, and calves nurse for 1.5 to two years. Sexual maturity is reached around 12 years of age with a very low reproduction rate and calving interval of approximately seven years. False killer whales prefer tropical to temperate waters that are deeper than 1,000 m. False killer whales feed during the day and at night on fishes and cephalopods, and are known to attack other marine mammals, indicating they may occasionally feed on them.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to MHI IFKWs. The most recent stock assessment report estimates abundance at 167 (coefficient of variation = 0.14), and a minimum population size of 149 individuals (Carretta et al. 2018b).

A current estimated population growth rate for MHI IFKWs is not available at this time (Carretta et al. 2018b). Reeves et al. (2009) suggested that the population may have declined during the last two decades, based on sighting data collected near Hawaii using various methods between 1989 and 2007. A modeling exercise conducted by Oleson et al. (2010) evaluated the probability of actual or near extinction, defined as fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. A variety of alternative scenarios were evaluated indicating the probability of decline to fewer than 20 animals within 75 years as greater than 20 percent. Although causation was not evaluated, all models indicated current declines at an average rate of negative nine percent since 1989.

The MHI IFKW is considered resident to the Main Hawaiian Islands and is genetically and behaviorally distinct compared to other stocks. Genetic data suggest little immigration into the Main Hawaiian Islands Insular DPS of false killer whale (Baird et al. 2012a). Genetic analyses indicated restricted gene flow between false killer whales sampled near the Main Hawaiian Islands, the Northwestern Hawaiian Islands, and pelagic waters of the Eastern and Central North Pacific.

NMFS currently recognizes three stocks of false killer whales in Hawaiian waters: the Main Hawaiian Islands Insular, Hawaii pelagic, and the Northwestern Hawaiian Islands. All false killer whales found within 40 km of the Main Hawaiian Islands belong to the insular stock and all false killer whales beyond 140 km belong to the pelagic stock. Animals belonging to the Northwest Hawaiian Islands stock are insular to the Northwest Hawaiian Islands (Bradford et al. 2012), however, this stock was identified by animals encountered off Kauai.

Vocalizations and Hearing

Functional hearing in mid-frequency cetaceans, including MHI IFKWs, is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007e). There are three categories of sounds that odontocetes make. The first includes echolocation sounds of high intensity, high frequency, high repetition rate, and very short duration (Au et al., 2000). The second category of odontocete sounds is comprised of pulsed sounds. Burst pulses are generally very complex and fast, with frequency components sometimes above 100 kHz and average repetition rates of 300 per second (Yuen et al. 2007).

The final category of odontocete sounds is the narrowband, low frequency, tonal whistles (Au et al. 2000b; Caldwell et al. 1990). With most of their energy below 20 kHz, whistles have been observed with an extensive variety of frequency patterns, durations, and source levels, each of which can be repeated or combined into more complex phrases (Tyack and Clark 2000; Yuen et al. 2007).

In general, odontocetes produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of hertz (Hz) to tens of kHz (Southall et al. 2007e) with source levels in the range of 100–170 dB re 1 μPa (See Richardson et al. 1995g). They also generate specialized clicks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au et al. 1993). Echolocation clicks have source levels that can be as high as 229 dB re 1 μPa peak-to-peak (Au et al. 1974).

Nachtigall and Supin (2008) investigated the signals from an echolocating false killer whale and found that the majority of clicks had a single-lobed structure with peak energy between 20 and 80 kHz false rather than dual-lobed clicks, as has been demonstrated in the bottlenose dolphin. Navy researchers measured the hearing of a false killer whale and demonstrated the ability of this species to change its hearing during echolocation (Nachtigall and Supin. 2008). They found that there are at least three mechanisms of automatic gain control in odontocete echolocation, suggesting that echolocation and hearing are a very dynamic process (Nachtigall and Supin. 2008). For instance, false killer whales change the focus of the echolocation beam based on the difficulty of the task and the distance to the target. The echo from an outgoing signal can change by as much as 40 dB, but the departing and returning signal are the same strength entering the brain (Nachtigall and Supin. 2008) . The Navy demonstrated that with a warning signal, the false killer whale can adjust hearing by 15 dB prior to sound exposure (Nachtigall and Supin. 2008).

Status

The exact causes for the decline in the MHI IFKW are not specifically known, but multiple factors have threatened and continue to threaten the population. Threats to the DPS include small population size, including inbreeding depression and Allee effects, exposure to environmental contaminants, competition for food with commercial fisheries, and hooking, entanglement, or intentional harm by fishermen. Recent photographic evidence of dorsal fin disfigurements and mouthline injuries suggest a high rate of fisheries interactions for this population compared to others in Hawaiian waters (Baird et al. 2015b).

Recovery Goals

There is currently no recovery plan available for MHI IFKWs, but the plan is currently being prepared. In 2016, NMFS issued a recovery outline for the DPS (NMFS 2016d). The outline is meant to serve as an interim guidance document to direct recovery planning until a full recovery plan is developed and approved. The recovery outline presented a number of short and long-term actions that will improve the potential for the DPS' recovery. Actions include reducing incidental take from commercial and recreational fisheries and monitoring to better understand the effects of contaminants, among others.

7.2.8 Guadalupe Fur Seal

Guadalupe fur seals were once found throughout Baja California, Mexico and along the California coast. Currently, the species breeds mainly on Guadalupe Island, Mexico, off the coast of Baja California. A smaller breeding colony, discovered in 1997, appears to have been established at Isla Benito del Este in the San Benito Archipelago, Baja California, Mexico (Belcher and T.E. Lee 2002) (Figure 35).

Figure 35. Guadalupe fur seal historic range.

Guadalupe fur seals are medium sized, sexually dimorphic otariids (Belcher and T.E. Lee 2002; Reeves et al. 2002). Distinguishing characteristics of the Guadalupe fur seal include the digits on their hind flippers (all of similar length), large, long foreflippers, and unique vocalizations (Reeves et al. 2002). Guadalupe fur seals are dark brown to black, with the adult males having tan or yellow hairs at the back of their mane. Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252). Information available from recent stock assessment reports and available literature were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Guadalupe fur seals prefer rocky habitats and can be found in natural recesses and caves (Fleischer 1978). 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). 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). Foraging trips can last between four to twenty-four days days (average of fourteen days). Tracking data show that adult females spend seventy-five percent of their time sea, and twenty-five percent at rest (Gallo-Reynoso et al. 1995).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Guadalupe fur seal.

At the time of listing, the population was estimated at 1,600 individuals, compared to approximately 30,000 before hunting began. 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).

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. When the most recent stock assessment report for Guadalupe fur seals was published in 2000, the breeding colonies in Mexico were increasing; more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). After compiling data from counts over thirty years, Gallo calculated that the population of Guadalupe fur seals in Mexico was increasing, with an average annual growth rate of 13.3 percent on Guadalupe Island (Gallo-Reynoso 1994). More recent estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997-2007) indicates 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).

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. 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 mitochondrial 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).

Guadalupe fur seals have been known to travel great distances, with sightings occurring thousands of kilometers away from the main breeding colonies (Aurioles-Gamboa et al. 1999). Guadalupe fur seals are infrequently observed in U.S. waters. They can be found on California's Channel Islands, with as many fifteen individuals being sighted since 1997 on San Miguel Island, including three females and reared pups. New 2014 to 2015, yet to be published, satellite tracking data for Guadupe fur seals tagged on Guadalupe Island demonstrated most animals traveling or foraging well past the continential shope off Southern California (T. Norris, pers. comm. to C. Johnson, Navy, 2018).

Vocalizations and Hearing

Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to several tens of kHz 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 (See Richardson et al. 1995g).

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 two species present in the Study Area: California sea lion (Kastak and Schusterman 1998) and northern fur seal (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.

Status

A number of human activities may have contributed to the current status of this species, historic commercial hunting was likely the most devastating. Commercial sealers in the nineteenth century decimated the Guadalupe fur seal population, taking as many 8,300 fur seals from San Benito Island (Townsend 1924). 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 that could be found. In 1954, during a survey of the island Hubbs (1956) discovered at least fourteen individuals. Although population surveys occurred on an irregular basis in subsequent years, evidence shows that the Guadalupe fur seal has been increasing ever since. 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. 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

No critical habitat has been designated for the Guadalupe fur seal.

Recovery Goals

There has been no recovery plan prepared for Guadalupe fur seals.

7.2.9 Hawaiian Monk Seal

The Hawaiian monk seal is a large phocid ("true seal") that is one of the rarest marine mammals in the world. The Hawaiian monk seal inhabits the Northwestern Hawaiian Islands and Main Hawaiian Islands (Figure 36).

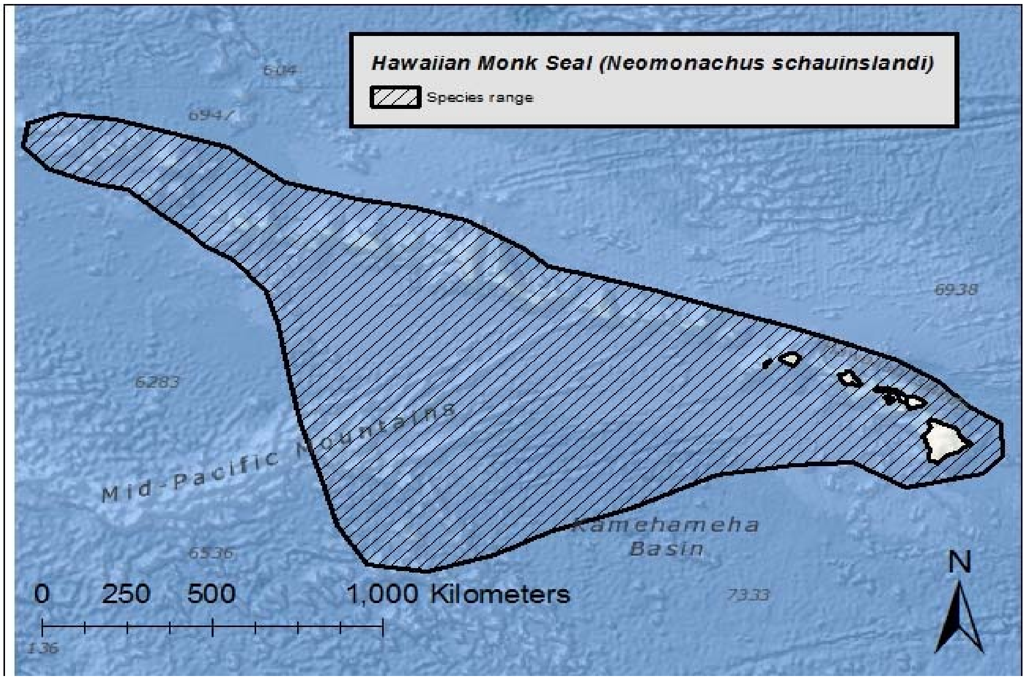


Figure 36. Map identifying the range of the endangered Hawaiian monk seal.

Hawaiian monk seals are silvery-grey with a lighter creamy coloration on their underside (newborns are black), they may also have light patches of red or green tinged coloration from attached algae. The Hawaiian monk seal was originally listed as endangered on November 23, 1976 (41 FR 51611). Information available from the recovery plan (NMFS 2007b), recent stock assessment report (Carretta et al. 2016c), and status review (NMFS 2007a) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Hawaiian monk seals can live, on average, twenty-five to thiry years. Sexual maturity in females is reached around five years of age and it is thought to be similar for males but they do not gain access to females until they are older. They have a gestation period of ten to eleven months, and calves nurse for approximately one month while the mother fasts and remains on land. After nursing, the mother abandons her pup and returns to the sea for eight to ten weeks before returning to beaches to molt. Males compete in a dominance hierarchy to gain access to females (i.e., guarding them on shore). Mating occurs at sea, however, providing opportunity for female mate choice. Monk seals are considered foraging generalist that feed primarily on benthic and demersal prey such as fish, cephalopods, and crustaceans. They forage in subphotic zones either because there areas host favorable prey items or because these areas are less accessible by competitors (Parrish et al. 2000).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Hawaiian monk seal.

The entire range of the Hawaiian monk seal is located within U.S. waters. In addition to a small but growing population found on the main Hawaiian islands there are six main breeding subpopulations in the northwestern Hawaiian islands identified as: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals. The best estimate of the total population of Hawaiian monk seals is 1,324. This estimate is the sum of estimated abundance at the six main northwestern Hawaiian islands subpopulations, an extrapolation of counts at Necker and Nihoa Islands (smaller breeding sub-populations), and an estimate of minimum abundance in the main Hawaiian islands. The minimum population size for the entire species is 1,261. While the most recent NMFS stock assessment report for this species states that it is not currently possible to unequivocally conclude population trends, information on abundance trends for Hawaiian monk seals is encouraging (Figure 37). The point estimate for 2014 was higher than for 2013, and the point estimate for 2015 was even higher (Carretta et al. 2018c).

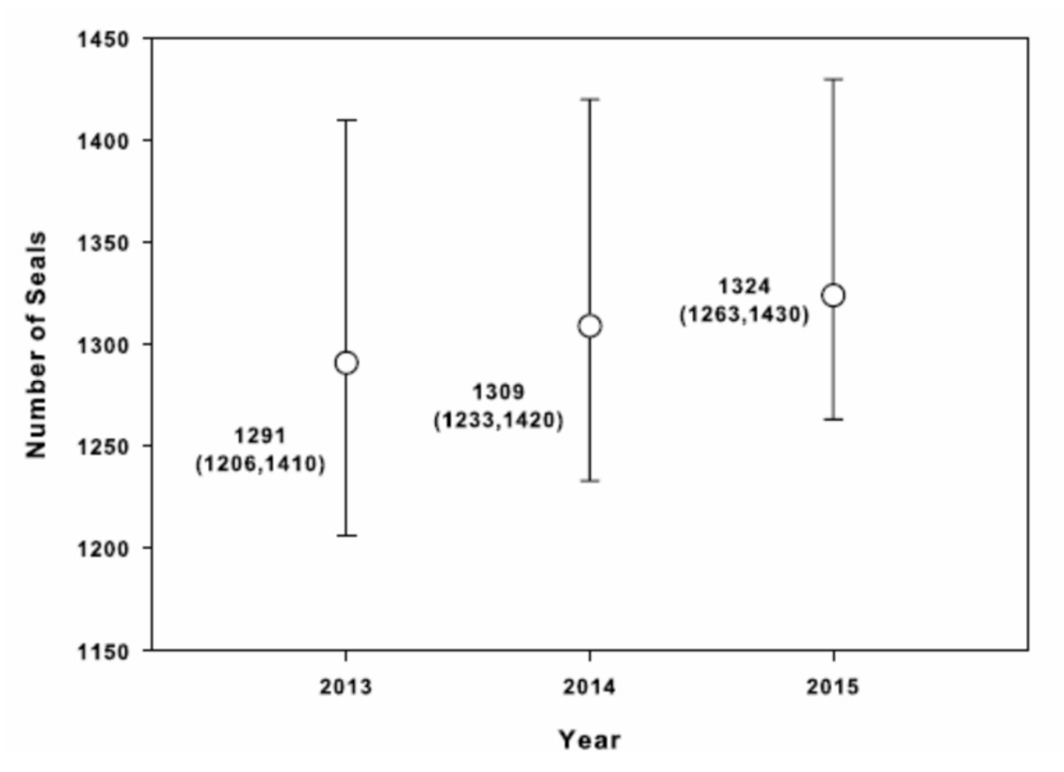


Figure 37. Range-wide abundance of Hawaiian monk seals (Baker et al. 2016, as cited in Caretta et al 2018). Medians and 95 percent confidence limits are shown.

Genetic analysis indicates the species is a single panmictic population, thus warranting a single stock designation (Schultz et al. 2011). Genetic variation among monk seals is extremely low and may reflect a long-term history at low population levels and more recent human influences (Kretzmann et al. 2001; Schultz et al. 2009). In addition to low genetic variability, studies by Kretzmann et al. (1997) suggest the species is characterized by minimal genetic differentiation among sub-populations and, perhaps some naturally occurring local inbreeding. The potential for genetic drift should have increased when seal numbers were reduced by European harvest in the nineteenth century, but any tendency for genetic divergence among sub-populations is probably mitigated by the inter-island movements of seals. Since the population is so small there is concern about long-term maintenance of genetic diversity making it quite likely that this species will remain endangered for the foreseeable future.

Vocalizations and Hearing

The information on the hearing capabilities of endangered Hawaiian monk seals is somewhat limited, but they appear to have their most sensitive hearing at 12 to 28 kHz. Below 8 kHz, their hearing is less sensitive than that of other pinnipeds. Their sensitivity to high frequency sound drops off sharply above 30 kHz (Richardson et al. 1995a; Richardson et al. 1995g; Thomas et al. 1990b). An underwater audiogram for Hawaiian monk seal, based on a single animal whose hearing may have been affected by disease or age, was best at 12 to 28 kHz and 60 to 70 kHz (Thomas et al. 1990b). The hearing showed relatively poor hearing sensitivity, as well as a narrow range of best sensitivity and a relatively low upper frequency limit (Thomas et al. 1990b).

Status

Hawaiian monk seals were once harvested for their meat, oil, and skins, leading to extirpation in the main Hawaiian islands and near-extinction of the species by the twentieth century (Hiruki and Ragen 1992; Ragen 1999). The species partially recovered by 1960, when hundreds of seals were counted on northwestern Hawaiian islands beaches. Since then, however, the species has declined in abundance. Though the ultimate cause(s) for the decline remain unknown, threats include: food limitations in northwestern Hawaiian islands, entanglement in marine debris, human interactions, loss of haul-out and pupping beaches due to erosion in northwestern Hawaiian islands, disease outbreaks, shark predation, male aggression towards females, and low genetic diversity. With only approximately 1,324 individuals remaining, the species' resilience to further perturbation is low.

Recovery Goals

See the 2007 Final Recovery Plan for the Hawaiian monk seal for complete down listing/delisting criteria for each of the four following recovery goals.

1. Improve the survivorship of females, particularly juveniles, in sub-populations of the northwestern Hawaiian islands.
2. Maintain the extensive field presence during the breeding season in the northwestern Hawaiian islands.
3. Ensure the continued natural growth of the Hawaiian monk seal in the main Hawaiian islands by reducing threats including interactions with recreational fisheries, disturbance

of mother-pup pairs, disturbance of hauled out seals, and exposure to human domestic animal diseases.

4. Reduce the probability of the introduction of infectious diseases into the Hawaiian monk seal population.

7.2.10 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 (Figure 38).

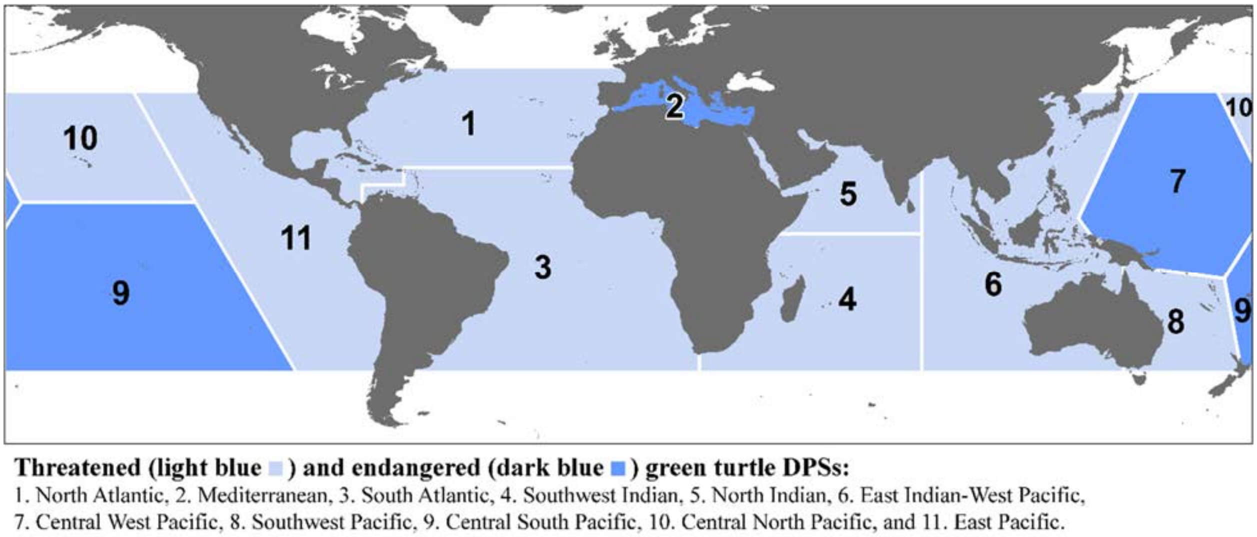


Figure 38. Map depicting range and DPS boundaries for green turtles.

The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 lbs (159 kilograms) and a straight carapace length of greater than 3.3 ft (1 m) (Figure 39). The species was listed under the ESA on July 28, 1978.

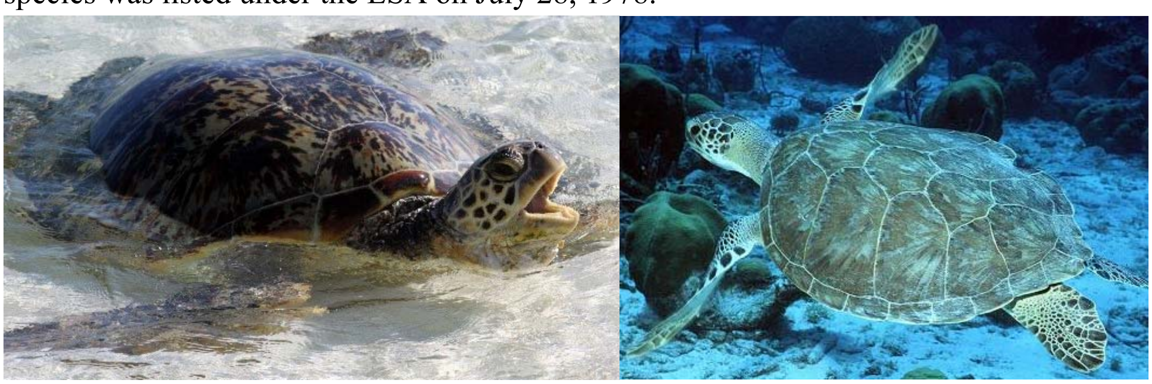


Figure 39. Green sea turtle. Photos: Mark Sullivan, NOAA (left), Andy Bruckner, NOAA (right).

On April 6, 2016, NMFS listed eleven DPSs of green sea turtles as threatened or endangered under the ESA (Table 54). Eight DPSs are listed as threatened: Central North Pacific, East

Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific. Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean. The DPSs considered in this biological opinion that occur within the action area are the threatened Central North Pacific and East Pacific DPSs.

We used information available in the 2007 five-year review (NMFS and USFWS 2007a) and 2015 Status Review (Seminoff et al. 2015) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Age at first reproduction for females is twenty to forty years. Green sea turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green sea turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges and other invertebrate prey.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes population growth rate, genetic diversity, and distribution as it relates to the green sea turtle.

Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). Table 55 shows by DPS the number of nesting females, nesting sites and the percentage of nesting females at the largest nesting site.

Table 55. Green sea turtle nesting abundance in each DPS (Seminoff et al. 2015).

Distinct Population Segment	Abundance Estimate (nesting females)	Number of Nesting Sites	Largest Nesting Site	Percentage at largest nesting site
Central North Pacific	3,846	12	East Island, French Frigate Shoals, Hawaii	96%
East Pacific	20,062	39	Colola, Mexico	58%

Population Growth Rate

Many green sea turtle nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates for a DPS. Available information on the population growth rates and trends for the two DPSs in the action area is presented below.

Central North Pacific DPS

There are thirteen known nesting sites for the Central North Pacific DPS, with an estimated 3,846 nesting females. The DPS is very thoroughly monitored, and it is believed there is little chance that there are undocumented nesting sites. The largest nesting site is at French Frigate Shoals, Hawaii, which hosts ninety-six percent of the nesting females for the DPS (Seminoff et al. 2015). Nesting surveys have been conducted since 1973 for green turtles in the Central North Pacific DPS. In recent year the nesting abundance at East Island, French Frigate Shoals has increased by about five percent annually.

East Pacific DPS

There are thirty-nine nesting sites for the East Pacific DPS, with an estimated 20,062 nesting females. The largest nesting site is at Colola, Mexico, which hosts fifty-eight percent of the nesting females for the DPS (Seminoff et al. 2015). There are no estimates of population growth. Only one nesting site in the East Pacific DPS at Colola, Mexico, has sufficient long-term data to determine population trends. Data analysis indicates that the population there is increasing and is likely to continue to do so.

Genetic Diversity

Globally, the green sea turtle is divided into eleven DPSs; available information on the genetic diversity for the two DPSs in the action area is presented below.

Central North Pacific DPS

The majority of nesting for the Central North Pacific DPS is centered at one site on French Frigate Shoals, and there is little diversity in nesting areas. Overall, the Central North Pacific DPS has a relatively low level of genetic diversity and stock sub-structuring (Seminoff et al. 2015).

East Pacific DPS

Rare and unique haplotypes are present in the East Pacific DPS. Genetic sampling has identified four regional stocks in the Eastern Pacific DPS: Revillagigedos Archipelago, Mexico, Michoacán, Mexico, Central America (Costa Rica), and the Galápagos Islands, Ecuador (Seminoff et al. 2015).

Distribution

The green sea turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than eighty countries. The green sea turtle is distributed in tropical, subtropical, and to a lesser extent, temperate waters (Figure 40).

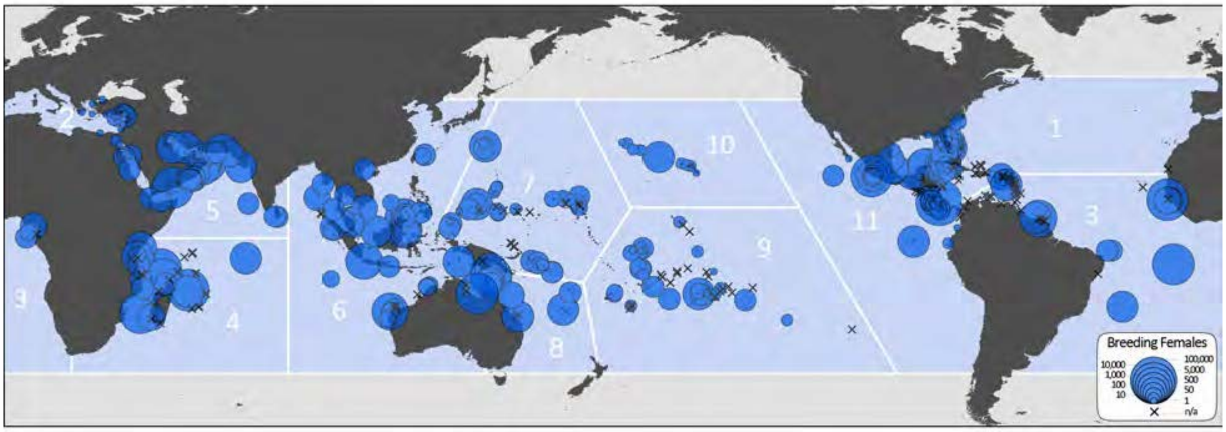


Figure 40. Map of all *Chelonia mydas* nesting sites indicating delineation of DPSs (Seminoff et al. 2015).

Central North Pacific DPS

Green turtles in the Central North Pacific DPS are found in the Hawaiian Archipelago and Johnston Atoll. The major nesting site for the DPS is at East Island, French Frigate Shoals, in the Northwestern Hawaiian Islands; lesser nesting sites are found throughout the Northwestern Hawaiian Islands and the Main Hawaiian Islands (Figure 41).

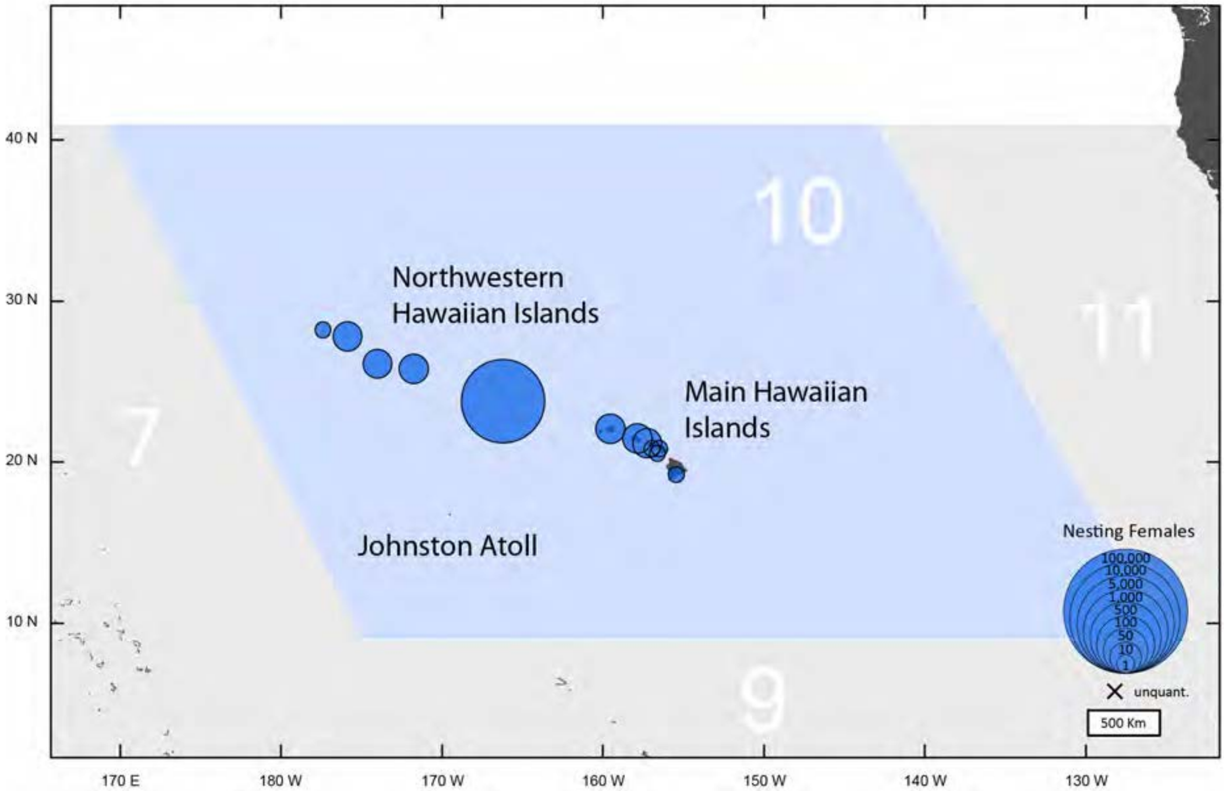


Figure 41. Nesting distribution of green turtles in the Central North Pacific DPS (water body labeled '10'). Size of circles indicates estimated nester abundance (Seminoff et al. 2015).

East Pacific DPS

Green turtles in the East Pacific DPS are found from the California/Oregon border south to central Chile. Major nesting sites occur at Michoacán, Mexico, and the Galápagos Islands, Ecuador (Figure 42). Smaller nesting sites are found on the Pacific coast of Costa Rica, and in the Revillagigedos Archipelago, Mexico. Scattered nesting occurs in Columbia, Ecuador, Guatemala and Peru (Seminoff et al. 2015).

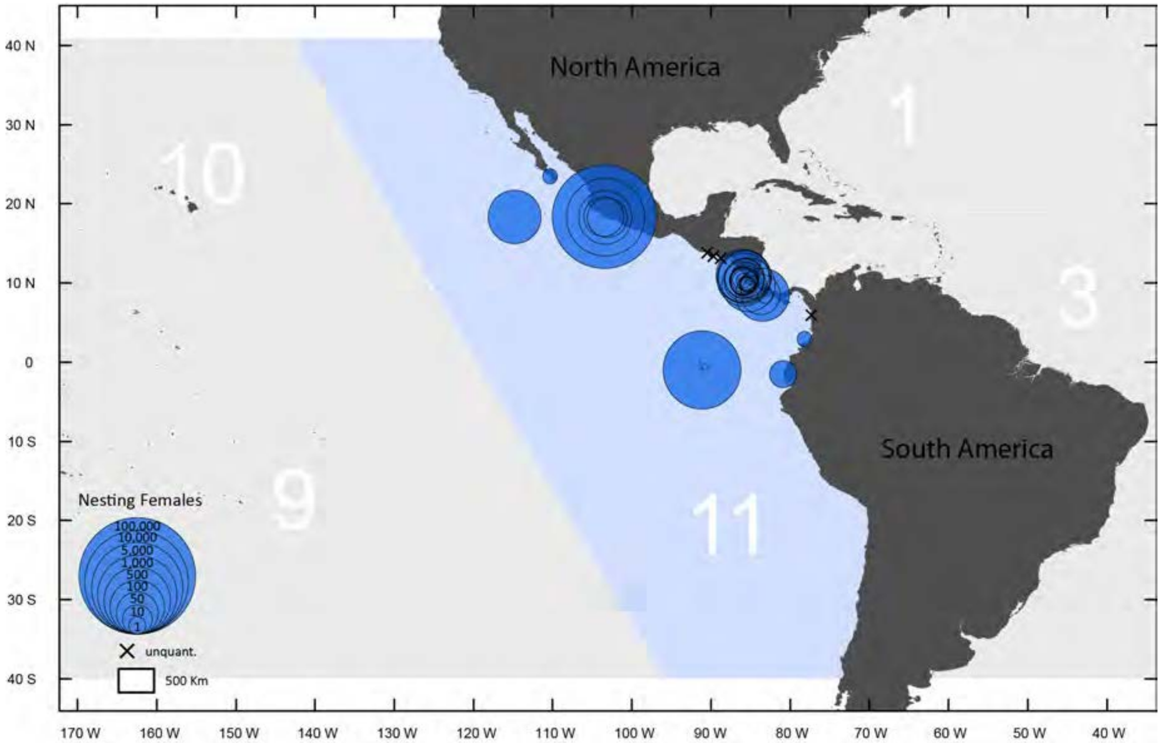


Figure 42. Nesting distribution of green turtles in the East Pacific DPS (water body labeled '11'). Size of circles indicates estimated nester abundance. Locations marked with an 'x' indicate sites lacking abundance information (Seminoff et al. 2015).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006a; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Piniak et al. (2016) found green sea turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Other studies have similarly found greatest sensitivities between 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Bartol and Ketten 2006a; Ridgway et al. 1969b).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

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. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net and trawl fisheries kill thousands of green sea turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Central North Pacific DPS

Green sea turtles in the Hawaiian Archipelago 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 the population. Although these threats persist, the increase in annual nesting abundance, continuous scientific monitoring, legal enforcement and conservation programs are all factors that favor the resiliency of the DPS.

East Pacific DPS

The population decline for the East Pacific DPS was primarily caused by commercial harvest of green turtles for subsistence and other uses (e.g., sea turtle oil as a cold remedy). Conservation laws are in place in several countries across the range of the DPS, but enforcement is inconsistent, limiting effectiveness. Incidental bycatch in commercial fishing gear, continued harvest, coastal development and beachfront lighting are all continuing threats for the East Pacific DPS. The observed increases in nesting abundance for the largest nesting aggregation in the region (Michocán, Mexico), a stable trend at Galápagos, and record high numbers at sites in Costa Rica suggest that the population is resilient, particularly in Mexico.

Critical Habitat

No critical habitat has been designated for green sea turtle Central North Pacific and Eastern Pacific DPSs.

Recovery Goals

See the 1998 and 1991 recovery plans for the Pacific, East Pacific and Atlantic populations of green sea turtles for complete down-listing/delisting criteria for recovery goals for the species (NMFS and USFWS 1991; NMFS and USFWS 1998b). Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

7.2.11 Hawksbill Sea Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical oceans (Figure 43).

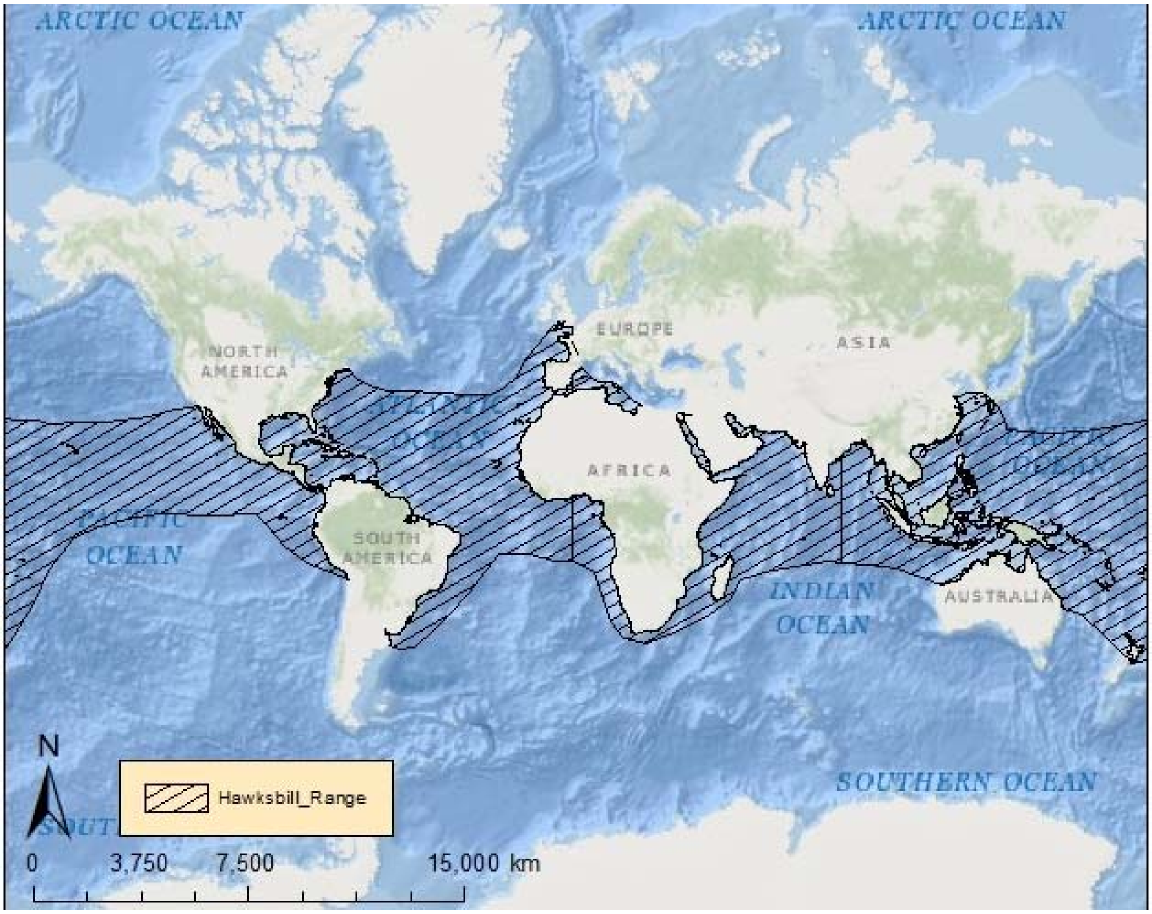


Figure 43. Map identifying the range of the endangered hawksbill sea turtle.

The hawksbill sea turtle has a sharp, curved, beak-like mouth and a "tortoiseshell" pattern on its carapace, with radiating streaks of brown, black, and amber (Figure 44).

Figure 44. Hawksbill sea turtle. Photo: Tom Moore, NOAA.

The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973 (Table 54). We used information available in the 2007 and 2013 five-year reviews (NMFS and USFWS 2007b; NMFS and USFWS 2013b) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Hawksbill sea turtles reach sexual maturity at twenty to forty years of age. Females return to their natal beaches every two to five years to nest and nest an average of three to five times per season. Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately twenty two to twenty five centimeters in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbills use their sharp beak-like mouths to feed on sponges and corals. Hawksbill sea turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging locations ranges from a few hundred to a few thousand kilometers (Horrocks et al. 2001; Miller et al. 1998).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes population growth rate, genetic diversity, and distribution as it relates to the hawksbill sea turtle.

Surveys at eighty eight nesting sites worldwide indicate that 22,004 to 29,035 females nest annually (NMFS and USFWS 2013b). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining.

From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased fifteen percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2013b).

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (McClellan et al. 2010; Monzón-Argüello et al. 2010). Hawksbills in the Caribbean seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000 to 300,000 years ago (Leroux et al. 2012).

The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbills can be found in mats of floating vegetation; post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006a; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Piniak et al. (2012) found hawksbill turtle hatchlings capable of hearing underwater sounds at frequencies of between 50 Hz to 1.6 kHz (maximum sensitivity at 200 to 400 Hz). These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status

Long-term data on the hawksbill sea turtle indicate that sixty-three sites have declined over the past twenty to one hundred years (historic trends are unknown for the remaining twenty-five sites). Recently, twenty-eight sites (sixty-eight percent) have experienced nesting declines, ten have experienced increases, three have remained stable, and forty-seven have unknown trends. The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels, especially in southeast Asia where collection approaches one hundred percent in some areas. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low.

Critical Habitat

There is no designated critical habitat within the action area for this species.

Recovery Goals

See the 1992 Recovery Plan for the U.S. Caribbean, Atlantic and Gulf of Mexico (NMFS and USFWS 1993) and the 1998 Recovery Plan for the U.S. Pacific populations (NMFS and USFWS 1998c) of hawksbill sea turtles, for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the recovery plans:

5. Identify important nesting beaches.
6. Ensure long-term protection and management of important nesting beaches.
7. Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters.
8. Identify important marine habitats; protect and manage populations in marine habitat.
9. Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion.
10. Prevent the degradation of reef habitat caused by sewage and other pollutants.
11. Monitor nesting activity on important nesting beaches with standardized index surveys.
12. Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
13. Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
14. Determine nesting beach origins for juveniles and subadult populations.

7.2.12 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 45).

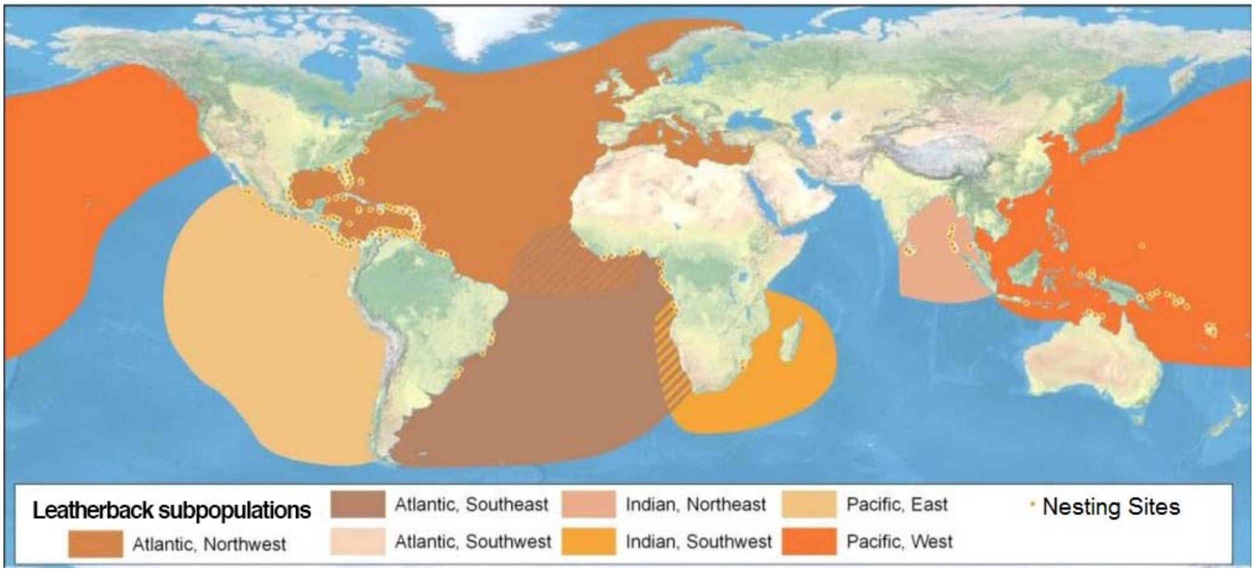


Figure 45. Map identifying the range of the leatherback sea turtle with the seven subpopulations and nesting sites. Adapted from (Wallace et al. 2010a).

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 (Figure 46).

Figure 46. Leatherback sea turtle adult and hatchling. Photos: R. Tapilatu (left), N. Pilcher (right).

The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1970 (Table 54). We used information available in the 2013 five-year review (NMFS and USFWS 2013c) and the critical habitat designations to summarize the life history, population dynamics and status of the species, as follows.

Life History

Leatherback age at maturity has been difficult to ascertain, with estimates ranging from five to twenty-nine years (Avens et al. 2009; Spotila et al. 1996). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams

(Reina et al. 2002; Wallace et al. 2007). The number of leatherback hatchlings that make it out of the nest onto the beach (i.e., emergent success) is approximately fifty percent worldwide (Eckert et al. 2012). Females nest every one to seven years.

Leatherback sea turtles are distributed in oceans throughout the world. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011). 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 thirty-three 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, in general, 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).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the leatherback sea turtle.

Leatherbacks are globally distributed, with nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherbacks in the North Atlantic (TEWG 2007). In contrast, leatherback populations in the Pacific are much lower. Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Leatherback subpopulations in the Atlantic Ocean, however, are showing signs of improvement.

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 HSTT action area. Western Pacific leatherbacks nest in the Indo-Pacific, primarily in Indonesia, Papua New Guinea and the Solomon Islands. A proportion of this population migrates north through the waters of Indonesia, Malaysia, Philippines, and Japan, and across the Pacific past Hawaii to feeding areas off the Pacific coast of North America. Unlike populations in the Caribbean and Atlantic Ocean, which are generally stable or increasing, western Pacific leatherbacks have declined more than 80 percent and eastern Pacific leatherbacks have declined by more than 97 percent since the 1980's (Santidrián Tomillo et al. 2007; Tapilatu et al. 2013). Because the threats to these subpopulations have not ceased, the International Union for Conservation of Nature has predicted a decline of 96 percent for the western Pacific subpopulation and a decline of nearly 100 percent for the eastern Pacific subpopulation by 2040, which is only one generation from now (Wallace 2013).

In the western Pacific, the major nesting beaches in Papua, Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu (Dutton et al. 2007; Limpus 2002) consist of approximately 2,700-4,500 breeding females. This number is substantially higher than the population estimate of 1,775 to 1,900 western Pacific breeding females published in 2000 and used to predict possible extinction in the Pacific (Spotila et al. 2000). However, this estimate should be interpreted with caution because it was derived from nest counts, and reliable data on the number of nests per female are not available (Dutton et al. 2007). The current overall estimate for Papua Barat, Indonesia, Papua New Guinea, and Solomon Islands is 5,000 to 10,000 nests per year (Nel et al. 2013).

Analyses of mitochondrial DNA from leatherback sea turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian oceans suggest that each of the rookeries represent demographically independent populations (NMFS and USFWS 2013c).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol and Ketten 2006a; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Piniak (2012) measured hearing of hatchlings leatherback turtles in water and in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kHz in air and between 50 Hz and 1.2 kHz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 Hz). These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 to 4 kHz (Patterson 1966).

Status

The leatherback sea turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise. The species' resilience to additional perturbation is low.

Critical Habitat

There is no designated critical habitat within the action area for this species.

Recovery Goals

See the U.S. Pacific (NMFS and USFWS 1998a) and U.S. Caribbean, Gulf of Mexico and Atlantic Recovery Plans (NMFS and USFWS 1992) for leatherback sea turtles for complete down listing/delisting criteria for each of their respective recovery goals. The top five recovery actions identified in the Leatherback Five Year Action Plan were 1) Reduce fisheries interactions; 2) Improve nesting beach protection and increase reproductive output; 3) International cooperation; 4) Monitoring and research and 5) Public engagement.

7.2.13 Loggerhead Sea Turtle

Loggerhead sea turtles are circumglobal, and are found in the temperate and tropical regions of the Indian, Pacific and Atlantic Oceans (Figure 47).

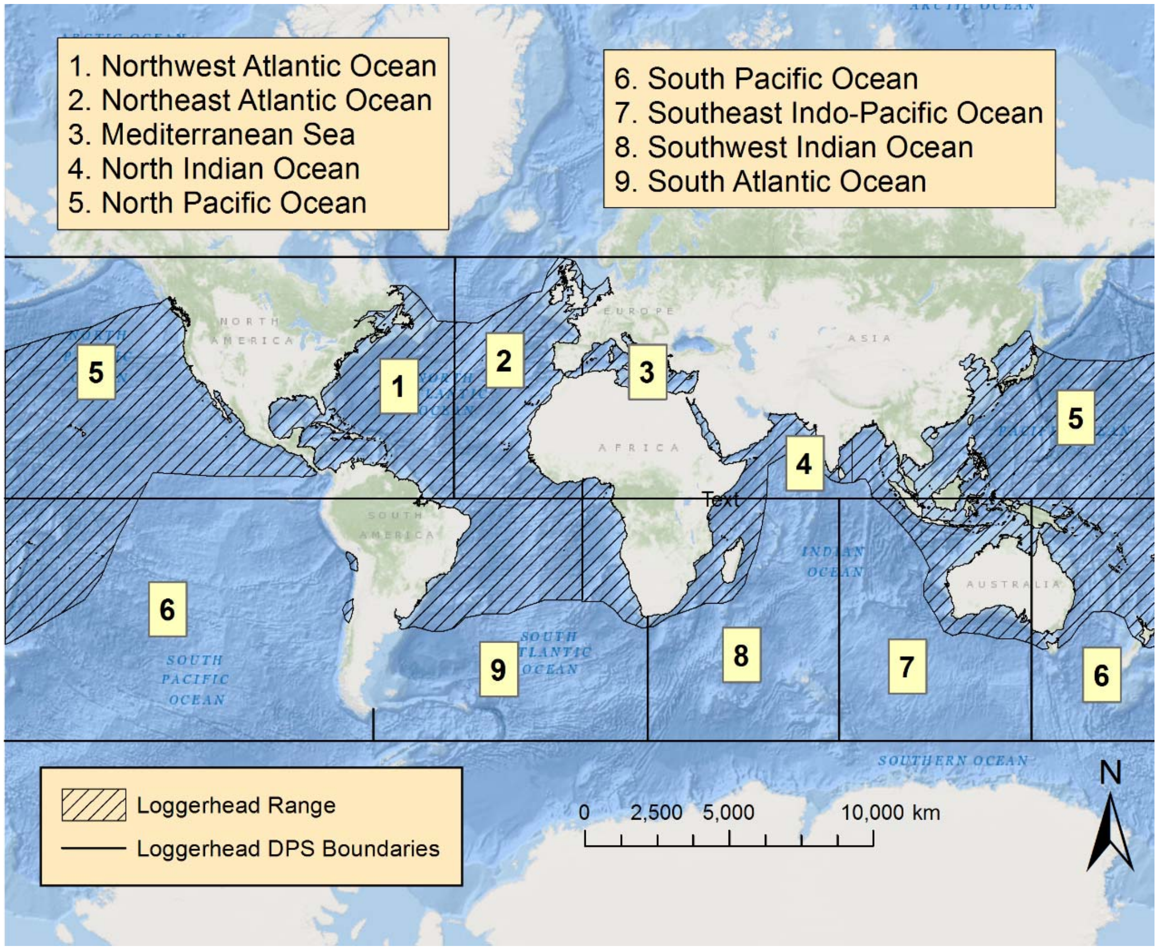


Figure 47. Map identifying the range and DPS boundaries of the loggerhead sea turtle.

The loggerhead sea turtle is distinguished from other turtles by its large head and powerful jaws (Figure 48).

Figure 48. Loggerhead sea turtle. Photo: National Oceanic and Atmospheric Administration.

The species was first listed as threatened under the ESA in 1978. On September 22, 2011, the NMFS designated nine DPSs of loggerhead sea turtles: South Atlantic Ocean and Southwest Indian Ocean as threatened as well as Mediterranean Sea, North Indian Ocean, North Pacific Ocean, Northeast Atlantic Ocean, Northwest Atlantic Ocean, South Pacific Ocean, and Southeast Indo-Pacific Ocean as endangered (Table 54). Recent ocean-basin scale genetic analysis supports this conclusion, with additional differentiation apparent based upon nesting beaches (Shamblin et al. 2014). The only loggerhead DPS occurring within the action area and considered in this biological opinion is the North Pacific Ocean DPS.

We used information available in the 2009 status review (Conant et al. 2009) and the final listing rule (76 FR 58868) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Mean age at first reproduction for female loggerhead sea turtles is 30 years (standard deviation = 5). Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the turtle during the middle of the incubation period. Turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerheads.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the loggerhead sea turtle.

The North Pacific Ocean DPS has a nesting population of about 2,300 nesting females (Matsuzawa 2011). Loggerhead abundance on foraging grounds off the Pacific Coast of the Baja California Peninsula, Mexico, was estimated to be 43,226 individuals (Seminoff et al. 2014).

Overall, Gilman (2009) estimated that the number of loggerheads nesting in the Pacific has declined by eighty percent in the past twenty years. There was a steep (fifty to ninety percent) decline in the annual nesting population in Japan during the last half of the twentieth century (Kamezaki et al. 2003). Since then, nesting has gradually increased, but is still considered to be depressed compared to historical numbers, and the population growth rate is negative (-0.032) (Conant et al. 2009).

There are nine loggerhead DPSs, which are geographically separated and genetically isolated, as indicated by genetic, tagging, and telemetry data. Our understanding of the genetic diversity and population structure of the different loggerhead DPSs is being refined as more studies examine samples from a broader range of specimens using longer mitochondrial DNA sequences.

Recent mitochondrial DNA analysis using longer sequences has revealed a more complex population sub-structure for the North Pacific Ocean DPS than previously thought. Previously, five haplotypes were present, and now, nine haplotypes have been identified in the North Pacific Ocean DPS. This evidence supports the designation of three management units in the North Pacific Ocean DPS: 1) the Ryukyu management unit (Okinawa, Okinoerabu, and Amami), 2) Yakushima Island management unit and 3) Mainland management unit (Bousou, Enshu-nada, Shikoku, Kii and Eastern Kyushu) (Matsuzawa et al. 2016). Genetic analysis of loggerheads captured on the feeding grounds of Sanriku, Japan, found only haplotypes present in Japanese rookeries (Nishizawa et al. 2014).

Distribution

Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerheads undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground.

Hatchlings from Japanese nesting beaches use the North Pacific Subtropical Gyre and the Kurishio Extension to migrate to foraging grounds. Two major juvenile foraging areas have been identified in the North Pacific Basin: Central North Pacific and off of Mexico's Baja California Peninsula. Both of these feeding grounds are frequented by individuals from Japanese nesting beaches (Abecassis et al. 2013; Seminoff et al. 2014).

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol and Ketten 2006a; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999b) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: 1 µPa and two-year olds: about 86 dB re: 1 µPa), with threshold increasing rapidly above and below that frequency (Bartol and Ketten 2006a). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012b). The lowest threshold recorded in this study was 98 dB re: 1 µPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 ha and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responds beyond 3 or 4 kHz (Patterson 1966).

Status

Once abundant in tropical and subtropical waters, loggerhead sea turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of turtles in foraging areas remain the greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net and trawl fisheries kill thousands of loggerhead sea turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations.

Neritic juveniles and adults in the North Pacific Ocean DPS are at risk of mortality from coastal fisheries in Japan and Baja California, Mexico. Habitat degradation in the form of coastal development and armoring pose a threat to nesting females. Based on these threats and the relatively small population size, the Biological Review Team concluded that the North Pacific Ocean DPS is currently at risk of extinction (Conant et al. 2009).

Critical Habitat

No critical habitat has been designated for loggerhead sea turtle North Pacific Ocean DPS.

7.2.14 Olive Ridley Sea Turtle

The olive ridley sea turtle is a small, mainly pelagic, sea turtle with a circumtropical distribution (Figure 49).

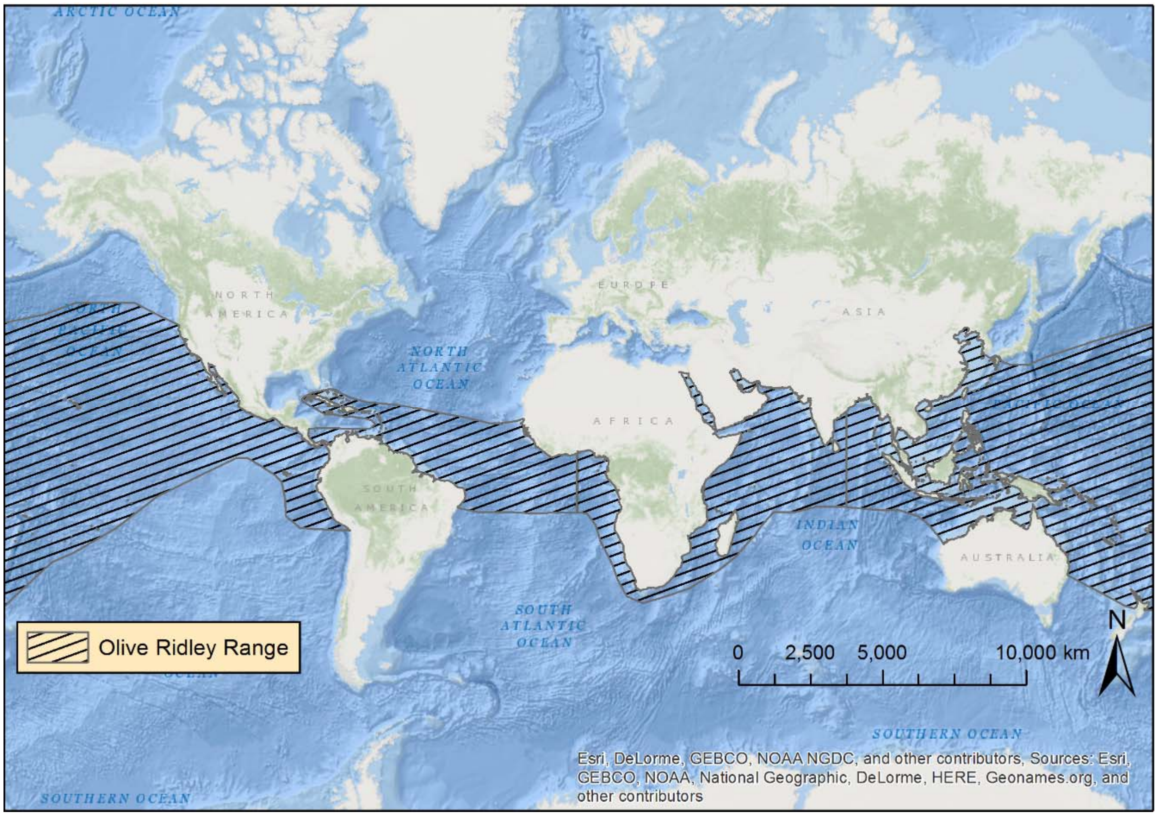


Figure 49. Map identifying the range of the olive ridley sea turtle.

Olive ridley sea turtles are olive or grayish-green in color, with a heart-shaped carapace (Figure 50).

Figure 50. Olive ridley sea turtle. Photo: Reuven Walder (left), Michael Jensen (right).

The species was listed under the ESA on July 28, 1978. The species was separated into two listing designations: endangered for breeding populations on the Pacific coast of Mexico, and threatened wherever found except where listed as endangered (i.e., in all other areas throughout its range) (Table 54). We used information available in the 2014 five-year review (NMFS and

USFWS 2014) to summarize the life history, population dynamics and status of the threatened olive ridley sea turtle, as follows.

Life History

Olive ridley females mature at ten to eighteen years of age. They lay an average of two clutches per season (three to six months in duration). The annual average clutch size is one hundred to 110 eggs per nest. Olive ridleys commonly nest in successive years. Females nest in solitary or in arribadas, large aggregations coming ashore at the same time and location. As adults, olive ridleys forage on crustaceans, fish, mollusks, and tunicates, primarily in pelagic habitats.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the endangered range-wide population of the olive ridley sea turtle.

Mexico's Pacific Coast Breeding Population

There are six primary arribada nesting beaches in Mexico, the largest being La Escobilla, with about one million nesting females annually. There are several monitored nesting beaches where solitary nesting occurs. At Nuevo Vallarta, about 4,900 nests are laid annually. Based on the number of olive ridleys nesting in Mexico, populations appear to be increasing in one location (La Escobilla: from 50,000 nests in 1988 to more than one million in 2000), decreasing at Chacahua, and stable at all others. At-sea estimates of olive ridleys off of Mexico and Central America also support an increasing population trend.

All Other Populations

Globally, olive ridley sea turtles can be found in tropical and subtropical waters in the Atlantic, Pacific and Indian Oceans. The range of the endangered Pacific coast breeding population extends as far south as Peru and up to California. Olive ridley sea turtles of the Pacific coast breeding colonies nest on arribada beaches at Mismaloya, Ixtapilla and La Escobilla, Mexico. Solitary nesting takes place all along the Pacific coast of Mexico.

Olive ridley sea turtles are thought to be the most abundant species of sea turtle, and can be found in the Atlantic, Indian and Pacific Oceans. There is no global estimate of olive ridley abundance, and we rely on nest counts and nesting females to estimate abundance in each of the ocean basins, described below. However, Eguchi et al. (2007) estimated a weighted average of the yearly abundance estimates as 1.39 million (confidence interval: 1.15 to 1.62 million).

There are no known arribada nesting beaches in the western Pacific Ocean; however, some solitary nesting occurs in Australia, Brunei, Malaysia, Indonesia and Vietnam. Data are lacking for many sites. Terengganu, Malaysia had ten nests in 1998 and 1999. Alas Purwo, Indonesia, had 230 nests annually from 1993 to 1998. In the eastern Pacific Ocean (excluding breeding populations in Mexico), there are arribada nesting beaches in Nicaragua, Costa Rica and Panama. La Flor, Nicaragua had 521,440 effective nesting females in 2008 and 2009; Chacocente, Nicaragua had 27,947 nesting females over the same period (Gago et al. 2012). Two other arribada nesting beaches are in Nicaragua, Masachapa and Pochomil, but there are no abundance estimates available. Costa Rica hosts two major arribada nesting beaches; Ostional has between 3,564 and 476,550 turtles per arribada, and Nancite has between 256 and 41,149 turtles per arribada. Panama has one arribada nesting beach, with 8,768 turtles annually. There are several solitary nesting beaches in the East Pacific Ocean (excluding breeding populations in Mexico); however no abundance estimates are available for beaches in El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Columbia and Ecuador. On Hawaii Beach in Guatemala, 1,004 females were recorded in 2005 (NMFS and USFWS 2014).

Population Growth

Population growth rate and trend information for the threatened population of olive ridley sea turtles is difficult to discern, owing to its range over a large geographic area, and a lack of consistent monitoring data in all nesting areas. Below, we present the known population trend information for olive ridley sea turtles by ocean basin (NMFS and USFWS 2014).

Nesting at arribada beaches in French Guiana appears to be increasing, while in Suriname, nesting has declined by more than ninety percent since 1968. Solitary nesting also occurs elsewhere in Suriname, Guyana and French Guiana; no trend data are available. Solitary nesting in Brazil appears to be increasing, with one hundred nests recorded in 1989 to 1990, to 2,606 in 2002 to 2003. In the Eastern Atlantic, trend data is not available for most solitary nesting beaches. Nest counts in the Republic of Congo decreased from 600 nests in 2003 and 2004 to less than 300 in 2009 and 2010.

The three arribada nesting beaches in India: Gahirmatha, Rushikulya, and Devi River are considered stable over three generations. There is no trend data available for several solitary nesting beaches in the Indian Ocean. However, even for the few beaches with short-term monitoring, the nest counts are believed to represent a decline from earlier years.

There are no arribada nesting beaches in the Western Pacific Ocean. Data are lacking or inconsistent for many solitary nesting beaches in the Western Pacific, so it is not possible to assess population trends for these sites. Nest counts at Alas Purwo, Indonesia, appear to be increasing, the nest count at Terengganu, Malaysia, is thought to be a decline from previous years.

Population trends at Nicaraguan arribada nesting beaches are unknown or stable (La Flor). Ostional, Costa Rica arribada nesting beach is increasing, while trends Nancite, Costa Rica, and Isla Cañas, Panama, nesting beaches are declining. For most solitary nesting beaches in the East Pacific Ocean, population trends are unknown, except for Hawaii Beach, Guatemala, which is decreasing.

Genetic Diversity

Genetic studies have identified four main lineages for the olive ridley: east India, Indo-Western Pacific, Atlantic, and the eastern Pacific. In the eastern Pacific, rookeries on the Pacific Coasts of

Costa Rica and Mexico were not genetically distinct, and fine-scale population structure was not found when solitary and arribada nesting beaches were examined. There was no population subdivision among olive ridleys along the east India coastline. Low levels of genetic diversity among Atlantic French New Guinea and eastern Pacific Baja California nesting sites are attributed to a population collapse caused by past overharvest (NMFS and USFWS 2014).

Distribution

Globally, olive ridley sea turtles can be found in tropical and subtropical waters in the Atlantic, Pacific and Indian Oceans. Major nesting arribada beaches are found in Nicaragua, Costa Rica, Panama, India and Suriname. The range of the endangered Pacific coast breeding population extends as far south as Peru and up to California. Olive ridley sea turtles of the Pacific coast breeding colonies nest on arribada beaches at Mismaloya, Ixtapilla and La Escobilla, Mexico. Solitary nesting takes place all along the Pacific coast of Mexico.

Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006a; Bartol et al. 1999b; Lenhardt 1994; Lenhardt 2002; Ridgway et al. 1969b). These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 to 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status

Mexico's Pacific Coast Breeding Population

In the first half of the twentieth century, there was an estimated ten million olive ridleys nesting on the Pacific coast of Mexico. Olive ridleys became targeted in a fishery in Mexico and Ecuador, which severely depleted the population; there was an estimated one million olive ridleys by 1969. Olive ridley breeding populations on the Pacific coast of Mexico were listed as endangered in response to this severe population decline. Legal harvest of olive ridleys has been prohibited, although illegal harvest still occurs. The population is threatened by incidental capture in fisheries, exposure to pollutants and climate change. In spite of the severe population decline, the olive ridley breeding populations on the Pacific coast of Mexico appear to be resilient, evidenced by the increasing population.

All Other Populations

It is likely that solitary nesting locations once hosted large arribadas. Since the 1960s, populations have experienced declines in abundance of fifty to eighty percent. Many populations continue to decline. Olive ridley sea turtles continue to be harvested as eggs and adults, legally in some areas, and illegally in others. Incidental capture in fisheries is also a major threat. The olive ridley sea turtle is the most abundant sea turtle in the world; however, several populations are declining as a result of continued harvest and fisheries bycatch. The large population size of the range-wide population, however, allows some resilience to future perturbation.

Critical Habitat

No critical habitat has been designated for olive ridley sea turtles.

Recovery Goals

There has not been a Recovery Plan prepared specifically for olive ridley sea turtles of the breeding populations of the Pacific coast of Mexico. The 1998 Recovery Plan was prepared for olive ridleys found in the U.S. Pacific. Olive ridley sea turtles found in the Pacific could originate from the Pacific coast of Mexico or from another nesting population. As such, the recovery goals in the 1998 Recovery Plan for the U.S. Pacific olive ridley sea turtle can apply to both listed populations. See the 1998 Recovery Plan for the U.S. Pacific olive ridley sea turtles for complete down listing/delisting criteria for their recovery goals. The following items were the recovery criteria identified to consider delisting:

1. All regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters.
2. Foraging populations are statistically significantly increasing at several key foraging grounds within each stock region.
3. All females estimated to nest annually at source beaches are either stable or increasing for over ten years.
4. Management plan based on maintaining sustained populations for turtles is in effect.
5. International agreements in place to protect shared stocks.

7.2.15 Steelhead Trout – Southern California DPS

This DPS includes naturally spawned anadromous *Oncorhynchus mykiss* (steelhead) originating below natural and manmade impassable barriers from the Santa Maria River to the U.S.-Mexico Border (Figure 51).

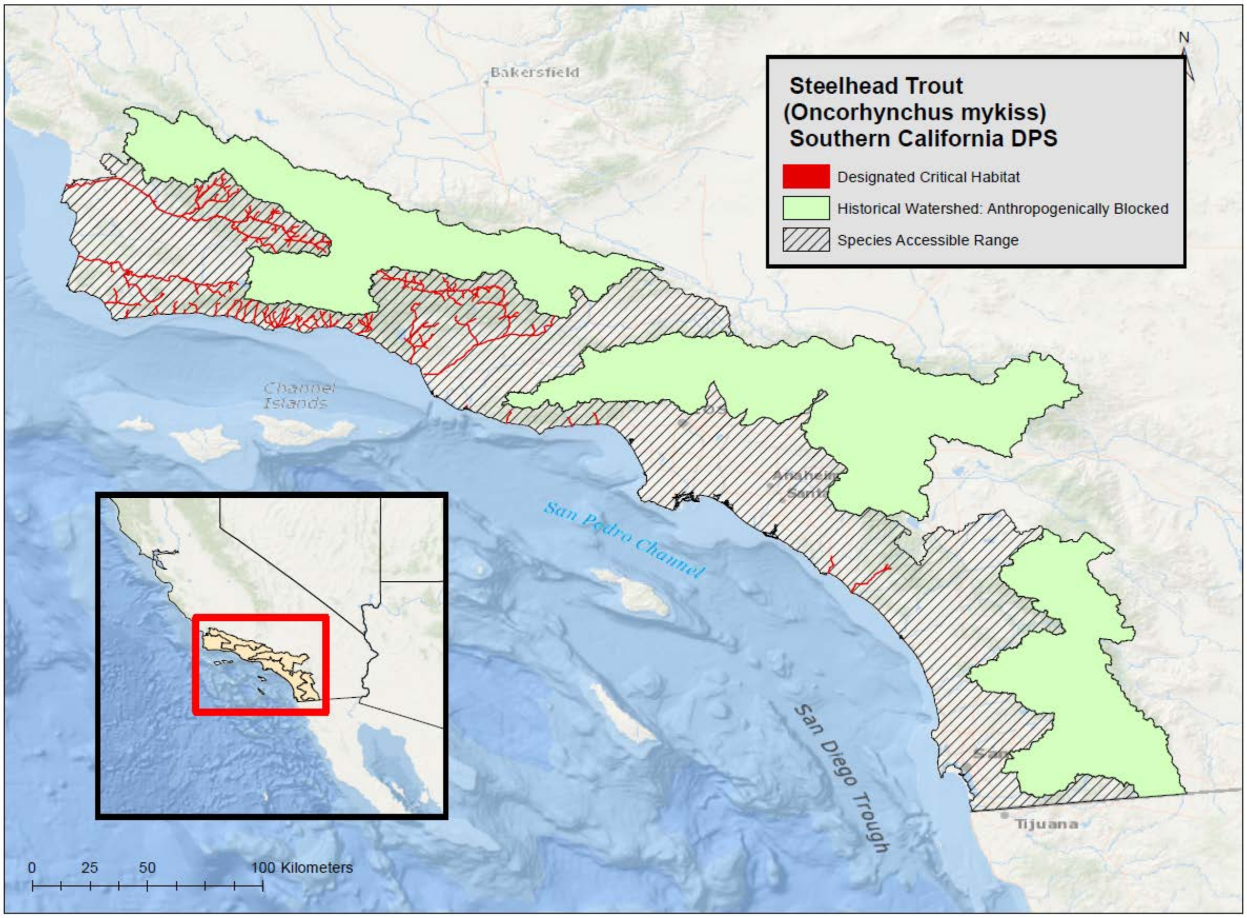


Figure 51. Geographic range a designated critical habitat of Southern California DPS steelhead.

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).

Life history

There is limited life history information for Southern California steelhead. In general, migration and life history patterns of Southern California steelhead populations are dependent on rainfall and stream flow (Moore 1980). Steelhead within this DPS can withstand higher temperatures compared to populations to the north. The relatively warm and productive waters of the Ventura River have resulted in more rapid growth of juvenile steelhead compared to the more northerly populations (Moore 1980). In general, this species spends approximately 1-3 years in freshwater, then migrates rapidly through estuaries, bypassing coastal migration routes of other salmonids, moving into oceanic offshore feeding grounds (Daly et al. 2014; Quinn and Myers 2004).

Population dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to Southern California steelhead.

Limited information exists on Southern California steelhead runs. Based on combined estimates for the Santa Ynez, Ventura, and Santa Clara rivers, and Malibu Creek, an estimated 32,000 to 46,000 adult steelhead occupied this DPS historically. In contrast, less than 500 adults are estimated to occupy the same four waterways presently. The last estimated run size for steelhead in the Ventura River, which has its headwaters in Los Padres National Forest, is 200 adults (Busby et al. 1996).

There are currently no population trend estimates for this DPS. Limited information is available regarding the structural and genetic diversity of the Southern California steelhead.

Vocalizations and Hearing

Data on sound production in species in the family Salmonidae is scarce but they do appear to produce some sounds during spawning that may be used for intraspecific signally, including high and low frequency drumming sounds likely produced by the swimbladder (Neproshin and Kulikova 1975, and Neproshin 1972 as reviewed in Kuznetsov 2009).

Salmonidae are all thought to have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007a). While steelhead hearing has not been tested at frequencies higher than 500 Hz (Hawkins & Johnstone, 1978; Ladich & Fay, 2013), this species can likely hear frequencies up to 1 kHz, similar to other salmonids. Steelheads and other salmonids exhibit similar inner ear and swim bladder morphologies, the latter of which is likely not involved in hearing (Hawkins & Johnstone, 1978).

Status

Trends in abundance and reproductive success of Pacific salmonids are typically observed through monitoring in the streams and rivers in which they spawn. Boughton et al. (2005) assessed the occurrence of steelhead in southern California coastal watersheds in which the species occurred historically by conducting a combination of field reconnaissance and spot checks (snorkel surveys). Surveys indicated that between 38 percent and 45 percent of the streams surveyed in the range of the Southern California steelhead DPS contained the species, but that there were higher extirpation rates in the southern end of the range. Anthropogenic barriers appeared to be the factor most associated with extirpations. Of the 11 streams surveyed that drain into the action area, only San Mateo Creek contained steelhead. Though the authors expressed some uncertainty, NMFS (2005b) concluded that, with the exception of the small population in San Mateo Creek, the anadromous form of the species appears to be completely extirpated from all systems between the Santa Monica Mountains and the Mexican border. The San Mateo Creek population was formerly considered extirpated (Nehlsen et al. 1991), but California Department of Fish and Game documented presence of the species in 2003 NMFS (2005b). Many of the streams in this region contain resident populations of *O. mykiss* ((Boughton et al. 2005); NMFS (2005b)). However, fish from these populations in the watersheds that drain into the HSTT action area (e.g., San Diego River, Sweetwater River, Otay River) are not known to exhibit anadromy due to anthropogenic barriers to fish passage. The most recent monitoring data available for the Southern California steelhead DPS is from watersheds north of the HSTT action area (i.e., Santa Ynez River, Ventura River, Santa Clara River, Topanga Creek, Malibu Creek). Surveys indicated that very small (less than 10 fish), but consistent, runs of the species occur on an annual basis (Ford 2011). A recent status review report for the Southern California steelhead DPS questioned how such small annual runs could persist, and suggested that the runs could be maintained either by strays from some another source population or by production of smolts from the resident population of rainbow trout (Ford 2011).

There is little new evidence to indicate that the status of the Southern California steelhead DPS has changed appreciably in either direction since the last status review (Williams et al. 2011). The extended drought and the recent genetic data documenting the high level of introgression and extirpation of native *O. mykiss* stocks in the southern portion of the DPS has elevated the threats level to the already endangered populations; the drought, and the lack of comprehensive monitoring, has also limited the ability to fully assess the status of individual populations and the DPS as whole. The systemic anthropogenic threats identified at the time of the initial listing have remained essentially unchanged over the past 5 years, though there has been significant progress in removing fish passage barriers in a number of the smaller and mid-sized watersheds. Threats to the Southern California steelhead DPS posed by environmental variability resulting from projected climate change are likely to exacerbate the factors affecting the continued existence of the DPS.

Recovery Goals

See the 2012 recovery plan for the Southern California steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species.

7.2.16 Scalloped Hammerhead Shark – Eastern Pacific DPS

All hammerhead sharks belong to the family *Sphyrnidae* and are classified as ground sharks (order: Carcharhiniformes). The hammerhead sharks are recognized by their laterally expanded head that resembles a hammer, hence the common name “hammerhead.” The scalloped hammerhead shark is distinguished from other hammerheads by a noticeable indentation on center and front portion of the head, along with two more indentations on each side of this central indentation, giving the head a “scalloped” appearance. It has a broadly arched mouth and the back of the head is slightly swept backward.

The scalloped hammerhead shark is found throughout the world (Figure 52) and lives in coastal warm temperate and tropical seas. It occurs over continental shelves and the shelves surrounding islands, as well as adjacent deep waters, but is seldom found in waters cooler than 22°C (Compagno 1984b). It ranges 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). It has also been documented entering enclosed bays and estuaries.

On July 3, 2014, NMFS listed the Eastern Pacific scalloped hammerhead DPS as endangered (79 FR 38213).

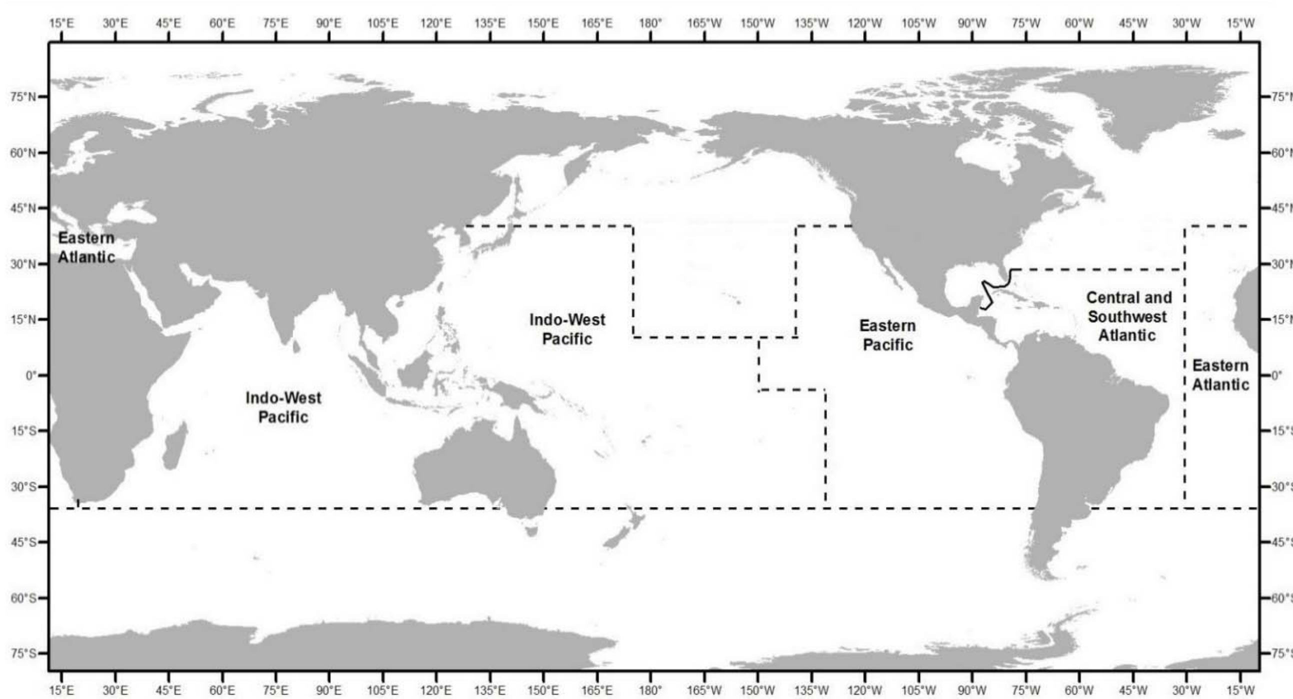


Figure 52. Scalloped hammerhead shark DPS boundaries.

Life history

The scalloped hammerhead shark gives birth to live young (i.e., “viviparous”), with a gestation period of 9-12 months (Branstetter 1987; Stevens and Lyle 1989), which may be followed by a 1-year resting period (Liu and Chen 1999). Females attain maturity around 6.5-8 ft (2.0-2.5 m) total length, while males reach maturity at smaller sizes (range 4-6.5 ft [1.3-2.0 m] total length). The age at maturity differs by region. For example, in the Gulf of Mexico, Branstetter (1987) estimated that females mature at about 15 years of age and males at around 9-10 years of age. In northeastern Taiwan, Chen et al. (1990) calculated age at maturity to be 4 years for females and 3.8 years for males. On the east coast of South Africa, age at sexual maturity for females was estimated at 11 years (Dudley and Simpfendorfer 2006). Parturition, however, does not appear to vary by region and may be partially seasonal, with neonates present year round but with abundance peaking during the spring and summer months (Duncan and Holland 2006; Noriega et al. 2011). Females move inshore to birth, with litter sizes anywhere between 1 and 41 live pups. Off the coast of northeastern Australia, Noriega et al. (2011) found a positive correlation between litter size and female shark length for scalloped hammerheads, as did White et al. (2008) in Indonesian waters. However, off the northeastern coast of Brazil, Hazin et al. (2001) found no such relationship. Size at birth is estimated between 1 ft and 2 ft (0.3-0.6 m) total length.

Population Dynamics

Historical estimates of effective population size (or the number of breeding individuals in the population) in the eastern Pacific range from 34,995 to 43,551 individuals (Nance et al. 2011). Using 15 microsatellite loci and mitochondrial DNA from eastern Pacific tissue samples, Nance et al. (2011) discovered that the current effective population size is significantly smaller (1-3 orders of magnitude) than the historical effective population size, indicating that scalloped hammerheads in the eastern Pacific experienced a bottleneck and suffered significant declines. While current abundance data for this DPS are sparse, local and regional population declines have been indicated from recent fishery dependent data. Using fishing mortality estimates calculated from 1997 and 1998 catches, INP (2006) estimated that the scalloped hammerhead shark population in the Gulf of Tehuantepac (Mexico) is decreasing by six percent per year. In Michoacán, hammerheads represent 70 percent of the catch, with fishing effort concentrated in breeding areas and directed towards juveniles and pregnant females (CITES 2012). In Costa Rica, shark catches reported by artisanal and longline fisheries have shown a dramatic decline (~50%) after reaching a maximum of 5,000 tonnes in 2000 (SINAC 2012). Available data on relative abundance of pelagic sharks in general in the Costa Rica Exclusive Economic Zone (EEZ) suggest sharp declines (approximately 58%) between 1991 and 2002 (Arauz et al. 2004).

Vocalization and Hearing

Scalloped hammerhead sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Myrberg 2001; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012a). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes, including scalloped hammerheads, suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012a; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013b; Myrberg 1978; Myrberg 2001; Olla 1962). A study involving unidentified hammerhead sharks of the genus Sphyrna, indicates attraction to low frequency sound between 20 and 60 Hz (Nelson and Gruber 1963). However, a study specifically on scalloped hammerheads found no attraction to similar low frequency sound (Klimley and Nelson. 1981).

Status

Evidence of heavy fishing pressure by artisanal fisherman, limited regulatory mechanisms and poor enforcement indicate that the Eastern Pacific DPS is currently at or near a level of abundance and productivity that places its current and future persistence in question (Miller et al. 2014).

Critical Habitat

No critical habitat has been designated for the scalloped hammerhead shark.

Recovery Goals

NMFS has not prepared a recovery plan for the scalloped hammerhead shark.

7.2.17 Oceanic Whitetip Shark

The oceanic whitetip shark is distributed worldwide in tropical and subtropical waters between 10° North and 10° South, usually found in open ocean and near the outer continental shelf (Figure 53).

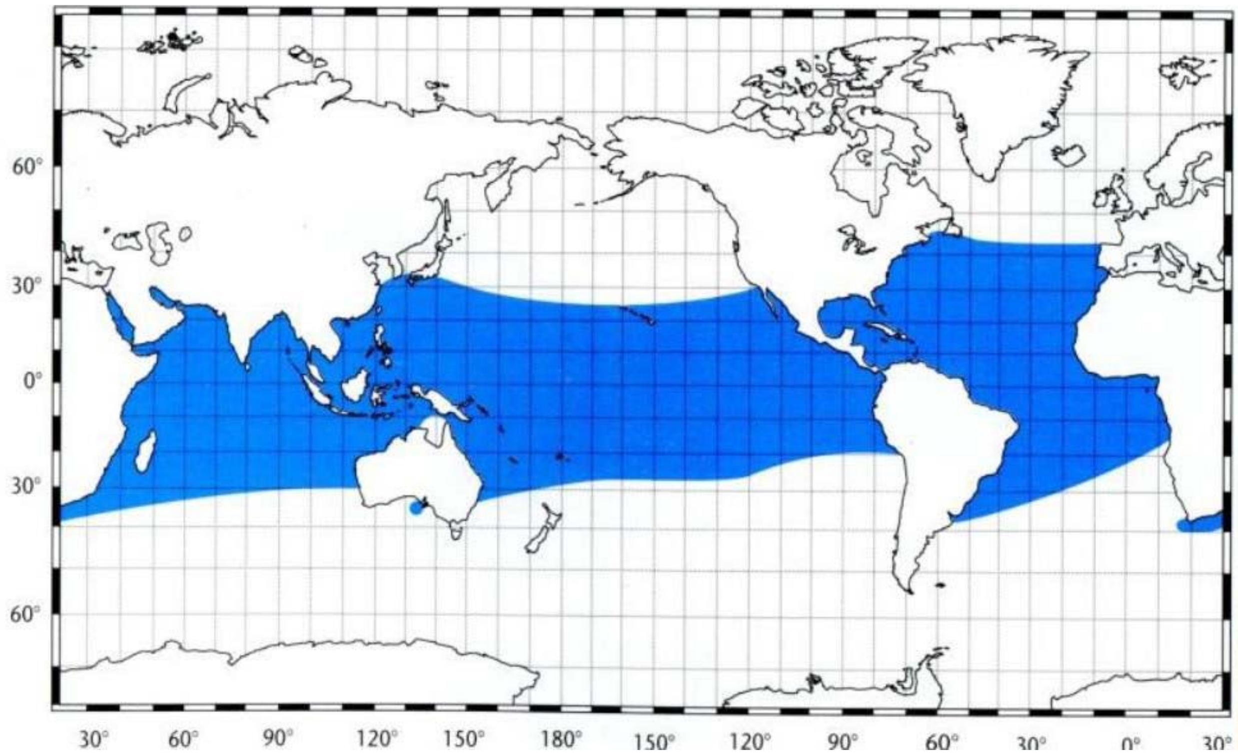


Figure 53. Geographic range of the oceanic whitetip shark [adapted from Last and Stevens (2009)].

Oceanic whitetip sharks have very long and wide paddle-shaped pectoral fins with characteristic mottled white tips (also present on the front dorsal and caudal fins). Its body is grayish bronze to brown, and white underneath. Adults can grow up to 3.4 m and 230 kilograms. The oceanic whitetip shark was listed as threatened under the ESA on January 30, 2018.

We used information available in the 2017 Status Review (Young et al. 2017), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

Life History

The oceanic whitetip shark gives birth to live young (i.e., "viviparous"). Their reproductive cycle is thought to be biennial, giving birth on alternate years, after a lengthy 10 to 12-month gestation period. The number of pups in a litter ranges from one to 14 (mean = 6), and a positive correlation between female size and number of pups per litter has been observed, with larger sharks producing more offspring (Bonfil et al. 2008; Compagno 1984a; IOTC 2014; Seki et al. 1998). Not a great deal is known about oceanic whitetip sharks' lifespan. Estimates range from 12 to 13 years (Lessa et al. 1999; Seki et al. 1998), to 17 years, and even up to 20 years old (Young et al. 2017). They are a slow-growing species, and growth rates are believed to be similar between the sexes (Joung et al. 2016; Lessa et al. 1999; Seki et al. 1998; Young et al. 2017). Age at maturity varies by ocean region, with six to seven years old recorded in the southwest Atlantic, and four to nine years old in the North Pacific, with the sexes having similar ages at maturity (Joung et al. 2016; Lessa et al. 1999; Seki et al. 1998).

Little is known about the movement or possible migration paths of the oceanic whitetip shark. Although the species is considered highly migratory and capable of making long distance movements, tagging data provides evidence that this species also exhibits a high degree of philopatry (i.e., site fidelity) in some locations. In the Atlantic, young oceanic whitetip sharks have been found well offshore along the southeastern coast of the U.S., suggesting that there may be a nursery in oceanic waters over this continental shelf (Bonfil et al. 2008; Compagno 1984a). In the southwestern Atlantic, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho et al. 2009; Frédou et al. 2015; Tambourgi et al. 2013; Tolotti et al. 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi et al. 2013). Pregnant females are often found close to shore, particularly around the Caribbean Islands.

Oceanic whitetip sharks are regarded as opportunistic feeders, eating teleosts (bony fishes) and cephalopods. Large pelagic fish species commonly found in the stomachs of oceanic whitetips include, blackfin tuna, white marlin, and barracuda.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the oceanic whitetip shark.

There is no range-wide abundance estimate available for oceanic whitetip sharks. However, the species was once one of the most abundant sharks in the ocean. Catch data from individual ocean basins indicate that the populations have undergone significant declines (Young et al. 2017). In the Northwest Atlantic and Gulf of Mexico, declines are estimated to be between 57 and 88 percent (Young et al. 2017). Populations in the Eastern Pacific Ocean are thought to have declined between 80 and 90 percent since the late 1990s (Hall 2013). Although generally not targeted, due to their vertical and horizontal distribution oceanic whitetip sharks are frequently caught as bycatch in many fisheries, including pelagic longline fisheries targeting tuna and swordfish, purse seine, gillnet, and artisanal fisheries. They are also a preferred species for their large, morphologically distinct fins, as they obtain a high price in the Asian fin market.

While there is limited research on the genetic diversity of oceanic whitetip sharks, that which exists indicates low genetic diversity. Compared to other pelagic sharks (e.g., silky sharks (*Carcharhinus falciformis*), oceanic whitetip sharks display relatively low mitochondrial DNA genetic diversity (Camargo et al. 2016; Clarke et al. 2015; Ruck 2016). As noted previously, the species appears to display a high degree of philopatry to certain sites, with females giving birth on one side of a basin or the other, indicating little if any mixing with individuals of other regions (Howey-Jordan et al. 2013; Tolotti et al. 2015; Young et al. 2017). Thermal barriers (i.e., water temperatures less than 15° C) may prevent inter-ocean basin movements. Based in genetic analyses, there is significant population structuring between the Western Atlantic and Indo-Pacific Ocean populations (Ruck 2016).

Oceanic whitetip sharks are distributed throughout open ocean waters, the outer continental shelf, and around oceanic islands, primarily from 10° North to 10° South, but up to 30° North and 35° South (Young et al. 2017). They can be found at the ocean surface and down to at least 152 m deep, but most frequently stay between depths of 25.5 and 50 m (Carlson and Gulak 2012; Young et al. 2017). They display a preference for water temperatures above 20° Celsius, but can be found in waters between 15° and 28° Celsius, and can briefly tolerate waters as cold as 7.75° Celsius during dives to the mesopelagic zone (Howey-Jordan et al. 2013; Howey et al. 2016).

In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. Essential Fish Habitat for the oceanic whitetip shark includes localized areas in the central Gulf of Mexico and Florida Keys, and depths greater than 200 m in the Atlantic (from southern New England to Florida, Puerto Rico, and the U.S. Virgin Islands). In the Northwest Atlantic, historically the species was widespread, abundant, and the most common pelagic shark warm waters (Backus et al. 1956). However, recent information suggests the species is now relatively rare in this region (Young et al. 2017).

Vocalization and Hearing

Oceanic whitetip sharks are elasmobranchs and like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Myrberg 2001; Myrberg et al. 1978; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012a). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001).

Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012a; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013b; Myrberg 2001). Studies involving oceanic whitetip sharks show attraction to low frequency sounds, particularly those between 25 and 50 Hz, with less but still noticeable attraction at higher frequencies between 500 and 1,000

Hz (Myrberg 2001; Myrberg et al. 1975a; Myrberg et al. 1975b; Myrberg et al. 1976; Myrberg et al. 1978).

Status

In addition to declines in oceanic whitetip catches throughout its range, there is also evidence of declining average size over time in some areas, and is a concern for the species' status given evidence that litter size is potentially correlated with maternal length. Such extensive declines in the species' global abundance and the ongoing threat of overutilization, the species' slow growth and relatively low productivity, makes them generally vulnerable to depletion and potentially slow to recover from overexploitation. Related to this, the low genetic diversity of oceanic whitetip sharks is also cause for concern and a viable risk over the foreseeable future for this species. Loss of genetic diversity can lead to reduced fitness and a limited ability to adapt to a rapidly changing environment. The biology of the oceanic whitetip shark indicates that it is likely to be a species with low resilience to fishing and minimal capacity for compensation (Rice and Harley 2012).

Critical Habitat

No critical habitat has been designated for the oceanic whitetip shark.

Recovery Goals

NMFS has not prepared a recovery plan for the oceanic whitetip shark.

7.2.18 Giant Manta Ray

The giant manta ray is an elasmobranch species that occupies tropical, subtropical, and temperate oceanic waters and productive coastlines (Figure 54).

Figure 54. Map depicting the range of the giant manta ray [adapted from Lawson et al. (2017)]

Giant manta rays a diamond-shaped body with wing-like pectoral fins measuring up to 25 ft (8 m) across. On January 22, 2018, NMFS published a final rule listing the giant manta ray (*Manta birostris*) as threatened under the ESA.

We used information available in the 2017 Status Review (Miller and Klimovich 2017), the final ESA-listing rule, and the scientific literature to summarize the life history, population dynamics, and status of the species, as follows.

Life History

Giant manta rays reach sexual maturity at about 10 years old. They are viviparous, giving birth to one pup every two to three years. Gestation lasts between 12 to 13 months. Giant manta rays can live up to 40 years, so a female may only produce between five to 15 pups in a lifetime (FAO 2012).

Giant manta rays are migratory, capable of undertaking migrations up to 1,500 km (Graham et al. 2012; Hearn et al. 2014), although some tagged individuals have been observed staying in the same location (Stewart et al. 2016). Giant manta rays have been observed in aggregations of 100 to 1,000 individuals (Miller and Klimovich 2017; Notarbartolo-di-Sciara and Hillyer 1989), at particular sites. These sites are thought to be feeding or cleaning locations, or where courtships take place.

Giant manta rays are planktivores, using gill plates (also known as gill rakers) to feed on zooplankton. They conduct night descents to between 200 and 450 m, and can even dive to depths of over 1,000 m. During the day, they can also be found feeding in shallow waters (less than 10 m) (Miller and Klimovich 2017).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the giant manta ray.

There are no current or historical estimates of range-wide abundance, although there are some rough estimates of subpopulation size based on anecdotal accounts from fishermen and divers. It is difficult to obtain reliable abundance estimates as the species is only sporadically observed. There are about 11 subpopulations estimates worldwide (perhaps more), and these subpopulation estimates range from 100 to 1,500 individuals each (FAO 2012; Miller and Klimovich 2017). The only abundance data for giant manta rays in the Atlantic comes from two sources; the Flower Garden Banks Marine Sanctuary in the Gulf of Mexico, with more than 70 individuals, and in the waters off Brazil, with about 60 individuals (Miller and Klimovich 2017).

There is not a great deal of information on the population structure of giant manta ray. Some evidence suggests that there are isolated subpopulations (Stewart et al. 2016), and possibly a subspecies resident to the Yucatán (Hinojosa-Alvarez et al. 2016).

Data on population trends globally are largely unavailable. However, there have been decreases in landings of up to 95 percent in the Indo-Pacific, though these declines have not been observed in other subpopulations such as Mozambique and Ecuador (Miller and Klimovich 2017).

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). In the Atlantic Ocean, giant manta rays have been observed as far north as New Jersey.

Vocalization and Hearing

Giant manta rays are elasmobranchs, and although there is no known information on their sound production and hearing abilities, these abilities have been studied in other elasmobranchs species. Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders, and thus are unable to detect sound pressure (Casper et al. 2012a). The lack of a swimbladder also means elasmobranchs are not capable of producing many of the sounds produced by teleost fish that have swim bladders. In fact, elasmobranchs likely produce very few sounds, if any, and instead focus on listening to the sounds of their prey (Myrberg 2001). Data for elasmobranchs fishes suggest they can detect sound between 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012a; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009a; Ladich and Fay 2013b; Myrberg 2001).

Status

The Status Review found that giant manta rays are at risk throughout a significant portion of their range, due in large part to the observed declines in the Indo-Pacific. There are few known natural threats to giant manta rays. Disease and shark attacks were ranked as low risk threats, and giant manta rays exhibit high survival rates after maturity (Miller and Klimovich 2017).

The most significant threat to giant manta ray populations is commercial fishing. Giant manta rays are a targeted species for the mobuild gill raker market. Gills from mobuilds (i.e., rays of the genus *Mobula*, including *Manta* spp.) are dried and sold in Asian dried seafood and traditional Chinese medicine markets (O'Malley et al. 2017). Sources for gill rakers sold in these markets include China, Indonesia, Vietnam, Sri Lanka, and India; one market in Guangzhou, China, accounts for about 99 percent of the total market volume. In 2011, there was an estimated 60.5 tons of mobuild gill rakers, which almost doubled to 120.5 tons in 2015 (O'Malley et al. 2017).

In addition to the threat from directed fishing, giant manta rays are also captured incidentally in industrial purse seine and artisanal gillnet fisheries. Incidental bycatch is a particular concern in the eastern Pacific Ocean, and the Indo-Pacific (Miller and Klimovich 2017).

Designated Critical Habitat

No critical habitat has been designated for the giant manta ray.

Recovery Goals

NMFS has not prepared a recovery plan for the giant manta ray.

7.3 Designated Critical Habitat that May be Affected

This section examines critical habitat in the action area that may be affected by the proposed action and discusses the condition and current function of such habitats, including the physical and biological features (PBFs) that contribute to that conservation value of the critical habitat.

7.3.1 Black Abalone

Critical habitat was designated for black abalone on October 27, 2011 (76 FR 66805). Most of the designated critical habitat lies along the California coast north of the action area (Figure 55). Designated critical habitat includes rocky intertidal and subtidal habitats from the mean higher high water line to a depth of approximately 20 ft (6 m), as well as the waters encompassed by these areas. Designated critical habitat extends from Del Mar Landing Ecological Reserve to the Palos Verdes Peninsula.

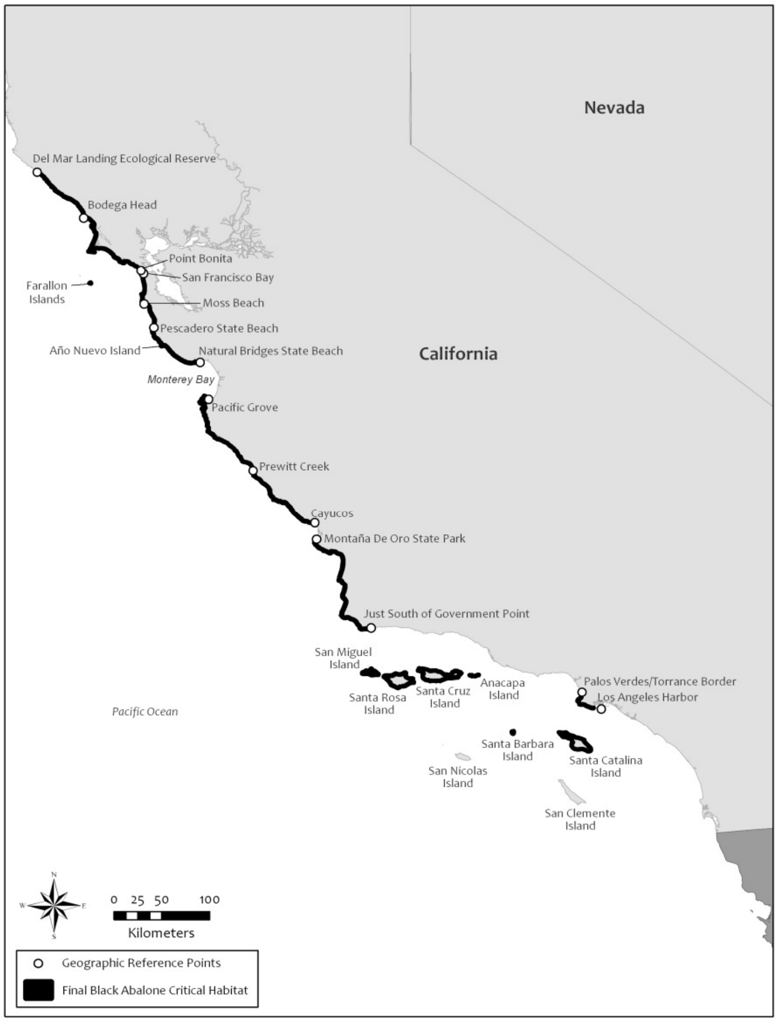


Figure 55. Designated critical habitat for black abalone.

Within the action area, critical habitat occurs on Santa Catalina and Santa Barbara Islands. The specific areas proposed for designation off San Nicolas and San Clemente Islands were determined to be ineligible for designation because the Navy's Integrated Natural Resources Management Plans provide benefits to black abalone in those areas. The critical habitat designation identified primary constituent elements, which are habitat elements essential for the conservation of the species. The primary constituent elements for black abalone are rocky substrate, food resources, juvenile settlement habitat, suitable water quality, and suitable nearshore circulation patterns.

7.3.2 Hawaiian Monk Seal

Hawaiian monk seal critical habitat was originally designated on April 30, 1986 (51 FR 16047) and was extended on May 26, 1988 (53 FR 18988). It includes all beach areas, sand spits, and islets (including all beach crest vegetation to its deepest extent inland), lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms (37 m) around the northwestern Hawaiian islands breeding atolls and islands. The marine component of this habitat serves as foraging areas, while terrestrial habitat provides resting, pupping, and nursing habitat.

On September 21, 2015, NMFS published a final rule to revise critical habitat for Hawaiian monk seals (80 FR 50925), extending the current designation in the northwestern Hawaiian islands out to the 200 m depth contour (including Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island) (Figure 56). It also designates six new areas in in the main Hawaiian islands (i.e., terrestrial and marine habitat from five meters inland from the shoreline extending seaward to the 200 m depth contour around Kaula, Niihau, Kauai, Oahu, Maui Nui, and Hawaii).

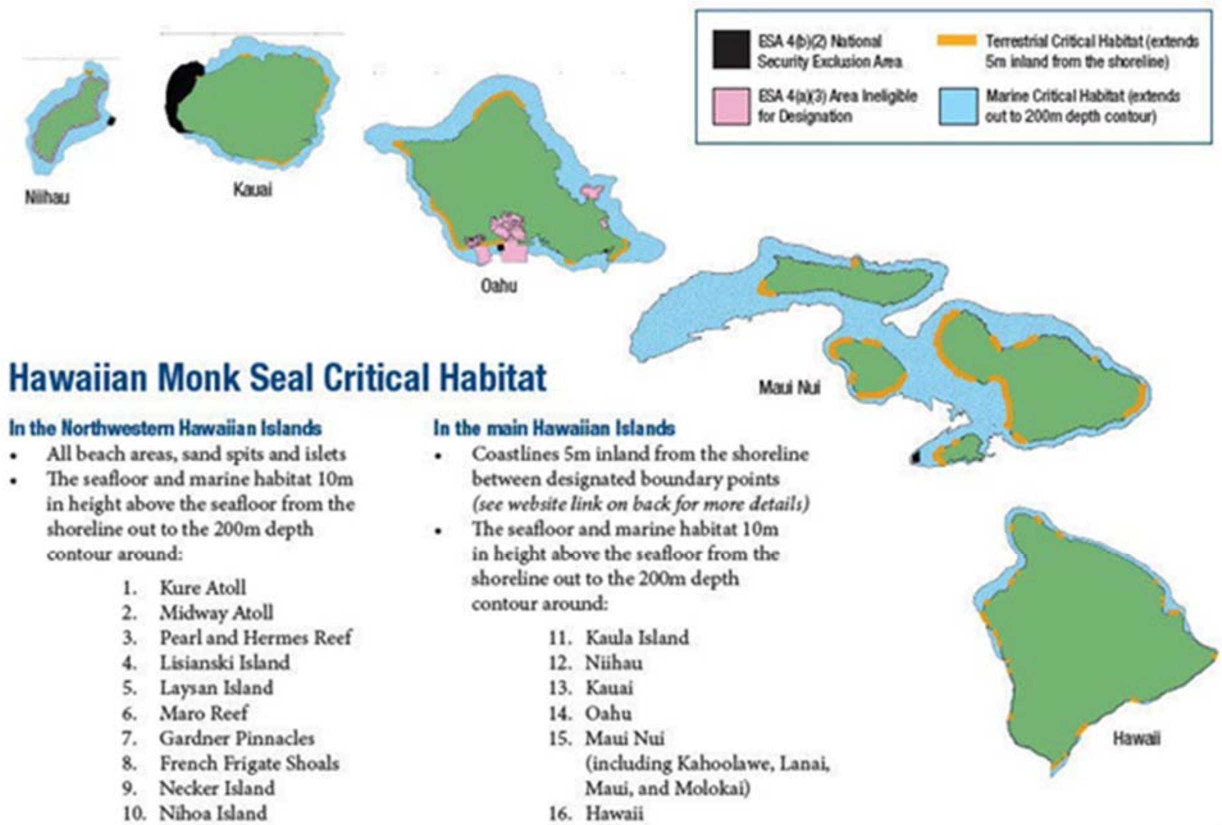


Figure 56. Hawaiian monk seal designated critical habitat.

The physical and biological features of designated critical habitat for monk seals essential for the conservation of the species include the following:

- Terrestrial areas and adjacent shallow, sheltered aquatic areas with characteristics preferred by monk seals for pupping and nursing
- Marine areas from 0 to 200 m in depth that support adequate prey quality and quantity for juvenile and adult monk seal foraging
- Significant areas used by monk seals for hauling out, resting, or molting

7.3.3 Main Hawaiian Islands Insular DPS False Killer Whale

Critical habitat for the MHI IFKW was designated on July 24, 2018, with an effective date of August 23, 2018 (83 FR 35062). The designation includes waters from the 45 m depth contour to the 3,200 m depth contour around the Main Hawaiian Islands. Parts of the designation are excluded for national security or economic reasons (Figure 57).

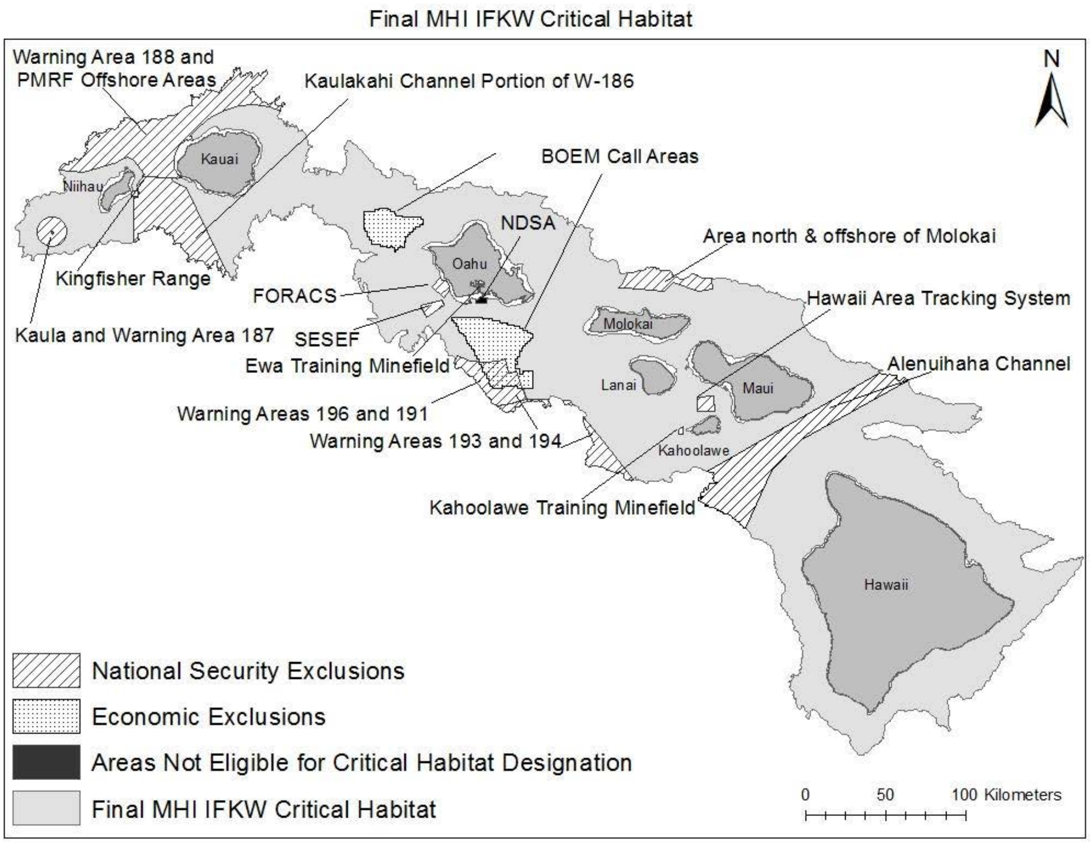


Figure 57. Designated critical habitat for Main Hawaiian Islands Insular DPS false killer whale.

The designated critical habitat includes one PBF essential for conservation of the species, with the following four characteristics:

- Adequate space for movement and use within shelf and slope habitat.
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth.
- Waters free of pollutants of a type and amount harmful to MHI IFKWs.
- Sound levels that would not significantly impair false killer whales' use or occupancy.

Of importance to this consulation, the MHI IFKW diet consists primarily of pelagic fish and squid (NMFS 2018a), but without further information on prey preferences, NMFS was unable to determine where prey resources of higher value exist for MHI IFKW within or outside designated critical habitat (NMFS 2018a). MHI IFKW prey may include various tuna species, marlin species, jack species, mahi mahi, wahoo, moonfish, and squid (NMFS 2018a). Recent stomach content analysis from MHI IFKWs that stranded from 2010-2016 has detected seven Genus of fish and four species of cephalopods. Of those, diamondback squid (*Thysanoteuthis rhombus*) were the most common prey item.

Regarding the characteristic specific to sound levels, the final rule to designate critical habitat defined these sound levels as those that inhibit MHI IFKW's "*…ability to receive and interpret sound for the purposes of navigation, communication, and detection of predators and prey. Such noises are likely to be long-lasting, continuous, and/or persistent in the marine environment and, either alone or added to other ambient noises, significantly raise local sound levels over a significant portion of an area*" (83 FR 35062). The final biological report developed in support of the final rule discussed the complexity of analyzing how human activities may change an animal's use of an area (NMFS 2018a). The biological report emphasized that "*…the duration of the offending or masking noise will determine whether the effects or degradation to the habitat may be temporary or chronic, and whether such alterations to the soundscape may alter the conservation value of that habitat*" (NMFS 2018a).

The final rule to designate critical habitat identified several activities that may threaten the PBF essential to conservation such that species management considerations or protections may be required. Major categories of activities included in the final rule were (1) in-water construction (including dredging); (2) energy development (including renewable energy projects); (3) activities that affect water quality; (4) aquaculture/mariculture; (5) fisheries; (6) environmental restoration and response activities (including responses to oil spills and vessel groundings, and marine debris clean-up activities); and (7) some military readiness activities.

8 ENVIRONMENTAL BASELINE

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 (50 C.F.R. §402.02).

8.1 Global Climate Change

Global annually averaged surface air temperature has increased by about 1.8 degrees Fahrenheit (1.0 degrees Celsius) over the last 115 years (1901 to 2016) (Wuebbles et al. 2017). This period is now the warmest in the history of modern civilization. It is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence (Wuebbles et al. 2017). These global trends are expected to continue over climate timescales. The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse gases (especially carbon dioxide) emitted globally. Without major reductions in emissions, the increase in annual average global temperature relative to preindustrial times could reach nine degrees Fahrenheit (five degrees Celsius) or more by the end of this century (Wuebbles et al. 2017). With significant reductions in emissions, the increase in annual average global temperature could be limited to 3.6 degrees Fahrenheit (two degrees Celsius) or less (Wuebbles et al. 2017). The global atmospheric carbon dioxide concentration has now passed 400 parts per million, a level that last occurred about three million years ago, when both global average temperature and sea level were significantly higher than today. There is broad consensus that the further and the faster the Earth system is pushed towards warming, the greater the risk of unanticipated changes and impacts, some of which are potentially large and irreversible (Wuebbles et al. 2017).

Changes in air and sea surface temperatures can affect marine ecosystems in several ways including changes in ocean acidity, precipitation patterns, sea level, and ocean currents. Global average sea level has risen by about seven to eight inches since 1900, with almost half (about three inches) of that rise occurring since 1993. Human-caused climate change has made a substantial contribution to sea level rise, contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years (Wuebbles et al. 2017). Global average sea levels are expected to continue to rise by at least several inches in the next 15 years, and by one to four feet by 2100. Ocean circulation for major basin wide currents is also thought to have been influenced by climate change including intensity and position of western boundary currents (Gennip et al. 2017). These changes have potential for impact to the rest of the biological ecosystem in terms of nutrient availability as well as phytoplankton and zooplankton distribution (Gennip et al. 2017).

Effects of climate change on marine species include altered reproductive seasons and locations, shifts in migration patterns, reduced distribution and abundance of prey, and changes in the abundance of competitors and/or predators. Variations in sea surface temperature can affect an ecological community's composition and structure, alter migration and breeding patterns of fauna and flora and change the frequency and intensity of extreme weather events. For species that undergo long migrations (e.g., whales, sea turtles), individual movements are usually associated with prey availability or habitat suitability. If either is disrupted, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). Over the long term, increases in sea surface temperature can also reduce the amount of nutrients supplied to surface waters from the deep sea leading to declines in fish populations (EPA 2010), and, therefore, declines in those species whose diets are dominated by fish. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence.

The potential for invasive species to spread may increase under the influence of climatic change. As water temperatures warm, native species ranges may shift poleward, opening ecological niches that could be occupied by invasive species introduced via ships ballast water or other sources (Philippart et al. 2011; Ruiz et al. 1999). Invasive species that are better adapted to warmer water temperatures can also outcompete native species that are physiologically geared towards lower water temperatures (Lockwood and Somero 2011). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott. 2009). For example, it has been suggested that increases in harmful algal blooms could result from increases in sea surface temperature (Simmonds and Eliott. 2009). Moore et al. (2011) estimated that the impacts of a dinoflagellate establishment would likely intensify with a warming climate, resulting in roughly 13 more days of potential bloom conditions per year by the end of the 21st century.

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the community structure and function of marine, coastal, and terrestrial ecosystems in the near future (IPCC 2014; McCarty 2001). Climate change will likely have its most pronounced effects on vulnerable species whose populations are already in tenuous positions (Williams et al. 2008). As such, we expect the risk of extinction for ESA-listed species to rise with the degree of climate shift associated with global warming. Increasing atmospheric temperatures have already contributed to documented changes in the quality of freshwater, coastal, and marine ecosystems and to the decline of endangered and threatened species populations (Karl 2009; Mantua et al. 1997).

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). Climate-related shifts in marine mammal range and distribution have been observed in some populations (Silber et al. 2017). Marine mammal species often exhibit strong dependence on or fidelity to particular habitat types, oceanographic features, and migration routes (Sequeira et al. 2018). Specialized diets, restricted ranges, or reliance on specific substrates or sites (e.g., for pupping) make many marine mammal populations particularly vulnerable to climate change (Silber et al. 2017). Marine mammals with restricted distributions linked to water temperature may be exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, 47 percent would be negatively affected, and 21 percent would be put at risk of extinction. 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. He 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 sea turtles were predicted to gain core habitat area, whereas loggerhead sea turtles and blue whales were predicted to experience losses in available core habitat. Such range shifts could affect marine mammal and sea turtle foraging success as well as sea turtle reproductive periodicity (Birney et al. 2015; Pike 2014).

Shifting ranges of important prey item for marine mammals have been observed across all ocean regions (Poloczanska et al. 2016). Climate change can influence marine mammal reproductive success and fitness by altering prey availability. For example, reduced prey availability resulting from increased sea surface temperatures has been suggested to explain lower rates of conception in female sperm whales (Whitehead 1997). Breeding in many marine mammal species may be timed to coincide with maximum abundance of suitable prey, either for the lactating mother or the calf at weaning, so that any changes in the environmental conditions which determine prey abundance may cause a mismatch in synchrony between predator and prey, either in time or location (Learmonth et al. 2006). Migratory species that travel long distances between feeding and breeding areas may be particularly vulnerable to mismatching.

Significant impacts to marine mammals and sea turtles from ocean acidification will be indirectly tied to foraging opportunities resulting from ecosystem changes (Busch et al. 2013; Chan et al. 2017; Haigh et al. 2015). Nearshore waters off California have already shown a persistent drop in pH from the global ocean mean pH of 8.1 to as low as 7.43 (Chan et al. 2017). The distribution, abundance and migration of baleen whales reflects the distribution, abundance and movements of dense prey patches (e.g., copepods, euphausiids or krill, amphipods, and shrimp), which have in turn been linked to oceanographic features affected by climate change (Learmonth et al. 2006). Ocean acidification may cause a shift in phytoplankton community composition and biochemical composition that can impact the transfer of essential compounds to predators that eat plankton (Bermúdez et al. 2016). 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). Krill have been shown to suffer decreased larval development and survival under lower pH conditions (McLaskey et al. 2016). Krill also have lower metabolic rates after both short-term and long-term exposure to low pH (Cooper et al. 2016). Increased ocean acidification may also have serious impacts on fish development and behavior (Raven et al. 2005), including sensory functions (Bignami et al. 2013) and fish larvae behavior that could impact fish populations (Munday et al. 2009) and piscivorous ESA-listed species that rely on those populations for food.

Sea turtles occupy a wide range of terrestrial and marine habitats, and many aspects of their life history have been demonstrated to be closely tied to climatic variables such as ambient temperature and storminess (Hawkes et al. 2009). Pike et al. (2006) concluded that warming sea surface temperatures may lead to potential fitness consequences in sea turtles resulting from altered seasonality and duration of nesting. Sea turtles may also expand their range as temperature-dependent distribution limits change (McMahon and Hays 2006; Poloczanska et al. 2009a).

Sea turtles have temperature-dependent sex determination, and many populations produce highly female-biased offspring sex ratios, a skew likely to increase further with global warming (Jensen et al. 2018; Newson et al. 2009; Patrício et al. 2017). Within the action area for this opinion, female biased green sea turtle sex ratios have been reported at foraging locations in San Diego Bay, California (Allen et al. 2017). For the Hawaii green sea turtle population, Chaloupka et al. (2008) reported no gender bias in strandings data from 1982-2003. The most recent (2014) pubished sea turtle strandings report for Hawaii also indicates little to no apparent bias in green sea turtle sex ratio (50 females, 43 males, 155 unknown/indeterminable) (NMFS 2015b). However, preliminary (unpublished) data from Allen et al. (2017) suggests there may be a female biased sex ratio in this population. Genetic analyses and behavioral data suggest that populations with temperature-dependent sex determination may be unable to evolve rapidly enough to counteract the negative fitness consequences of rapid global temperature change (Hays 2008 as cited in Newson et al. 2009). Altered sex ratios have been observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not yet appear to have affected population viabilities through reduced reproductive success, although average nesting and emergence dates have changed over the past several decades by days to weeks in some locations (Poloczanska et al. 2009a). A fundamental shift in population demographics may lead to increased instability of populations that are already at risk from several other threats. In addition to altering sex ratios, increased temperatures in sea turtle nests can result in reduced incubation times (producing smaller hatchling), reduced clutch size, and reduced nesting success due to exceeded thermal tolerances (Azanza-Ricardo et al. 2017; Fuentes et al. 2010; Fuentes et al. 2011; Fuentes et al. 2009b).

Other climatic aspects, such as extreme weather events, precipitation, ocean acidification and sea level rise also have potential to affect marine turtle populations. Changes in global climatic patterns will likely have profound effects on the coastlines of every continent, thus directly impacting sea turtle nesting habitat (Wilkinson and Souter 2008). In some areas, increases in sea level alone may be sufficient to inundate turtle nests and reduce hatching success by creating hypoxic conditions within inundated eggs (Caut et al. 2009; Pike et al. 2015). Flatter beaches, preferred by smaller sea turtle species, would likely be inundated sooner than would steeper beaches preferred by larger species (Hawkes et al. 2014). Relatively small increases in sea level can result in the loss of a large proportion of nesting beaches in some locations. For example, a study in the northwestern Hawaiian Islands predicted that up to 40 percent of green turtle nesting beaches could be flooded with a 0.9 m sea level rise (Baker et al. 2006). The loss of nesting beaches would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form, or if the newly formed beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. Poloczanska et al. (2009b) noted that extant marine turtle species have survived past climatic shifts, including glacial periods and warm events, and therefore may have the ability to adapt to ongoing climate change (e.g., by finding new nesting beaches). However, the authors also suggested since the current rate of warming is very rapid, expected changes may outpace sea turtles' ability to adapt. Sea level rise is also predicted to result in significant levels of terrestrial habitat loss for ESA-listed Hawaiian monk seals within the HSTT action area. Monk seals may experience more crowding and competition for landing sites when islands shrink.

Changing patterns of coastal erosion and sand accretion, combined with an anticipated increase in the number and severity of extreme weather events, may further exacerbate the effects of sea level rise on turtle nesting beaches (Wilkinson and Souter 2008). Climate change is expected to affect the intensity of hurricanes through increasing sea surface temperatures, a key factor that influences hurricane formation and behavior (EPA 2010). Extreme weather events may directly harm sea turtles, causing "mass" strandings and mortality (Poloczanska et al. 2009a). Studies examining the spatio-temporal coincidence of marine turtle nesting with hurricanes, cyclones and storms suggest that cyclical loss of nesting beaches, decreased hatching success and hatchling emergence success could occur with greater frequency in the future due to global climate change (Hawkes et al. 2009).

Studies examining the effects of long-term climate change to salmon and steelhead populations have identified a number of common mechanisms by which climate variation is likely to influence sustainability of steelhead populations (NMFS 2016b). Climate effects on salmonids tend to be negative across multiple life-stages (Wade et al. 2013; Wainwright and Weitkamp 2013). Considering the action area for this opinion, we focus here on the effects of climate change on steelhead in the marine environment. Northward range shifts are a climate response expected in many marine fish species, including salmon (Cheung et al. 2015). Steelhead marine migration patterns could be affected by climate-induced contraction of thermally suitable habitat. Abdul-Aziz et al. (2011) modeled changes in summer thermal ranges in the open ocean for Pacific salmon and steelhead under multiple Intergovernmental Panel on Climate Change warming scenarios. For steelhead, they predicted contractions in suitable marine habitat of 30-50 percent by the 2080s under the medium and high greenhouse gas emissions scenarios.

Numerous researchers have reported that salmon and steelhead marine survival is highly variable over time and often correlated with large-scale climate indices (Litzow et al. 2014; Petrosky and Schaller 2010; Stachura et al. 2013; Sydeman et al. 2014). Many fish communities, including key salmon and steelhead prey and predators, experience changes in abundance and distribution during warm ocean periods (Cheung et al. 2009; Pearcy 2002). However, food chain dynamics in the open ocean are flexible and difficult to predict into the future, and in the case of steelhead poorly understood (Grimes 2007). To what extent a future warmer ocean will mimic historic conditions of warm-ocean, low-survival periods is not known. Current indications are that a warmer Pacific Ocean is generally less productive at mid latitudes, and hence likely to be less favorable for salmon and steelhead (NMFS 2016b). The full implications of ocean acidification on salmon are not known at this time (Council 2010). Olfaction and predator-avoidance behavior are negatively affected in some fish species, including pink salmon (Leduc et al. 2013; Ou et al. 2015). Pink salmon also showed reductions in growth and metabolic capacity under elevated carbon dioxide conditions (Ou et al. 2015). Some high-quality salmon prey (e.g., krill) might be negatively affected by ocean acidification, but there are several possible pathways by which higher trophic levels might compensate for changes at a lower trophic level and impacts could conceivably be positive (Busch et al. 2013).

Because habitat for many shark and ray species is comprised of open ocean environments occurring over broad geographic ranges, large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics, may impact these species. Chin et al. (2010) conducted an integrated risk assessment to assess the vulnerability of several shark and ray species on the Great Barrier Reef to the effects of climate change. Scalloped hammerheads were ranked as having a low overall vulnerability to climate change, with low vulnerability to each of the assessed climate change factors (i.e., water and air temperature, ocean acidification, freshwater input, ocean circulation, sea level rise, severe weather, light, and ultraviolet radiation). In another study on potential effects of climate change to sharks, Hazen et al. (2012) used data derived from an electronic tagging project and output from a climate change model to predict shifts in habitat and diversity in top marine predators in the Pacific out to the year 2100. Results of the study showed significant differences in habitat change among species groups but sharks as a whole had the greatest risk of pelagic habitat loss. Environmental changes associated with global climate change are occurring within the HSTT action area and are expected to continue into the future. Marine populations that are already at risk due to other threats are particularly vulnerable to the direct and indirect effects of climate change. Several ESA-listed species and habitats considered in this opinion have likely already been impacted by this threat through the pathways described above.

8.2 Sound

The ESA-listed species that occur in the action area are regularly exposed to multiple sources of anthropogenic sounds. Anthropogenic sound is generated by commercial and recreational vessels, aircraft, sonar, ocean research activities, dredging, construction, offshore mineral exploration, military testing and training activities, and other human activities. These activities occur within the action area to varying degrees throughout the year. ESA-listed species have the potential to be impacted by increased levels of both background sound and high intensity, short-term sounds. Sources of anthropogenic noise are becoming both more pervasive and more powerful, increasing both oceanic background sound levels and peak intensity levels (Hildebrand 2004).

Sounds are often considered to fall into one of two general types, impulsive and non-impulsive, which differ in the potential to cause physical effects to animals (See Southall et al. (2007b) for in-depth discussion). Impulsive sound sources produce brief, broadband signals that are atonal transients and occur as isolated events or repeated in some succession. They are characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period, and generally have an increased capacity to induce physical injury. Non-impulsive sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous. Some can be transient signals of short duration but without the essential properties of pulses (e.g., rapid rise time). The duration of non-impulsive sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Anthropogenic sound within the marine environment is recognized as a potential stressor that can harm marine animals and significantly interfere with their normal activities (NRC 2005). The species considered in this opinion may be impacted by anthropogenic sound in various ways. Damage to marine mammal hearing and mass stranding events due to high-intensity sound exposure have been documented (Hildebrand 2004). Anthropogenic sounds may also produce a behavioral response including, but not limited to, changes in habitat to avoid areas of higher sound levels, changes in diving behavior, or (for cetaceans) changes in vocalization (MMC 2007). Many researchers have described behavioral responses of marine mammals to the sounds produced by boats and vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, and dredging and construction. Most observations have been limited to short-term behavioral responses, which include temporary cessation of feeding, resting, or social interactions. Habitat abandonment can lead to more long-term effects, which may have implications at the population level. Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Francis 2013). 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). Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. Recent scientific evidence suggests that marine mammals, including blue and fin whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Mcdonald et al. 2006a; Parks 2003; Parks 2009).

There are limited studies on the hearing abilities of sea turtles, their uses of sounds, and their vulnerability to sound exposure. Some evidence suggests that sea turtles are able to detect (Bartol and Ketten 2006b; Bartol et al. 1999a; Martin et al. 2012a; Ridgway et al. 1969a) and behaviorally respond to acoustic stimuli (DeRuiter and Doukara 2012; McCauley et al. 2000b; Moein et al. 1995; O'Hara and Wilcox 1990a). Sea turtles may use sound for navigation, locating prey, avoiding predators, and general environmental awareness (Dow Piniak et al. 2012).

Despite the potential impacts on individual ESA-listed marine mammals and sea turtles, information is not currently available to determine the potential population level effects of cumulative anthropogenic sound sources in the marine environment (MMC 2007). For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the population being considered. As a result, the consequences of anthropogenic sound on ESA-listed marine mammals and sea turtles at the population or species scale remain uncertain.

This section is divided into subsections addressing the potential stressors from the following major of anthropogenic sound sources: vessels and commercial shipping; seismic surveys; military activities; active sonar; and pile driving and construction. A more detailed discussion of the effects on these sound sources on ESA-listed species can be found in the effects analysis Section 9.3 below.

8.2.1 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 m for fast-moving (greater than 20 knots) supertankers to 140 dB re: μPa^2-s at 1 m for smaller vessels (NRC 2003b). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kHz, which may interfere with important biological functions of cetaceans (Holt 2008a). 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 2009c; Mckenna et al. 2012a; NRC 2003b). Shipping constitutes a major source of low-frequency (five to 500 Hz) sound in the ocean (Hildebrand 2004), 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.

Approximately 89 percent of all vessel traffic in the HRC is from civilian ships, eight percent from Navy ships, two percent foreign Navy ships, and one percent from U.S. Coast Guard ships (Mintz 2016). In Southern California, about 96 percent of all vessel traffic is civilian shipping and four percent from Navy ships. Cargo and bulk carrier traffic dominate much of the offshore areas within the HSTT action area and combined account for about 70 percent of commercial vessel traffic (Figure 58). Tankers are prominent in nearshore areas around San Diego, while tugs dominate inter-island traffic among the Main Hawaiian Islands (Mintz 2012).

The heaviest vessel traffic within the HSTT action area is along the coast of Southern California and near the main Hawaiian Islands (Mintz 2016). The geographic distribution of nonmilitary vessel traffic is shown in Figure 59 and Figure 60 for the Hawaii and SOCAL Range Complexes and surrounding areas, respectively. Marine species dependent upon coastal and estuarine nearshore environments around the main Hawaiian Islands or off Southern California may be particularly susceptible to the cumulative effects of vessels sound.

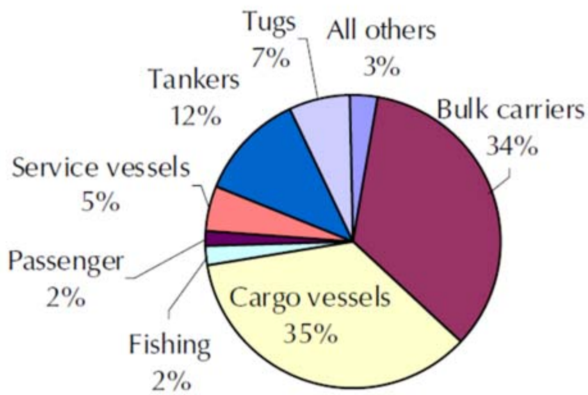


Figure 58. Commercial traffic in action area by vessel type (Mintz 2012).

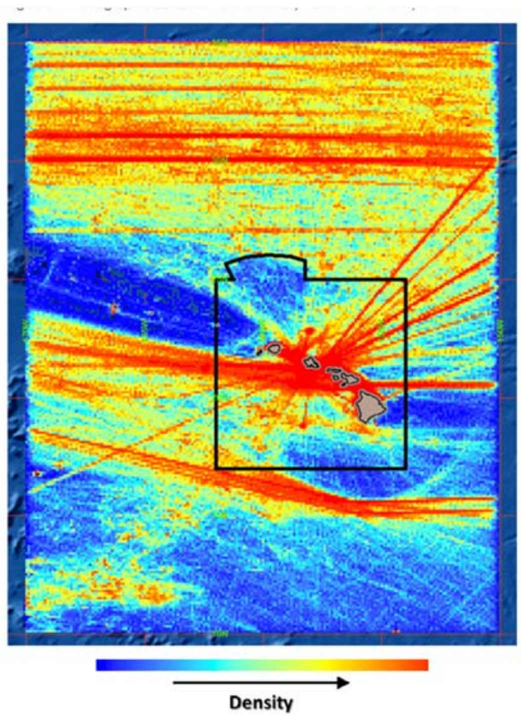


Figure 59. Geographic distribution of nonmilitary vessel traffic for the Hawaii Range Complex and surrounding areas (Mintz 2016).

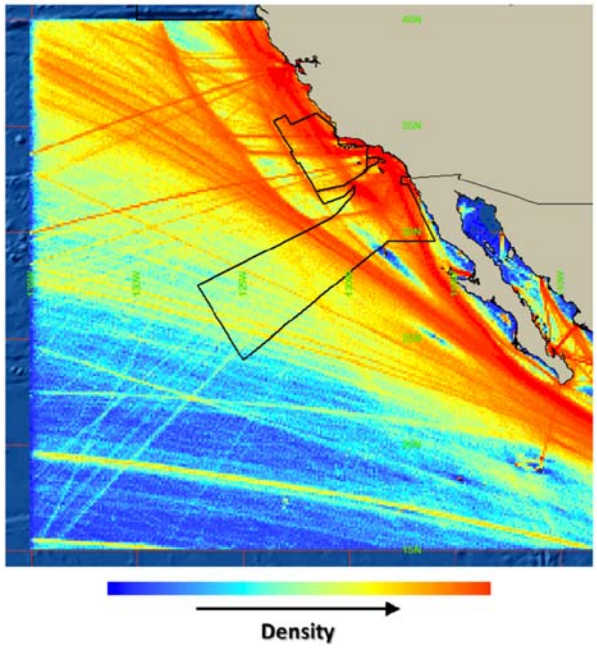


Figure 60. Geographic distribution of nonmilitary vessel traffic for the Southern California Range Complex and surrounding areas (Mintz 2016).

8.2.2 Seismic Surveys

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 coast of California (Figure 61) and within the HRC over the past several decades. Unlike other regions (e.g., Gulf of Mexico) where the large majority of seismic activity is associated with oil and gas development, seismic surveys conducted in the HSTT action area are primarily for scientific research, to identify possible seafloor or shallow-depth geologic hazards, and to locate potential archaeological resources and benthic habitats that should be avoided.

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. When an airgun array fires an acoustic energy pulse is emitted and reflected or refracted back from the seafloor. These reflected/refracted acoustic signals create pressure fluctuations, which are detected and recorded by the streamers. Seismic airguns generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10 to 20 seconds for extended periods (NRC 2003a). Most of the energy from airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak SPLs from airguns usually reach 235 to 240 decibels at dominant frequencies of five to 300 Hz (NRC 2003a). 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 kHz), echosounders (single-beam at 12-240 kHz; multibeam at 50-400 kHz), boomers (at 300-3,000 Hz), sparkers (at 50-4,000 Hz), compressed high intensity radar pulse sub-bottom profiler (at 4-24 kHz), pingers (at 2 kHz), and side-scan sonars (16-1,500 kHz). These sound sources are typically powered either mechanically or electromagnetically.

Exposure of cetaceans to very strong 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 2015). 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. 2007f; 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. 2000b). McCauley et al. (2000b) 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 m water depth this corresponds to behavioral changes at around two kilometers and avoidance around one kilometer.

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

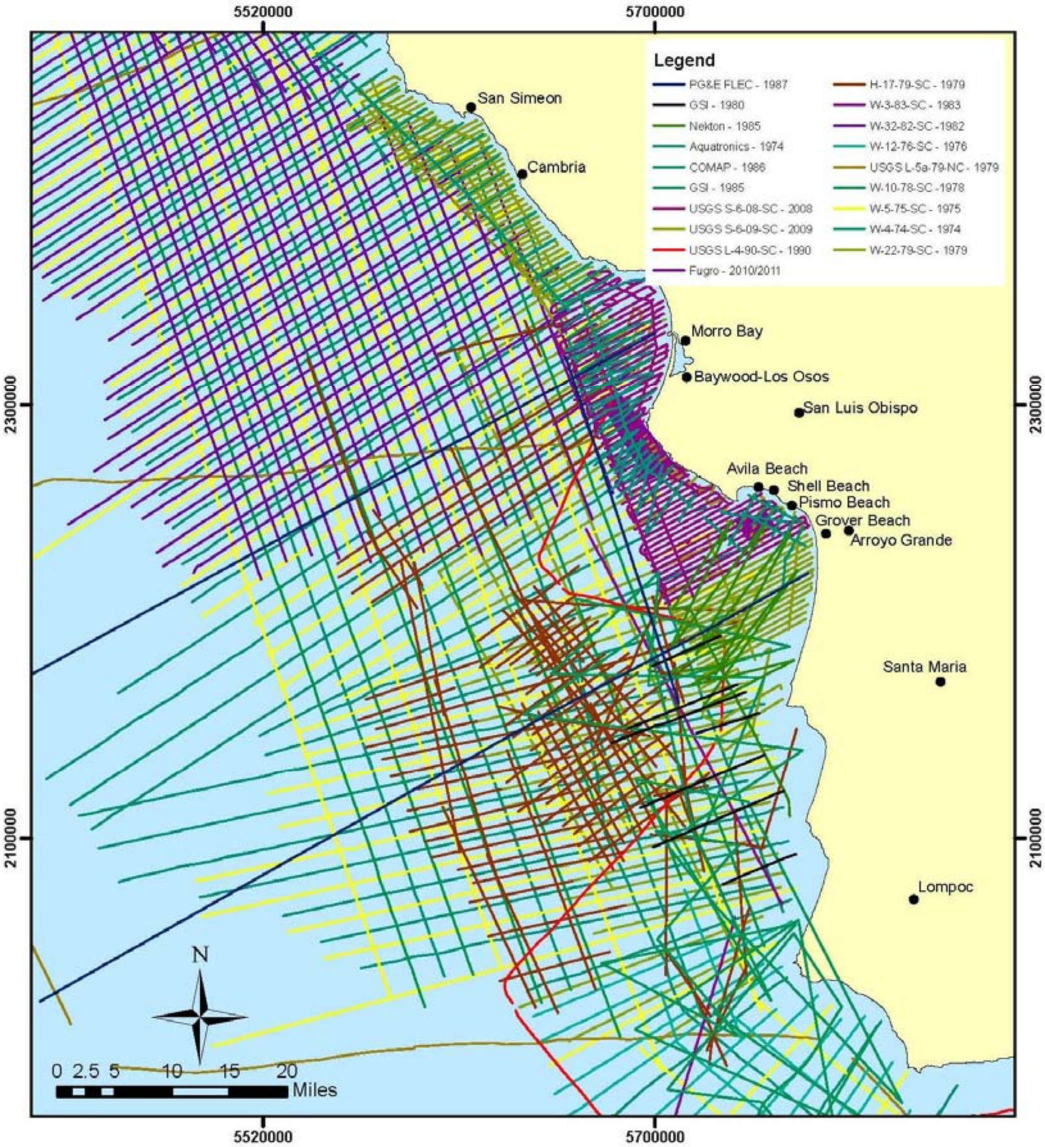


Figure 61. Seismic surveys north of the Navy's Southern California operating area (NMFS 2015a).

8.2.3 Military Training and Testing Activities

The Navy has conducted training and testing activities and other military readiness activities in the Hawaiian and SOCAL Range Complexes in the past, and these activities are ongoing and are expected to continue into the future. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. 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.

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 these Navy activities have previously undergone section 7 consultations. 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 the HSTT action area. Conservation measures include employing visual observers and implementing mitigation zones when training and testing using active sonar or explosives.

The Air Force has conducted training and testing activities in the action area in the past, and these activities are ongoing and are expected to continue into the future. Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles, rockets, and gunnery rounds) from aircraft towards targets located on the surface, though Air Force training exercises may also involve boats. These activities impact ESA-listed species through physical disturbance, boat strikes, debris, ingestion, and effects from sound and pressure produced by detonations. Air Force training and testing activities constitute a federal action and take of ESA-listed species resulting from these Air Force activities have previously undergone separate section 7 consultations.

The effects of military activities within the action area on ESA-listed species are described in more detail below (See *Ongoing Military Training and Testing Activities in the Action Area*).

8.2.4 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 kHz and less, mid frequency for one to 10 kHz; high frequency for 10 to 100 kHz; and very high frequency for greater than 100 kHz (Hildebrand 2004). Low frequency systems are designed for long-range detection (Popper et al. 2014b). The effective source level of an low-frequency active array, when viewed in the horizontal direction, can be 235 dB re 1μPa @ 1 m or higher (Hildebrand 2004). Signal transmissions are emitted in patterned sequences that may last for days or weeks. An example of a low-frequency active sonar system is the U.S. Navy Surveillance Underwater Towed Array Sensor System (SURTASS), discussed in more detail below (See *Ongoing U.S. Navy Training and Testing Activities in the Action Area*). 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 includes 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 kHz, with source levels ranging from 150-235 dB re 1μPa @ 1 m (Hildebrand 2004). 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.

8.2.5 Pile Driving and Construction Sound

Industrial activities and construction both in the ocean and along the shoreline can contribute to underwater noise. Pile driving is commonly used for the construction of foundations for a large number of structures including bridges, buildings, retaining walls, harbor facilities, offshore wind turbines, and offshore structures for the oil and gas industry. Pile driving during construction activities is of particular concern because it generates noise with a very high source level. During pile installation, noise is produced when the energy from construction equipment is transferred to the pile and released as pressure waves into the surrounding water and sediments. The impulsive sounds generated by impact pile driving are characterized by a relatively rapid rise time to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures (Illingworth and Rodkin 2001; Illingworth and Rodkin 2007; Reyff 2012). The amount of noise produced by pile driving depends on a variety of factors, including the type and size of the impact hammer, size of the pile, the properties of the sea floor, and the depth of the water. The predominant energy in pile impact impulses is at frequencies below approximately 2000 Hz, with most occurring below 1000 Hz (Laughlin 2006; Reyff 2008; Reyff 2012). Pressure levels from 190-220 dB re 1 μPa were reported for piles of different sizes in a number of studies (NMFS 2006). Impact pile driving occurs over small spatial and temporal scales and produces high-intensity, low-frequency, impulsive sounds with high peak pressures that can be detected by mammals, sea turtles and other marine species (Dow Piniak et al. 2012). Injury to sea turtles and marine mammals is caused by pressure wave damage to hair cells, ear canals, or ear drums as these structures compress and expand with passage of the wave. Vibratory pile driving produces a continuous sound with peak pressures lower than those observed in impulses generated by impact pile driving (Popper et al. 2014b).

8.3 Dredging

Nearshore and offshore coastal areas are often dredged to support commercial shipping, recreational boating, construction of infrastructure, and marine mining. Hydraulic dredging can directly harm large marine animals (e.g., sea turtles) by lethally entraining them through the dredge drag-arms and impeller pumps. Large animals that are entrained in hydraulic dredges rarely survive the encounter. Hopper dredges, in particular, are capable of moving relatively quickly compared to turtles and fish which can be overtaken and entrained by the suction draghead of the advancing dredge.

Dredging can also indirectly affect marine species through habitat modification, changes in prey availability, and water quality degradation, including changes in dissolved oxygen and salinity gradients (Campbell and Goodman 2004; Jenkins et al. 1993; Secor and Niklitschek 2001). Dredging operations also emit sounds at levels that could potentially disturb individuals of many marine taxa. Depending on the type of dredge, peak SPLs from 100 to 140 dB re 1 micro Pascal (μPa) were reported in one study (Clarke et al. 2003). As with pile driving, most of the sound energy associated with dredging is in the low-frequency range, less than 1000 Hz (Clarke et al. 2003). Based on a literature review of the impacts of dredging activities on marine mammals, Todd et al. (2014) found that dredging is unlikely to cause physiological damage to marine mammal auditory systems, but is more likely to lead to masking and behavioral disturbances, and baleen whales could be more at risk than other taxa.

Dredging projects within the action area mainly occur in the harbors, ports and nearshore coastal areas of the Main Hawaiian islands and in San Diego Bay. Considering the locations of past and ongoing dredging, the species most likely affected by dredging within the action area are green sea turtles, hawksbill sea turtles, and olive ridley sea turtles.

8.4 Pollution

Several different types of anthropogenic pollution resulting from past, present and ongoing human activities adversely affect ESA-listed species and habitats within the action area. For this opinion, we focus on three primary categories of marine and estuarine pollutants: contaminants and pesticides; nutrient loading and algal blooms; and marine debris. This section provides a general discussion of the three major pollutant categories above, including the stressor pathways and anticipated effects on ESA- protected resources, with an emphasis on geographic areas, habitats or species within the action area that are particularly susceptible to these threats.

8.4.1 Contaminants and Pesticides

Coastal habitats are often in close proximity to major sources of pollutants and contaminants, which make their way into the marine environment from land-based industrial, domestic and agricultural sources. Sources include wastewater treatment plants, septic systems, industrial facilities, agriculture, animal feeding operations, and improper refuse disposal. Agricultural discharges, as well as discharges from large urban centers, contribute contaminants as well as coliform bacteria to coastal watersheds. Contaminants can be carried long distances from terrestrial or nearshore sources and ultimately accumulate in offshore pelagic environments (USCOP 2004). Global oceanic circulation patterns result in a considerable amount of pollutants that are scattered throughout the open ocean and accumulating in gyres and other places due to circulation patterns (Crain et al. 2009).

Chemical contaminants, particularly those that are persistent in the environment, are a particular concern for marine animals that often occupy high trophic positions. Persistent organic pollutants, which include legacy pesticides (e.g., dichlorodiphenyltrichloroethane [DDT], chlordane), legacy industrial-use chemicals (e.g., polychlorinated biphenyls), and emerging contaminants of concern (e.g., polybrominated diphenyl ethers and perfluorinated compounds), accumulate in fatty tissues of marine organisms and are magnified through the food web leading high exposure levels in upper trophic predators (National Academies of Sciences and Medicine 2016). Ocean contamination resulting from chemical pollutants is a concern for cetacean conservation and has been the subject of numerous studies (Desforges et al. 2016; Fair et al. 2010; Krahn et al. 2007; Moon et al. 2010; Ocean Alliance 2010). High concentrations of polychlorinated biphenyls (PCBs) and DDT have been reported in tissues of marine mammals in most parts of the world, particularly in coastal regions adjacent to heavy coastal development and/or industry. These legacy persistent organic pollutants have been linked to a number of adverse health effects including endocrine disruption, reproductive impairment or developmental effects, and immune dysfunction or disease susceptibility (National Academies of Sciences and Medicine 2016). Polybrominated diphenyl ethers commonly used as flame retardants, are another class of persistent organic pollutants that have spread globally in the environment and have also been reported in a broad array of marine mammal species (National Academies of Sciences and Medicine 2016).

Savery et al. (2014) documented detectable lead concentration in 93 percent of 337 blubber biopsies from sperm whales sampled throughout the world. Ylitalo et al. (2008) analyzed blubber and blood samples for organochlorines from 158 Hawaiian monk seals at four of their six primary breeding colonies in the Northwestern Hawaiian Islands. They found that the health and fitness of Hawaiian monk seals from three of the four subpopulations may be at risk from elevated contaminant levels. Lopez et al. (2012) examined concentrations of a large suite of persistent organic pollutants in blubber and serum of juvenile and adult monk seals from the Main Hawaiian Islands. Adult females had the lowest blubber levels of most persistent organic pollutants, whereas adult males had the highest levels. Contaminant levels from the Main Hawaiian Islands were at similar or lower levels than those from remote Northwestern Hawaiian Island populations. In an analysis of cetacean blubber samples obtained from animals stranded in Hawaii between 1997 and 2011, higher levels of persistent organic pollutants were found in killer whale and false killer whale, as opposed to baleen whales which had lower levels (Bachman et al. 2014).

Polycyclic aromatic hydrocarbons (PAHs) represent another group of organic compounds that can result in adverse effects on marine species. Anthropogenic sources of PAHs include crude oil, fumes, vehicle exhaust, coal, organic solvents, and wildfires. Exposure may be continual, associated with run-off from impervious cover in developed coastal regions, or natural seeps that produce low-level but steady exposure. Acute events such as oil spills may produce pulses of more significant exposure. Depending on the route of exposure (inhalation/aspiration, ingestion, direct dermal contact), PAHs can produce a broad range of health effects including lung disease, disruption of the hypothalamicpituitary-adrenal axis, and altered immune response (National Academies of Sciences and Medicine 2016). Although PAHs are more rapidly metabolized and do not accumulate, as is the case with persistent organic pollutants, the toxic effects (lung disease, hypothalamicpituitary-adrenal axis damage) may be long-lasting and initiate chronic disease conditions.

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 vertebrate (Gordon et al. 1998). Newly emerged hatchlings have higher concentrations than are present when eggs are laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996). Arsenic has been found to be very high in green turtle eggs (Van de Merwe et al. 2009). Sea turtle tissues have been found to contain organochlorines, including chlorobiphenyl, chlordane, lindane, endrin, endosulfan, dieldrin, perfluorooctane sulfonate, perfluorooctanoic acid, DDT, and PCB (Alava et al. 2006; Gardner et al. 2003; Keller et al. 2005; Oros et al. 2009; Storelli et al. 2007). PCB concentrations are reportedly equivalent to those in some marine mammals (Davenport et al. 1990; Oros et al. 2009). Levels of PCBs found in green sea turtle eggs have exceeded recommended levels for human consumption (Van de Merwe et al. 2009).

Several studies have reported correlations between organochlorine concentration level and indicators of sea turtle health or fitness. Organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2006; Oros et al. 2009). Accumulation of these contaminants can also lead to deficiencies in endocrine, developmental and reproductive health (Storelli et al. 2007). Balazs (1991) suggested that environmental contaminants are a possible factor contributing to the development of the viral disease fibropapillomatosis in sea turtles by reducing immune function. Day et al. (2007) investigated mercury toxicity in loggerhead sea turtles by examining trends between blood mercury concentrations and various health parameters. They concluded that subtle negative impacts of mercury on sea turtle immune function are possible at concentrations observed in the wild. Keller et al. (2004) investigated the possible health effects of organochlorine contaminants, such as PCBs and pesticides on loggerhead sea turtles. Although concentrations were relatively low compared with other species, they found significant correlations between organochlorine contaminants levels and health indicators for a wide variety of biologic functions, including immunity and homeostasis of proteins, carbohydrates, and ions.

The chemical components of pesticides used on land flow as runoff into the marine environment and can bioaccumulate in the bodies of marine mammals, which can then be transferred to their young through mother's milk (Fair et al. 2010). There is growing evidence that the presence of chemical contaminants in their tissues puts marine mammals at greater risk for adverse health effects and potential impact on their reproductive success (Fair et al. 2010; Godard-Codding et al. 2011; Krahn et al. 2007).

Exposure to chemical pollutants may act in an additive or synergistic manner with other stressors resulting in significant population level consequences (Desforges et al. 2016). Despite the vast evidence indicating that marine animals are exposed to anthropogenic, as well as natural, chemicals capable of producing significant toxic effects, only a few studies have actually examined the impacts on population survival or reproductive rates. Such observational assessments are inherently challenging due to the difficulty in controlling for confounding or interacting variables, as well as the sublethal but chronic nature of chemical contaminant effects, and the difficulty of observing mortality or reproductive endpoints, particularly in long-lived species such as cetaceans and sea turtles (National Academies of Sciences and Medicine 2016).

Many pollutants in the environment, such as brevotoxins, heavy metals, and PCBs, have the ability to bioaccumulate in fish species. A number of studies have shown that because of the higher trophic level position and longevity of some sharks and rays, these pollutants tend to biomagnify in liver, gill, and muscle tissues (Young 2018). The large size and vast lipid stores in the elasmobranch liver provide the capacity for a substantial sequestration of lipophilic contaminants. Overall, sharks and rays are likely exposed to a number of pollutants and contaminants in their habitat that have the potential to cause negative physiological impacts to these species, although the effects of these pollutants and potential risk to the viability of the species remain unknown.

8.4.2 Nutrient Loading and Algal Blooms

Industrial and municipal activities can result in the discharge of large quantities of nutrients into coastal waters. Excessive nutrient enrichment results in eutrophication, a condition associated with degraded water quality, algal blooms, oxygen depletion, loss of seagrass and coral reef habitat, and in some instances the formation of hypoxic “dead zones” (USCOP 2004). Hypoxia (low dissolved oxygen concentration) occurs when waters become overloaded with nutrients such as nitrogen and phosphorus, which can enter the marine environment from agricultural runoff, sewage treatment plants, bilge water, atmospheric deposition, and other sources. An overabundance of nutrients can stimulate algal blooms resulting in a rapid expansion of microscopic algae (phytoplankton). When excess nutrients are consumed, the algae population dies off and the remains are consumed by bacteria. Bacterial consumption decreases the dissolved oxygen level in the water which may result in mortality of fish and crustaceans, reduced benthic and demersal organism abundance, reduced biomass and species richness, and abandonment of habitat to areas that are sufficiently oxygenated (Craig et al. 2001; Rabalais et al. 2002). Higher trophic level species (e.g. turtles and marine mammals) may be impacted by the reduction of available prey as a result of hypoxic conditions.

Marine algal toxins are produced by unicellular algae that are often present at low concentrations but that may proliferate to form dense concentrations under certain environmental conditions (National Academies of Sciences and Medicine 2016). When high cell concentrations form, the toxins that they produce can harm marine life, and this is referred to as a harmful algal bloom. Marine mammals can be exposed to harmful algal bloom toxins directly by inhalation or indirectly through food web transfer, and these toxins can cause severe neurotoxic effects (Van Dolah 2005). Mortality and morbidity related to harmful algal bloom toxins have been increasingly reported over the past several decades, and biotoxicosis has been a primary contributor to large scale die-offs across marine mammal taxa (Simeone et al. 2015; Van Dolah 2005). A recent survey of the peer reviewed literature on marine mammal diseases and marine mammal mass mortality events suggests an increase in the frequency of marine mammal die-offs resulting from exposure to harmful algal blooms over the past 40 years (Gulland and Hall 2007).

California coastal harmful algal bloom problems are dominated by two organisms: *Alexandrium catenella* which produces saxitoxin, the causative agent of paralytic shellfish poisoning, and several *Pseudo-nitzschia* species whose toxic strains produce domoic acid, the causative agent for Amnesic Shellfish Poisoning (alternately called Domoic Acid Poisoning) (Anderson et al. 2008). Prior to 2000, toxic blooms were considered rare and unusual in southern California (Lange et al. 1994). In 2006, Busse et al. (2006) reported the presence of domoic acid in San Diego during elevated abundances of toxic Pseudo-nitzschia and concurrently in fish and mussels. This study provides evidence for the transfer of domoic acid from a local algal source in San Diego to higher trophic levels. Unlike many other ecosystems impacted by harmful algal blooms, the physical, chemical, and ecological characteristics of the coastal waters of California are largely dominated by upwelling. Consequently, upwelling circulation overrides both the nutrient limitation of stratified waters and the light limitation of well-mixed waters, and generally nourishes these waters with macronutrients in excess of anthropogenic sources (Anderson et al. 2008). This does not, however, preclude the possibility that the growth of these algae, their toxicity, and the frequency or duration of toxic events may be exacerbated by anthropogenic nutrient inputs once these populations reach nearshore waters (Anderson et al. 2008).

Red tides have been reported off the coast of southern California for over a century (McGowan et al. 2017). Red tides occur when blooms of marine phytoplankton reach such high concentrations that the sea surface becomes noticeably discolored. In La Jolla, California, blooms are often caused by bioluminescent dinoflagellates (e.g., *Lingulodinium polyedrum*) (McGowan et al. 2017). Red tides and other algal blooms in southern California can be caused by toxic algal species, resulting in fish and shellfish mortality (Lewitus et al. 2012). Regardless of toxicity, the sheer concentrations of organisms can lead to oxygen depletion and fish kills when blooms persist over extended periods.

8.4.3 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 is 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 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). Santos et al. (2015) found that a surprisingly small amount of plastic debris was sufficient to block the digestive tract and cause death. They reported that 10.7 percent of green turtles in Brazilian waters were killed by plastic ingestion, while 39.4 percent had ingested enough plastic to have killed them. These results suggest that debris ingestion is a potentially important source of turtle mortality, one that may be masked by other causes of death. Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives. 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. Based on their model, olive ridley turtles are the most at-risk species; green, loggerhead, and leatherback turtles were also found to be at a high and increasing risk from plastic ingestion (Schuyler et al. 2016). This study also found the North Pacific gyre, which encompasses much of the HSTT action area, 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). The reefs and islands of Northwestern Hawaiian Islands, in particular, act as a filter amassing marine debris that presents potentially lethal entanglement hazards and ingestion threats to numerous birds and marine animals within the action area. From 1996 through 2014, nearly 837 metric tons (1.8 million lbs) of marine debris, primarily derelict fishing gear, have been removed from the shallow reefs and shorelines of the Northwestern Hawaiian Islands (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). de Stephanis et al. (2013) also describe a case of mortality of a sperm whale related to the ingestion of large amounts of marine debris in the Mediterranean Sea.

Hawaiian monk seals become entangled in fishing and other marine debris at rates higher than reported for other pinnipeds (Henderson 2001). A total of 347 cases of monk seals entangled in fishing gear or other debris have been observed from 1982 to 2014 (Carretta et al. 2017a). Nine documented deaths resulted from entanglement in marine debris (Carretta et al. 2017a).

8.5 Whaling

Whale populations within the action area have historically been impacted by aboriginal subsistence hunting, small-scale commercial whaling and, more recently, large-scale commercial whaling using factory ships. From 1864 through 1985, at least 2,400,000 baleen whales (excluding minke whales) and sperm whales were killed worldwide (Gambell 1999). From 1900 to 1965 nearly 30,000 humpback whales were taken in the Pacific Ocean, with an unknown number of additional animals taken prior to 1900 (Perry et al. 1999). Sei whales were 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 and 25,800 sperm whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada 1972) (Barlow et al. 1997). Many of the whaling numbers reported in the twentieth century likely represent minimum estimates, as illegal or underreported catches are not included.

Prior to current prohibitions on whaling, most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. Since the end of large-scale commercial whaling, the primary threat to these species has been eliminated, although many whale species have not yet fully recovered from those historic declines. Although commercial whaling no longer targets the large, endangered whales in the proposed action area, historical whaling may have altered the age structure and social cohesion of these species in ways that continue to influence them.

In 1982, the International Whaling Commission issued a moratorium on commercial whaling, which went into effect in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that filed objections to the moratorium. Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the International Whaling Commission moratorium (i.e., Iceland and Norway). Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

8.6 Directed Harvest of Sea Turtles

Sea turtles have been harvested throughout history as both a protein source (for meat or eggs) and as raw material in the manufacture of ornaments and artifacts. An additional threat unique to hawksbill turtles is the tortoiseshell trade. Tortoiseshell is made from hawksbill scutes and is used to produce products such as sunglasses, bracelets, and ornamental boxes that are often sold illegally on the black market (Shattuck 2011).

For centuries, the harvest of sea turtles and turtle eggs was primarily limited to small-scale, artisanal and subsistence fisheries. In many parts of the world, the customs and traditions associated with the harvest, consumption and artistic use of sea turtle products have been passed from generation to generation and have developed cultural meaning and significance over time (Campbell 2003). Historically, green turtles have played a large role in Polynesian and Micronesian cultures. In addition to being used as a food source, native peoples all over the Pacific utilized all parts of the turtle making tools and jewelry out of the bones, and containers and utensils out of the carapace.

Although small-scale turtle fisheries still exist today, by the mid-20th century directed turtle harvest was dominated by large-scale commercial operations with access to global markets (Stringell et al. 2013). The Hawaiian green turtle was in a steep decline as of the 1970s because of direct harvest of both turtles and eggs by humans. By the late 1960s, the global capture of sea turtles had peaked at an estimated 17,000 tons (FAO 2011). Based on Japanese commercial import data, between 1970 and 1986 an estimated two million turtles (mostly hawksbills, greens, and olive ridleys) were harvested to satisfy the demand for turtle products in Japan alone (Milliken and Tokunaga 1987). To maximize efficiency, commercial harvesting effort was often concentrated at mass nesting sites or arribadas with high densities of breeding adult turtles.

Increased conservation awareness at the international scale has led to greater protection of marine turtles in recent decades. The Convention on International Trade in Endangered Species (CITES), which went into effect in 1975, helped to reduce demand and promote regional cooperation in increasing turtle populations. All six ESA-listed sea turtles are listed in CITES

Appendix I, which provides the greatest level of protection, including a prohibition on commercial trade. Marine turtle species have also been listed on the International Union for Conservation of Nature Red List of Threatened Species since 1982 (IUCN 2017). In 1981, Ecuador, one of the two largest turtle harvesting nations at the time, banned the export of sea turtle products. In 1990, following international pressures, Mexico, the other major turtle exporter, closed commercial fisheries and instituted a moratorium on the take of turtles and eggs (Senko et al. 2014).

Humber et al. (2014) documented the change in the legal take of sea turtles over the past three decades. Just considering the 46 countries that still allow sea turtle directed take (including the four with current moratoria), turtle harvest has decreased by more than 60 percent over the past three decades. The average number of turtles killed in these fisheries annually has declined steadily over time: 116,420 in the 1980s; 68,844 turtles in the 1990s; and 45,387 in the 2000s (Humber et al. 2014). While legal directed take of sea turtles has declined significantly, illegal harvest may still represent a significant source of sea turtle mortality, one that is more difficult to estimate. The scale of global illegal take is likely to be severely underreported due to the inherent difficulty in collecting data on such activity (Humber et al. 2014).

8.7 Human-Caused Mortality of Pinnipeds

There were 15 recorded human-related deaths and eight injuries (six non-serious; two serious) of Guadalupe fur seals from U.S. west coast strandings data for the most recent five-year period of 2012-2016 (Carretta et al. 2018d). Marine debris was recorded as the source of injury or mortality in twelve of these stranding cases. Other sources included entanglement in fishing nets, blunt force trauma and shootings. The actual number of Guadalupe fur seals killed or injured is likely greater since not all injured or killed animals strand (e.g., shark predation) and not all strandings are reported.

Currently, human activities in the Northwest Hawaiian Islands are limited and human disturbance is relatively rare, but human-seal interactions have become an important issue in the Main Hawaiian Islands. From 2010-2015 there have been nine reported human-caused mortalities of monk seals (Carretta et al. 2018d). Seven of these, although unconfirmed, appeared to be intentional based on probable cause of death which included skull fracture, blunt force trauma, and gunshot wound. Accidental causes of death during this time period include one probable boat strike (in 2015) and one research capture and handling related mortlaity (in 2015). In July 2014, a dog or pack of dogs on Kauai attacked and injured at least five monk seals, one of which, a nursing pup, died from the wounds sustained (Carretta et al. 2018d). While it is unlikely that all carcasses from human-caused monk seal mortalities are discovered and reported, the population withint the Main Hawaiian Islands is fairly well monitored.

8.8 Fisheries Bycatch

In this section, we summarize the best available information on fisheries bycatch of ESA-listed species in the action area.

8.8.1 Bycatch of Sea Turtles

Sea turtle bycatch occurs in both large-scale commercial fishing operations as well as small-scale and artisanal fisheries throughout the action area. Sea turtle bycatch rates (i.e., individuals captured per unit of fishing effort) and mortality rates (i.e., individuals killed per number captured) can vary widely both within and across particular fisheries due to a combination of factors. These include gear types and gear configurations, fishing methods (e.g., depth fished, soak times), fishing locations, fishing seasons, time fished (i.e., day versus night), and turtle handling and release techniques used (Lewison et al. 2013; Wallace et al. 2010b). Entanglement in fishing gear and/or plastics can result in severe ulcerative dermatitis, and amputation of flippers (Orós et al. 2005). If mortality is not directly observed during gear retrieval, it may occur after the turtle is released due to physiological stress and injury suffered during capture. Recent studies indicate that underwater entrapment in fishing gear (i.e., trawls and gillnets) followed by rapid decompression when gear is brought to the surface may cause gas bubble formation within the blood stream (i.e., embolism) and tissues leading to organ injury, impairment, and even post-release mortality in some bycaught turtles (Fahlman et al. 2017; Garcia-Parraga et al. 2014).

Lewison et al. (2014) used the bycatch data from 1990-2008 to identify global hotspots of turtle bycatch intensity. High-intensity sea turtle bycatch was most prevalent in three regions: the eastern Pacific Ocean, southwest Atlantic Ocean, and Mediterranean Sea. Spotila (2000) reported a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s of 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). Lewison et al. (2004) estimated between 2,600 and 6,000 loggerhead turtles were captured and killed in Pacific Ocean longline fisheries in 2000.

Below, we summarize the major U.S. commercial fisheries within the HSTT action area that result in sea turtle bycatch. The primary turtle species of concern for U.S. fisheries bycatch in the Pacific are leatherbacks and loggerheads, due to their critical conservation status (Moore et al. 2009a).

West Coast Longline Fishery

The west coast longline fishery operates in the north Pacific ocean, mainly from the U.S. EEZ west to 140 degree west longitude and from the equator to 35 degree north (NMFS 2016a). This fishery primarily targets bigeye tuna, although other tuna and non-tuna species are also caught and retained. As of 2016 there was only one boat participating in this fishery, although fishing effort is expected to increase in the future (NMFS 2016a). Sea turtle incidental take authorized over a ten-year period (starting in 2016) as provided for in the ITS of the 2016 biological opinion (NMFS 2016a) on this fishery is as follows:

- Green, East Pacific DPS and Central North Pacific DPS: one total (lethal or non-lethal).
- Leatherback: four total, including up to two lethal.

- Loggerhead, North Pacific DPS: one (lethal or non-lethal).
- Olive ridley: six total (lethal or non-lethal).

Hawaii Pelagic Longline

Domestic longline fishing around Hawaii consists of two separately managed fisheries: a deep-set fishery that primarily targets bigeye tuna and a shallow-set fishery that targets swordfish. The shallow-set fishery operates almost entirely north of Hawaii. The deep-set fishery operates primarily to the south of Hawaii between the equator and 35° N, although in some years this fishery expands northward and overlaps with the shallow-set fishery.

In 1999, the shallow-set longline fishery targeting swordfish was closed by court order due to high levels of sea turtle bycatch. Before the closure took effect, an estimated 417 loggerheads and 110 leatherbacks (McCracken 2000) were captured annually (with about 40 percent mortality) (Gilman et al. 2007) in Hawaii's longline fisheries (shallow and deep-set combined). Subsequent court orders led to regulations in 2001 prohibiting all Hawaii longline vessels from targeting swordfish until 2004. When the shallow-set fishery was reopened in 2004 it was restricted to considerably less fishing effort than pre-2001 levels. As a result, the deep-set fishery targeting tuna made up an increasingly larger proportion of Hawaii's longline fishing effort since 2004. A final rule published in 2004 (69 FR 17329) established a limited shallow-set swordfish fishery and required the use of circle hooks with mackerel-type bait, a combination that had proven effective at reducing interactions with leatherback and loggerhead turtles in the Atlantic longline fishery (Watson et al. 2005). The use of circle hooks with mackerel-type bait reduced sea turtle interaction rates by approximately 90 percent for loggerheads and 83 percent for leatherbacks compared to the previous period 1994-2002 when the shallow-set fishery was operating without these requirements (Gilman et al. 2007). Annual sea turtle bycatch limits (17 loggerhead or 16 leatherback turtles) were also established for the swordfish fishery as part of the 2004 rule. From 2005 through 2014, the Hawaii-based longline fisheries resulted in an estimated total of 15 loggerhead and 17 leatherback mortalities in the shallow-set fishery, and 16 loggerhead, 45 leatherback, and 264 olive ridley mortalities in the deep-set fishery (NMFS 2014a).

In addition to gear restrictions and bycatch limits, Hawaii longline vessel operators are required to take an annual NMFS protected species workshop that instructs fishermen in mitigation, handling, and release techniques for sea turtles, seabirds, and marine mammals. Longline fishermen must carry and use specific equipment, and follow certain procedures for handling and releasing sea turtles, seabirds, and marine mammals that may be caught incidentally.

In 2012, NMFS issued a biological opinion on the continued operation of the Hawaii shallow-set longline fishery (NMFS 2012a). Sea turtle incidental take authorized over a continuous two-year calendar period in the ITS of this opinion is as follows:

- Green: six total, including up to two lethal.

- Leatherback: 52 total, including up to 12 lethal.
- Loggerhead North Pacific DPS: 68 total, including up to 14 lethal.
- Olive ridley: four total, including up to two lethal.

In 2014, NMFS issued a biological opinion on the continued operation of the Hawaii deep-set longline fishery (NMFS 2014a). Sea turtle incidental take authorized over a three-year period in the ITS of this opinion is as follows:

- Green: nine total, including up to nine lethal.
- Leatherback: 72 total, including up to 27 lethal.
- Loggerhead North Pacific DPS: nine total, including up to nine lethal.
- Olive ridley: 99 total, including up to 96 lethal.

West Coast Drift Gillnet Fishery for Highly Migratory Species

The West coast drift gillnet fishery targets swordfish and thresher sharks in the U.S. EEZ and adjacent high seas off the coasts of California, Oregon, and Washington (NMFS 2013). In 2001, NMFS established Pacific Sea Turtle Conservation Areas that prohibit drift gillnet fishing in large portions of the historical fishing grounds, either seasonally or conditionally, to protect endangered leatherback and loggerhead sea turtle populations (66 FR 44549; August 24, 2001). Oregon and Washington state laws currently prohibit landings caught with drift gillnet gear, although vessels still fish drift gillnets in federal waters off these states and land their catch in California. The drift gillnet fishery can also be closed during El Niño events in order to reduce bycatch of loggerhead turtles that move further north on the warm El Niño currents from Mexico into U.S. waters (72 FR 31756, June 8, 2007).

In 2013, NMFS issued a biological opinion on the continued authorization of the West Coast drift gillnet fishery (NMFS 2013). Sea turtle incidental take authorized over a five-year period in the ITS of this opinion is as follows:

- Green: two total, including up to one lethal.
- Leatherback: ten total, including up to seven lethal.
- Loggerhead: seven total, including up to four lethal.
- Olive ridley: two total, including up to one lethal.

8.8.2 Marine Mammal Fishery Interactions

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused injury and mortality of marine mammal species. For some marine mammal populations, the impacts from fisheries likely have significant demographic effects (Read et al. 2006b). Many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to fully assess the magnitude of this threat. When not immediately fatal, entanglement or ingestion of fishing gear can impede the ability of marine mammals to feed and can cause injuries that eventually lead to infection and death (Cassoff et al. 2011; Moore and Van der Hoop 2012; Wells et al. 2008b). Other sublethal effects of entanglement include increased vulnerability to additional threats, such as predation and ship strikes, by restricting agility and swimming speed. There are also costs likely to be associated with nonlethal entanglements in terms of energy and stress (Moore and Van der Hoop 2012).

In 1994, the MMPA was amended to formally require the development of a take reduction plan when bycatch exceeds a level considered unsustainable and would lead to marine mammal population declines if not mitigated. At least in part as a result of the MMPA bycatch amendment, estimates of bycatch in the Pacific declined by a total of 96 percent from 1994 to 2006 (Geijer and Read 2013). Cetacean bycatch declined by 85 percent from 342 in 1994 to 53 in 2006, and pinniped bycatch declined from 1,332 to 53 over the same time period.

From 2000 to 2012, an average of eight large whale entanglements were observed and reported per year in California (Saez et al. 2013b). Confirmed reports of entangled animals likely represent only a small fraction of the total number of entanglements that are actually occurring. Humpback whales and gray whales are the most commonly entangled cetacean species off California. Other species reported over this time frame include sperm whales, minke whales and fin whales. Traps and pots are the most common fishing gears reported as entangling West Coast whales, accounting for about 45 percent of entanglements (Saez et al. 2013b). The number of large whale entanglements may be increasing over time. In 2016, 66 separate cases of entangled whales were reported off the coast of California, 51 of which were humpback whales (NMFS 2017a). About 20 percent of reported entanglements in 2016 were from Southern California (Santa Barbara, Los Angeles, Orange, and San Diego counties), including ten humpbacks, two blue whales and one gray whale.

Insufficient data exist on the incidental bycatch of Guadalupe fur seals in fishing gear, although some juvenile seals have been documented with entanglement injuries. There were 16 records of human-related deaths or serious injuries to Guadalupe fur seals from stranding data for the five-year period 2010-2014 (Carretta et al. 2017a). These strandings included entanglement in marine debris and gillnet of unknown origin, and shootings. Observed human-caused mortality and serious injury for this stock very likely represents a fraction of the true impacts because not all cases are reported or documented (Carretta et al. 2017a).

The total number of confirmed larges whales reported entangled in Hawaii from 2002 to 2014 was 88 or about seven per year (Lyman 2014). All but three of these reports (one sei whale and two sperm whales), were humpback whales. The most commonly reported gears associated with entanglements in Hawaii are fish pots (50 percent) and longlines (23 percent).

False killer whales in Hawaiian waters have been seen taking catches from commercial longlines and trolling lines (Nitta and Henderson 1993; Shallenberger et al. 1981). Interactions with these fisheries operations can result in injury, including disfigurement to dorsal fins (Baird and Gorgone 2005; Forney and Kobayashi. 2007; McCracken and Forney 2010; Nitta and Henderson 1993; Shallenberger et al. 1981; Zimmerman 1983). Carretta et al. (2013a) estimated that less than one (0.5) individual per year from the MHI insular false killer whale stock are killed or seriously injured during the course of fishing operations in the Hawaiian EEZ. NMFS published a final rule to implement the False Killer Whale Take Reduction Plan on November 29, 2012 (77 FR 71260). The final rule includes gear requirements ("weak" circle hooks and strong branch lines) in the deep-set longline fishery, longline closure areas, and training and certification for vessel owners and captains in marine mammal handling and release.

Fishery interactions with Hawaiian monk seals can include direct interaction with gear (hooking or entanglement), seal consumption of discarded catch, and competition for prey. Fishery interactions are a serious concern in the Main Hawaiian Islands, especially involving nearshore state managed commercial and recreational fisheries. Over the 30-year period between 1982 and 2012, approximately 11 Hawaiian monk seals have been observed entangled in fishing gear or other marine debris annually, with a total of nine documented deaths over the 31 years (Carretta et al. 2014). In 2014, 14 monk seal hookings were documented, 13 of which were classified as non-serious injuries, although nine of these would have been deemed serious had they not been mitigated (Carretta et al. 2017a). One monk seal was found dead as result of a hook perforating its esophagus and lung. Nearshore gillnets became a more common source of mortality in the 2000s, with three seals confirmed dead in these gillnets (2006, 2007, and 2010); no gillnet-related mortality or injuries have been documented since 2010 (Carretta et al. 2017a).

Gobush et al. (2017) individually identified 297 monk seals between 1988 and 2014 and recorded that 83 (28 percent) of these had at least one documented hooking or entanglement. Most individuals were aged two years or younger and a quarter of them were hooked or entangled multiple times. The proportion of monk seals alive one year after a documented fisheries interaction varied by age class and ranged between 76 percent and 84 percent (Gobush et al. 2017). Survival one year later for monk seals with a documented fisheries interaction versus matched controls (all age classes combined) was not significantly different.

No Guadalupe fur seals have been observed entangled in California gillnet fisheries between 1990 and 2014 (Julian and Beeson 1998, Carretta et al. 2004, Carretta et al. 2016b), although stranded animals have been found entangled in gillnet of unknown origin.

In addition to the threats of entanglement and entrapment, fisheries operations can also result in changes to the structure and function of marine ecosystems that adversely affect marine mammals, including loss of prey species and alteration of benthic structure. Overfishing of many fish stocks results in significant changes in trophic structure, species assemblages, and pathways of energy flow in marine ecosystems (Jackson et al. 2001; Myers and Worm 2003). These ecological changes may have important, and likely adverse, consequences for populations of marine mammals (DeMaster et al. 2001). For instance, depletion of preferred prey could lead to a less nutritional diet and decreased reproductive success.

8.8.3 Bycatch of Sharks and Rays

Scalloped hammerhead sharks are both targeted and taken as bycatch in many global fisheries (e.g., bottom and pelagic longlines, coastal gillnet fisheries, artisanal fisheries). This species is highly desired for the shark fin trade because of its fin size and high fin ray count. In the United States, scalloped hammerhead sharks are mainly caught as bycatch in longline and coastal gillnet fisheries and are known to suffer high post-release mortality rates (76 FR 72891). Many of the scalloped hammerhead sharks captured in U.S. fisheries are not from an ESA-listed DPS since the only non-foreign listed DPSs are the Central and Southwest Atlantic, Eastern Pacific, and Indo-West Pacific. In the Pacific, shark bycatch occurs primarily in the Hawaii-based pelagic longline fishery. An observer program has been in place since 1995 with targeted coverage of 25 percent in the deep-set sector and 100 percent in the shallow-set sector. Observer data from 1995-2006 indicated a very low catch of scalloped hammerhead sharks in this fishery (56 individuals on 26,507 sets total, both fishery sectors combined) (Miller et al. 2013). Scalloped hammerheads are also occasionally caught in U.S. recreational fisheries, although recreational catch estimates are often unreliable due to the rare event nature of capture and species identification issues.

The most significant threat to giant manta ray populations is commercial fishing. Giant manta rays are a targeted species for the mobuild gill raker market. Gills from mobuilds (i.e., rays of the genus Mobula, including *Manta* spp.) are dried and sold in Asian dried seafood and traditional Chinese medicine markets (O'Malley et al. 2017). In addition to the threat from directed fishing, giant manta rays are also captured incidentally in industrial purse seine, longline and artisanal gillnet fisheries. Incidental bycatch is a particular concern in the eastern Pacific Ocean, and the Indo-Pacific (Miller 2016). From 2010-2016, an average of 22 giant manta rays have been caught annually as bycatch in the Hawaii deep-set longline fishery (based on extrapolated estimates from observer covered trips) (Kapur and Yau 2018). An average of one giant manta ray has also been reported annually as bycatch in the Hawaii shallow-set longline fishery durng this time period (based on 100 percent observer coverage) (Kapur and Yau 2018),

Oceanic whitetip sharks are also captured incidentally in Hawaii's commercial longline fisheries. From 2010-2016, an average of 1,532 oceanic whitetip sharks have been caught annually as bycatch in the Hawaii deep-set longline fishery (based on extrapolated estimates from observer covered trips) (Kapur and Yau 2018). An average of 42 oceanic whitetip sharks have also been reported annually as bycatch in the Hawaii shallow-set longline fishery durng this time period (based on 100 percent observer coverage) (Kapur and Yau 2018), In the eastern Pacific, the oceanic whitetip shark is caught on a variety of gear, including longline and purse seine gear targeting tunas and swordfish. While the range of the oceanic whitetip in the eastern Pacific is noted as extending as far north as southern California waters, based on the available data, the distribution of the species appears to be concentrated in areas farther south, and in more tropical waters (Young 2018). Observer data of the West-Coast based U.S. fisheries further confirms this finding, with oceanic whitetip sharks generally not observed in the catches. For example, in the

California/Oregon drift gillnet fishery, which targets swordfish and common thresher sharks and operates off the U.S. Pacific coast, observers recorded zero oceanic whitetip sharks in 8,698 sets conducted over the past 25 years (from 1990-2015) (Young 2018).

8.9 Aquaculture

Marine aquaculture systems are diverse, ranging from highly controlled land-based systems to open water cages that release wastes directly into the environment. Species produced in the marine environment are also diverse, and include seaweeds, bivalve molluscs, echinoderms, crustaceans, and finfish (Langan 2004). Aquaculture supplies more than 50 percent of all seafood produced for human consumption globally (National Oceanic and Atmospheric Administration [NOAA] Marine Aquaculture website https://www.fisheries.noaa.gov/topic/aquaculture). The National Offshore Aquaculture Act of 2005 (S. 1195) promoted offshore aquaculture development within the EEZ and established a permitting process that encourages private investment in aquaculture operations, demonstrations, and research. Marine aquaculture is expected to expand in the U. S. EEZ due to increased demand for domestically grown seafood, coupled with improved technological capacity to farm in the open ocean.

Farming the sea is a part of Hawaii's rich oceanic heritage and the state has been at the forefront of aquaculture research and technology (HDOA 2018). Hawaii is the first state to successfully operate commercial open ocean aquaculture cages in the U.S. In 2011, Hawaii's total aquaculture sales were valued at $40 million, an increase from $10 million in 2010. Algae sales accounted for 63 percent of the value, ornamental category six percent, finfish four percent, shellfish one percent, with the remaining 26 percent from sales of seedstock, broodstock and fingerlings.

Open-ocean aquaculture encompasses a variety of infrastructure designs; in the U.S., submersible cages are the model used for offshore finfish production (Naylor 2006). Aquaculture cages are anchored to the sea floor but can be moved within the water column. Cages are tethered to buoys that contain an equipment room and feeding mechanism and can be large enough to hold hundreds of thousands of fish in a single cage. One of the negative effects attributed to finfish culture is enrichment of the water column with dissolved nutrients, resulting from the decomposition of uneaten feed, and from metabolic wastes produced by the fish (Langan 2004). There is growing interest in marine aquaculture systems that combine fed aquaculture species (e.g. finfish), with inorganic extractive aquaculture species (e.g. seaweeds) and organic extractive species (e.g. suspension- and deposit-feeders) cultivated in proximity to mitigate these negative effects. One type of offshore aquaculture system that is expected to grow is longline mussel aquaculture (Price et al. 2016). Aquaculture companies in Hawaii have also been experimenting with drifting, unanchored cages for open ocean fish production.

The growth of the aquaculture industry has drawn attention to the potential environmental impacts of offshore aquaculture, including impacts to protected species. Although aquaculture has the potential to relieve pressure on ocean fisheries, it can also threaten marine ecosystems through the introduction of exotic species and pathogens, effluent discharge, the use of wild fish to feed farmed fish, and habitat destruction. Marine aquaculture operations have the potential to displace marine mammals from their foraging habitats or cause other disruptions to their behavior (Markowitz et al. 2004).

The large amount of fixed gear (e.g., nets, cages, lines, buoys) used for open water aquaculture could also represent an entanglement risk for some protected species. Entanglement in nets or lines around fish and mussel farms may cause injury, stress or death to marine mammals. It is generally thought that echolocating marine mammals (toothed whales, dolphins and porpoises) can effectively perceive mussel and fish farms and, in most cases, navigate through or around them (Llyod 2003; Markowitz et al. 2004). Species of baleen whales are not evolved to echolocate and rely on visual and audio queues, which may put them at higher risk of entanglement (Llyod 2003). Global reports of cetacean interactions with aquaculture gear include humpback whales is Australia, Canada and Iceland, Bryde's whales in New Zealand, right whales in South Korea, Argentina, and the North Atlantic Ocean (Price et al. 2016). There are three known incidents involving leatherback sea turtles being entangled in mussel ropes in Notre Dame Bay, Newfoundland from 2009 through 2013 (Price et al. 2016). One leatherback was documented entangled in shellfish aquaculture gear in the Greater Atlantic Region of the U.S.. This animal was entangled in the vertical line associated with the anchoring system. Despite these reported incidents of entanglement, a literature review conducted by Price et al. (2016) does not indicate significant impacts to marine mammals, sea turtles or ESA-listed fish species from marine aquaculture structures and activities. The authors note that it is unclear if this is because aquaculture is relatively benign and poses little risk, or because the number and density of farms is so low that the detection level for harmful interactions is also very small (Price et al. 2016).

8.10 Ongoing Military Training and Testing Activities in the Action Area

Ongoing U.S. Navy and Air Force training and testing activities in the action area are discussed here as part of the environmental baseline. The Navy categorizes training exercises and testing activities into functional warfare areas called primary mission areas. Training exercises fall into the following eight primary mission areas: Anti-air warfare; Strike warfare; Anti-submarine warfare; Mine warfare; Amphibious warfare; Anti-surface warfare; Electronic warfare; and Naval special warfare. Details regarding each warfare area can be found in the *Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement (FEIS/OEIS)* (Navy 2013c)

8.10.1 Summary of Hawaii-Southern California Training and Testing Phase II Biological Opinion

In December 2013, we completed a section 7 consultation on U.S. Navy HSTT training and testing activities occurring from 2013 through 2018 (Phase II). We consulted with the Navy and with the NMFS Permits Division, pursuant to section 7 of the ESA, on the issuance of the proposed rule and draft LOAs under section 101(a)(5)(A) of the MMPA for HSTT activities. The following levels of marine mammal incidental take from acoustic stressors in the form of behavioral harassment and/or TTS were authorized for HSTT Phase II training exercises, by species:

- Blue whale: up to 4,325 per year; not to exceed 21,559 total in 5 years
- Fin whale: up to 1,719 per year; not to exceed 8,531 total in 5 years
- Humpback whale: up to 9,273 per year; not to exceed 46,365 total in 5 years
- Sei whale: up to 630 per year; not to exceed 2,996 total in 5 years
- Western North Pacific Gray Whale: up to 10 per year; not to exceed 50 total in 5 years
- MHI IFKW: up to 49 per year; not to exceed 220 total in 5 years
- Sperm whale: up to 3,332 per year; not to exceed 15,920 total in 5 years
- Hawaiian monk seal: up to 1,292 per year; not to exceed 6,334 total in 5 years
- Guadalupe fur seal: up to 2,603 per year; not to exceed 13,015 total in 5 years

No marine mammal take in the form of harm (i.e., PTS or injury) from acoustic stressors was authorized for HSTT Phase II training exercises. The ITS for this opinion did authorize up to one whale (i.e. blue, fin, humpback or sei) injury or mortality per year, not to exceed three over five years as a result of vessel strike. Take of sea turtles from acoustic stressors during HSTT training was authorized for any combination of Pacific turtle species (green, hawksbill, loggerhead, olive ridley, and leatherback turtles) in the HRC and Transit Corridor areas as follows: 594 TTS harass; 21 PTS harm; 13 injury harm; and 4 mortality.

The following levels of marine mammal incidental take from acoustic stressors in the form of behavioral harassment and/or TTS were authorized for HSTT Phase II testing activities, by species:

- Blue whale: up to 428 per year; not to exceed 2,140 total in 5 years
- Fin whale: up to 225 per year; not to exceed 1,125 total in 5 years
- Humpback whale: up to 927 per year; not to exceed 4,635 total in 5 years
- Sei whale: up to 51 per year; not to exceed 255 total in 5 years
- Western North Pacific Gray Whale: up to two per year; not to exceed ten total in 5 years
- MHI IFKW: up to four per year; not to exceed 20 total in 5 years
- Sperm whale: up to 263 per year; not to exceed 1,315 total in 5 years
- Hawaiian monk seal: up to 358 per year; not to exceed 1,790 total in 5 years
- Guadalupe fur seal: up to 269 per year; not to exceed 1,345 total in 5 years

No marine mammal take in the form of harm (i.e., PTS or injury) from acoustic stressors was authorized for HSTT Phase II testing activities. The ITS for this opinion did authorize up to two whale (i.e. blue, fin, humpback or sei) injuries or mortalities per year, not to exceed four over five years as a result of vessel strike. Take of sea turtles from acoustic stressors during HSTT testing activities was authorized for any combination of Pacific turtle species (green, hawksbill, loggerhead, olive ridley, and leatherback turtles) in the HRC and Transit Corridor areas as follows: 401 TTS harass; five PTS harm. Take of green sea turtles from acoustic stressors during HSTT testing activities was authorized for the SOCAL Range Complex area as follows: 616 TTS harass; 97 PTS harm.

8.10.2 Surveillance Towed Array Sensor System Low Frequency Active Sonar

The Navy's SURTASS sonar system has a vertical line array of 18 elements operating between 100 and 500 Hz. The typical low-frequency active sonar signal is not a constant tone but consists of various waveforms that vary in frequency and duration. A complete sequence of sound transmissions (waveforms) is referred to as a wavetrain (also known as a ping). These wavetrains last between 6 and 100 seconds, with an average length of 60 seconds. Within each wavetrain, a variety of signal types can be used, including continuous wave and frequency-modulated signals. The duration of each continuous-frequency sound transmission within a wavetrain is no longer than 10 seconds. The interval between transmissions varies between 6 and 15 minutes. SURTASS low-frequency active has a coherent low frequency signal with a duty cycle of less than 20 percent. The Navy's proposed action allows for each ship (of which they are four) to utilize a maximum of 255 hours per year, per ship (or 1,050 hours total). Prior to 2017, the Navy has only used SURTASS low-frequency active sonar in the western and central North Pacific Ocean. However, in 2017 the U.S. Navy requested programmatic section 7 consultation for the operation of SURTASS low-frequency active sonar from August 2017 through August 2022 in the non-polar region of the world's oceans (including within the action area). The consultation was concluded in August 2017 (NMFS 2017c) and considered the Navy's SURTASS low-frequency active program as well as specific SURTASS low-frequency active annual activities.

8.10.3 Air Force Training and Testing Activities

The Air Force conducts training and testing activities on range complexes on land and in U.S. waters. Aircraft operations and air-to-surface activities may occur in the action area (e.g., off Florida). Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles, rockets, and gunnery rounds) from aircraft towards targets located on the surface, though Air Force training exercises may also involve boats. These activities have the potential to impact ESA-listed species by physical disturbance, boat strikes, debris, ingestion, and effects from noise and pressure produced by detonations. Air Force training and testing activities constitute a federal action and take of ESA-listed sea turtles considered for these Air Force activities have previously undergone separate section 7 consultations.

8.11 Vessel Approaches – Commercial and Private Whale Watching

Studies investigating the behavioral responses of cetaceans to vessels suggest that individual whales experience stress responses to approaching vessels. While this type of stimulus is often stressful, the fitness consequences of this stress on individual whales remains unknown (Baker and Herman 1987; Baker et al. 1983b). Beale and Monaghan (2004a) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches.

Baker *et al.* (1983b) described two responses of whales to vessels: (1) *horizontal avoidance* of vessels 2,000 to 4,000 m away characterized by faster swimming and fewer long dives; and (2) *vertical avoidance* of vessels from 0 to 2,000 m away during which whales swam more slowly, but spent more time submerged. Watkins *et al.* (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 km from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels (Bauer 1986a; Bauer and Herman 1986b). Bauer (1986a) and Bauer and Herman (1986b) noted changes in humpback whale respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels.

Studies of other baleen whales, specifically bowhead and gray whales, document similar patterns of behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985b). For example, studies of bowhead whales revealed that they orient themselves in relation to a vessel when the engine is on, and exhibit significant avoidance responses when the vessel's engine is turned on even at a distance of about 900 m (3,000 ft). Jahoda *et al.* (2003b) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They found that close vessel approaches caused the whales to stop feeding and swim away from the approaching vessel. The fin whales studied also tended to reduce the time they spent at the surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. Whales that had been disturbed while feeding remained disturbed for hours after the exposure ended.

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, whale watching has the potential to harass whales by altering feeding, breeding, and social behavior or even injure them if the vessel gets too close and strikes a whale (New et al. 2015). Another concern is that preferred habitats may be abandoned if disturbance levels from whale watch boats are too high. Several studies have specifically examined the effects of whale watching on marine mammals, and investigators have observed a variety of short-term responses from animals, ranging from no apparent response to changes in vocalizations, duration of time spent at the surface, swimming speed, swimming angle or direction, respiration rate, dive time, feeding behavior, and social behavior (NMFS 2006). Responses appear to be dependent on factors such as vessel proximity, speed, and direction, as well as the number of vessels in the vicinity. Disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mothers' sides, which leads to greater energy expenditures by the calves (NMFS 2006). Au and Green (2000) concluded that it is unlikely that the levels of sounds produced by whale watching boats in Hawaii would have any grave effects on the auditory system of humpback whales. Although numerous short-term behavioral responses to whale watching vessels are documented, little information is available on whether long-term negative effects result from this activity (NMFS 2006) (New et al. 2015).

By regulation, humpback whales cannot be approached closer than 100 yd (90 m) by vessels in Hawaiian waters (50 C.F.R. 224.103). The only exception to these approach restrictions is for researchers who hold a scientific research permit authorized by NMFS. For all other cetaceans and for monk seals the recommended distance for observation is 50 yd when the animal is on land or in the water. Other guidelines have been issued by NMFS to minimize the impacts of wildlife viewing on marine mammals, including maximum vessel speeds, proper vessel positioning, limiting noise levels, and the use of extra caution in the vicinity of mothers and their young.

In Hawaii, most of the whale watching industry is based around humpback whales which winter in the islands from mid-December to the end of April (Hoyt 2001). Maui is the primary location for boat-based whale watching, but whale watching operations located at most major harbors around the state. The whale watching industry in Hawaii contributes approximately $20 million in total revenues per year. In the Southern Califronia portion of the action area, whale watching companies offer blue whale tours that leave from San Diego Bay from about mid-June through September. We have no information regarding the specific effects of whale watching operations within the action area. We anticipate that at least some short-term effects from whale watching, as described above, are affecting humpback and blue whales within the action area, although the regulations and mitigation measures in place likely reduce those effects to some extent.

8.12 Vessel Strike

Marine habitats occupied by ESA-listed species often feature both heavy commercial and recreational vessel traffic. Vessel strikes represent a recognized threat to several taxa of large air breathing marine vertebrates, including whales and sea turtles. The International Whaling Commission noted that human-induced mortality caused by vessel strikes can be an impediment to cetacean population growth (IWC 2017). Most whales killed by vessel strike likely end up sinking rather than washing up on shore. It is estimated that only 17 percent of vessel strikes of whales are actually detected (Kraus et al. 2005). Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of mortalities associated with vessel strikes.

Various types and sizes of vessels have been involved in ship strikes with large whales, including container/cargo ships/freighters, tankers, steamships, U.S. Coast Guard vessels, Navy vessels, cruise ships, ferries, recreational vessels, fishing vessels, whale-watching vessels, and other vessels (Jensen and Silber 2004a). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately ten knots, with faster vessels, especially of large vessels (80 m or greater), being more likely to cause serious injury or death (Conn and Silber 2013b; Jensen and Silber 2004b; Laist et al. 2001; Vanderlaan and Taggart 2007). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. Injuries to whales killed by vessel strikes include huge slashes, cuts, broken vertebrae, decapitation, and animals cut in half (Carillo and Ritter 2008). Measures to minimize the risk of ship strikes include re-routing shipping lanes, creating areas to be avoided, and vessel speed limits in areas where collisions are known to occur.

The west coast of the U.S. has some of the heaviest ship traffic associated with some of the largest ports in the country, including Los Angeles/Long Beach, San Francisco, Seattle, and the Columbia River. Blue, fin, humpback, and gray whales are the most vulnerable species to ship strikes because they migrate along the coast and utilize coastal areas for feeding. In California, gray whales are the most common baleen whale hit by ships, followed (in order of occurrence) by fin, blue, humpback, and sperm whales (Heyning and Dahlheim 1990; NMFS 2011c). NMFS declared an Unusual Mortality Event (UME) on October 11, 2007, because of the number of blue whales (four) struck and killed by vessels during the fall of that year. The magnitude of this threat for large whales populations along the U.S. West Coast could be considerably larger than indicated based on reported incidents due to the unknown number of vessel strikes that go undocumented (NMFS 2011c). For example, Rockwood et al. (2017) estimated ship strike mortality of blue, fin, and humpback whales using an encounter theory model that considered whale density, vessel traffic characteristics, and whale movement patterns. Using the estimates from Rockwood et al. (2017), Carretta et al. (2018a) estimated that the vessel strike detection rate of blue whales is approximately one percent, fin whales is approximately 3.7 percent, and humpback whales is approximately 12 percent.[19]

Collision with vessels is recognized as a threat to endangered humpback whales in Hawaii. Lammers et al. (2013) examined 37 years of historical records for evidence of vessel collisions with humpback whales in the main Hawaiian Islands. Between 1975 and 2011, 68 collisions between vessels and whales were reported including 59 witnessed collisions and 9 observed whale injuries that were consistent with a recent vessel collision. No collisions were immediately lethal. Over 63 percent of the collisions involved calves and subadults, suggesting a greater risk of collisions among younger animals (Lammers et al. 2013). The authors conclude that the significant increase in reports of non-lethal collisions between vessels and humpback whales from 1975–2011 in the main Hawaiian Islands likely reflects a combination of factors including the recovery of the population of North Pacific humpback whales, increases in traffic of particular vessel types, and increased reporting practices by operators of vessels (Lammers et al. 2013).

Impact from a boat hull or outboard motor, or cuts from a propeller can kill or severely injure turtles. Many recovered turtles display injuries that appear to result from interactions with vessels and their associated propulsion systems (Work et al. 2010). Turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases (Hazel et al. 2007). Results from a study by Hazel et al. (2007) suggest that green turtles cannot consistently avoid being struck by vessels moving at relatively moderate speeds (i.e., greater than four kilometers per hour). Vessel strikes have been identified as one of the important mortality factors in several near shore turtle habitats worldwide (Denkinger et al. 2013). Vessel strikes were identified as a source of mortality for green sea turtles in Hawaii waters, although reported incidence rates among stranded turtles are not as high as in the southeastern United States. Chaloupka et al. (2008) reported that 2.5 percent of green turtles found dead on Hawaiian beaches between 1982 and 2003 had been killed by vessel strike.

[19] Note that the Rockwood et al. (2017) modeling exercise focused on large tanker and cargo vessels with limited visibility and poor reaction capability. For that reason, they considered avoidance behavior by vessels to be close to zero in their modeling exercise. This is in contrast to what would be expected for Navy vessels, as described further in Section 9.2.1.4.

8.13 Invasive Species

The introduction of non-native species is considered one of primary threats to at-risk 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 International Union for Conservation of Nature database; 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).

When non-native plants and animals are introduced into habitats where they do not naturally occur, they can have significant impacts on ecosystems and native fauna and flora. Non-native aquatic species can be introduced through infested stock for aquaculture and fishery enhancement, ballast water discharge, and from the pet and recreational fishing industries. Non-native species can reduce native species abundance and distribution, and reduce local biodiversity by out-competing native species for food and habitat. They may also displace food items preferred by native predators, disrupting the natural food web. An example of indirect predatory effects caused by an invasive species is the European green crab, which has invaded both the east and west coasts of the U.S., resulting in trophic scale effects to ecosystems in both regions (Grosholz and Ruiz 1996). Invasive plants can cause widespread habitat alteration, including native plant displacement, changes in benthic and pelagic animal communities, altered sediment deposition, altered sediment characteristics, and shifts in chemical processes such as nutrient cycling (Grout et al. 1997; Ruiz et al. 1999; Wigand et al. 1997). Introduced seaweeds alter habitat by colonizing previously unvegetated areas, while algae form extensive mats that exclude most native taxa, dramatically reducing habitat complexity and the ecosystem services provided by it (Wallentinus and Nyberg 2007). Invasive algae can alter native habitats through a variety of impacts including trapping sediment, reducing the number of suspended particles that reach the benthos for benthic suspension and deposit feeders, reducing light availability, and adverse impacts to foraging for a variety of animals (Britton-Simmons 2004; Gribsholt and Kristensen 2002; Levi and Francour 2004; Sanchez et al. 2005). Pathogens and species with toxic effects not only have direct effects on listed species, but also may affect essential critical habitat features or indirectly affect the species through ecosystem-mediated impacts. There are a number of non-native species that have the potential to either expel toxins at low levels, only becoming problematic for other members of the ecosystem if their population grows to very large sizes, resulting in very large amounts of toxins being released.

As of 2013 there were 54 documented marine invasive species in San Diego Bay including tunicates (nine species), amphipods (eight species), polychaetes (six species), moss animals (six species), molluscs (five species), and isopods (four species) (Navy 2013e). Several of these invasions have resulted in ecosystem level effects. The Japanese mussel (*Musculista senhousia*) has spread rapidly throughout Mission Bay and San Diego Bay, reaching densities up to 27,000 mussels/m^2 in the intertidal zone and up to 178,000 per m^2 carpeting the shallow subtidal bay bottom (NAVY 2013d; Navy 2013e). Research has shown that the effect of this species can be both negative and positive (Crooks 1998). While the mussel's dense mats can crowd out native clams and dominate marsh restoration sites, the mats also provide new habitat that supports greater species diversity and densities of native macrofauna than other areas. However, the mussel's dense beds can inhibit growth and vegetative propagation of native eelgrass (Reusch and Williams 1998; Reusch and Williams 1999). Another invasive species in San Diego Bay producing ecosystem-level effects through habitat alteration is the isopod *Sphaeroma quoyanum* (Crooks 1997). High densities (greater than 10,000 per m^2) in some creeks that feed the bay have caused the overlying vegetated marsh flat to slump into the creek and the creek to widen. The ecosystem level changes produced by invasive species within San Diego Bay could potentially have detrimental impacts on ESA-listed green sea turtle habitat and prey, although no studies have specifically addressed this issue.

There are a total of 333 non-native species, and another 130 cryptogenic species (i.e., unknown origin), documented as part of the marine and estuarine biota of the six largest Hawaiian islands from Kauai to Hawaii (Carlton and Eldredge 2015). The greatest proportion of non-native and cryptogenic species are found in the majors harbors of Oahu, which receive the large majority of all vessel traffic in the Hawaiian Islands (Coles and Eldredge 2002). Approximately 20 percent of the benthic algae, fish, and macroinvertebrate species found these harbors are either non-native or cryptogenic. Algal species have become nuisance invaders of many Hawaiian reefs (Smith et al. 2002). With the exception of Kaneohe Bay, the largest embayment in Hawaii with a history of urban impact, few nonindigenous fish or invertebrates have been detected on Hawaiian reefs (Coles and Eldredge 2002). ESA-listed sea turtles and Hawaiian monk seals could be impacted by invasive species in Hawaii, although there are no studies indicating this is occurring.

8.14 Diseases

Fibropapillomatosis is a neoplastic disease that can negatively impact ESA-listed sea turtle populations. Fibropapillomatosis 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). Fibropapillomatosis 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). 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). Fibropapillomatosis primarily affects medium-sized immature turtles in coastal foraging pastures.

Fibropapillomatosis is characterized by both internal and external tumorous growths, which can range in size from very small to extremely large. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley et al. 2005). Renan de Deus Santos et al. (2017) assessed stress responses (corticosterone, glucose, lactate, and hematocrit) to capture and handling in green sea turtles with different fibropapillomatosis severity levels. Their findings suggest that moderate fibropapillomatosis severity may affect a turtle's ability to adequately feed themselves (as evidenced by poor body condition), and advanced-stage fibropapillomatosis severity may result in an impaired corticosterone response. Expression of fibropapillomatosis differs across ocean basins and to some degree within basins (Hargrove et al. 2016). In Hawaii, tumors have been reported on the internal organs of green sea turtles and oral tumors are common and often severe (Hargrove et al. 2016).

While fibropapillomatosis can result in reduced individual fitness and survival, documented mortality rates in Hawaii are low. The mortality impact of fibropapillomatosis is not currently exceeding population growth rates in some intensively monitored populations (e.g., Florida and Hawaii in the U.S., and the Southern Great Barrier Reef stock in Queensland, Australia) as evidenced by increasing nesting trends despite the incidence of fibropapillomatosis in immature foraging populations (Hargrove et al. 2016). However, fibropapillomatosis cannot be discounted as a potential threat to sea turtle populations (particularly green turtles) as the distribution, prevalence rate, severity, and environmental co-factors associated with the disease have the capacity to change over time (Jones et al. 2015).

Environmental factors likely play a role in the development of fibropapillomatosis. Most sites with a high frequency of fibropapillomatosis tumors are areas with some degree of water quality degradation resulting from altered watersheds (Hargrove et al. 2016). Despite there being a strong positive correlation between the prevalence of fibropapillomatosis in green turtle populations and areas with degraded water quality, it is difficult to identify one specific causal contaminant or a combination of such working synergistically to lead to fibropapillomatosis formation.

Infectious diseases and parasites are a threat to many cetacean populations worldwide. Cetacean morbilliviruses and papillomaviruses as well as *Brucella spp*. and *Toxoplasma gondii* are thought to interfere with population abundance by inducing high mortalities, lowering reproductive success, or by synergistically increasing the virulence of other diseases (Van Bressem et al. 1999). Genital papillomatosis has been observed in sperm whales from Iceland (Lambertsen et al. 1987). Jauniaux et al. (2000) reported evidence for morbillivirus infection in fin whales stranded on the Belgian and French coastlines.

Cetaceans have evolved with a group of parasites belonging to the genus *Crassicauda* (order Spirurida) (Lambertsen 1992). 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 1992). Anthropogenic environmental changes may increase the prevalence and severity of infectious illnesses and disease in cetaceans. A high prevalence of traumatic injuries or even minor skin lacerations from other stressors (e.g., vessel strike, fisheries interactions), in combination with a compromised immune system create ideal targets for opportunistic pathogens.

The potential population-level impact of infectious disease on Hawaiian monk seals could be severe given their critically endangered status, very low genetic diversity, and that this population has not been previously exposed to many diseases due to the isolation of the Hawaiian Archipelago (PIFSC 2018). Monk seals in the main Hawaiian Islands are often in close proximity to areas of human activity, domestic and feral animals, and agricultural areas, thus increasing the probability of infectious disease transmission. Infectious diseases that pose a risk to the monk seal population include distemper viruses, West Nile virus, *Leptospira spp*., and *Toxoplasma gondii* (PIFSC 2018). Risk factors for Hawaiian monk seals include cetaceans and non-native pinniped species that carry morbillivirus into Hawaiian waters and interactions between monk seals and infected dogs. Toxoplasmosis was first identified infecting a wild Hawaiian monk seal carcass examined in 2004 with disseminated disease and intra- and extracellular tachyzoites and tissue cysts in affected organs (Honnold et al. 2005). Barbieri et al. (2016) reported seven additional cases (eight total) and two suspect cases of protozoal-related mortality in Hawaiian monk seals between 2001 and 2015, including the first record of vertical transmission in this species. *Toxoplasma gondii* was the predominant apicomplexan parasite identified and was associated with 100 percent of confirmed protozoal-related mortalities (n = 8), and 50 percent of suspected cases (Barbieri et al. 2016).

Although the pathogen has not been associated with phocid mortality in the North Pacific to date, morbilliviruses have caused mass die offs of wild phocid populations in other parts of the world (PIFSC 2017). In 2016, NOAA developed the Hawaiian Monk Seal Vaccination Research and Response Plan to proactively address the threat of infectious diseases in this population, particularly for morbillivirus and West Nile virus infections. Studies of Guadalupe fur seals stranding off the coast of California have reported finding hemorrhagic gastroenteritis, nematodes, cestodes (Gerber et al. 1993), septicemia, and bacterial pneumonia (Hanni et al. 1997) in stranded animals.

There is also no information to indicate that disease is a factor affecting populations of scalloped hammerhead or oceanic whitetip sharks (Miller et al. 2014a; Young 2018). Like most sharks, these species likely carry a range of external parasites including cestodes, nematodes, leeches, copepods, and amphipods but there are no studies suggesting parasites are negatively affecting the fitness or survival of these species (Miller et al. 2014a; Young 2018). At least some oceanic whitetip sharks are infected with highly pathogenic *Vibrio harveyi*. This bacterium is known to cause deep dermal lesions, gastro-enteritis, eye lesions, infectious necrotizing enteritis, vasculitis, and skin ulcers in marine vertebrates (Austin and Zhang 2006). *Vibrio harveyi* is considered to be more serious in immunocompromised hosts, and therefore may act synergistically with the high pollutant loads that oceanic whitetip sharks potentially experience to create an increased threat to the species (Young 2018). However, there is no additional information available regarding the magnitude of impact these parasites may have on the health of oceanic whitetip populations (Young 2018).

8.15 Scientific Research and Permits

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 ESA-listed species 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. As required by regulation, 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. Section 10(a)(1)(A) permits are also issued to research facilities and educational display facilities for the captive research and educational display of ESA-listed species.

Over time, NMFS has issued dozens of permits on an annual basis for various forms of "take" of 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 "takes" of marine mammals are authorized for research activities.

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. On average, from 2007 to 2017 approximately 2,370 turtle (all species) takes were reported within the program in any given year. This includes an annual average of 831 sea turtles taken by capture with subsequent procedures, 157 sea turtles taken by conducting procedures only (i.e., capture authorized through different permit), and 1,382 sea turtles taken only during remote surveys. Most authorized take is sub-lethal. Mortality is rarely authorized by the Permits Division in sea turtle research permits and no lethal take was authorized for sea turtle research in the Pacific Ocean basin from 2007-2017. In 2017, NMFS concluded 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 (NMFS 2017b). This programmatic consultation allows for the authorization of up to the following number of sea turtle mortalities within the Pacific Ocean basin every ten years: nine green sea turtles (Central West Pacific, Central South Pacific, Central North Pacific, East Pacific DPSs combined); ten hawksbill; two leatherback; 12 loggerhead (North Pacific DPS); and eight olive ridely (NMFS 2017b). This programmatic also includes an ITS that allows for one green sturgeon Southern DPS lethal take every ten years and one scalloped hammerhead Eastern Pacific DPS lethal take every ten years.

9 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as the direct and indirect effects of an action on the species or designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. These effects are considered along with the environmental baseline and the predicted cumulative effects to determine the overall effects to the species for purposes of preparing this biological opinion on the proposed action. (50 C.F.R. §402.02).

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage 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 survival and recovery of the species.

The destruction and adverse modification analysis considers whether the action produces "a direct or indirect alteration that appreciably diminished the value of designated critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." 50 C.F.R. 402.02.

Previously in Section 6, we identified the potential stressors created by the Navy's testing and training activities. This section (Section 9) begins with a summary table of our effects determination by stressor category for each taxa and for each species (Table 56). This serves as a cross reference for the sections to follow that provide the analyses supporting these effects determinations.

Recall that in Section 7, we provided a complete list of ESA-listed species and designated critical habitat that may be affected by the proposed action. Further, in Section 7.1, we explained that some ESA-listed species were not likely to be adversely affected by any of the stressors associated with the proposed action. This is because any effects 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 addressed in Section 7.1 are included in the summary table below because this table reflects all species considered during consultation. However, ESA-listed species determined in Section 7.1 to not likely be adversely affected by any of the stressors associated with the proposed action are not discussed again in this opinion as there is no meaningful potential for the proposed action to affect their survival or recovery.

In Section 9.1 and 9.2, we discuss species that are *likely to be adversely affected* by at least one stressor associated with the proposed action (See Section 7.2 for the list of these species considered in this section). In Section 9.1, we discuss the stressors associated with the proposed action that we determined are *not likely to adversely affect* all species from a particular taxa (e.g., marine mammals, sea turtles; i.e., in the taxa row, labeled as NLAA in Table 56). We do not discuss these stressors again in this opinion as there is no meaningful potential for these stressors to affect their survival or recovery of species considered in this opinion. Finally, in Section 9.2, we summarize our analysis for the stressors and ESA-listed species combinations that are likely to result in adverse effects to individual ESA-listed species (in the taxa row of Table 56, labeled as LAA).

In Section 9.3, we discuss potential impacts of the proposed action on the designated critical habitat identified in Section 7.3.

Table 56. National Marine Fisheries Service ESA effects determinations by stressor for each species.

Note: The table also lists the overall effect determination by taxa for each stressor. If the determination for a particular taxa is NLAA, the analysis for that taxa and stressor is in section 9.1 of this opinion. If the determination for a particular taxa is LAA, the analysis for that taxa and stressor is in section 9.2 of this opinion. The determination for all designated critical habitat in the action area is that the action is not likely to destroy or adversely modify (NAD) the habitat. This is discussed in Section 9.3.

ESA-Listed Resource	Activity	Overall Determination	Acoustic Stressors						Explosive Stressors	Energy Stressors		Physical Disturbance and Strike Stressors			Entanglement Stressors			Ingestion Stressors		Secondary Stressors
			Sonar & Other Transducers	Air Guns	Pile Driving	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Water Electromagnetic Devices	High Energy Lasers	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators / Parachutes	Biodegradable Polymer	Military Expended Materials – Munitions	Military Expended Materials – Other than Munitions	
Marine Invertebrates	Training/Testing	NLAA	-	-	-	-	-	-	NLAA	-	-	-	NLAA	-	-	NLAA	-	-	-	NLAA
Black abalone	Training	NLAA	-	-	-	-	-	-	NLAA	-	-	-	NLAA	-	-	NLAA	-	-	-	NLAA
	Testing	NLAA	-	-	-	-	-	-	NLAA	-	-	-	NLAA	-	-	NLAA	-	-	-	
White abalone	Training	NLAA	-	-	-	-	-	-	NLAA	-	-	-	NLAA	-	-	NLAA	-	-	-	NLAA
	Testing	NLAA	-	-	-	-	-	-	NLAA	-	-	-	NLAA	-	-	NLAA	-	-	-	
Fishes	Training/Testing	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Scalloped hammerhead shark – Eastern Pacific DPS	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Steelhead – Southern California DPS	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Giant manta ray	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Oceanic whitetip shark	Training	**LAA**	NLAA	-		NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Sea Turtles	Training/Testing	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green turtle – Central North Pacific DPS	Training	**LAA**	NLAA	-ˉ	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Green turtle - Eastern Pacific DPS	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Hawksbill turtle	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	--	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Leatherback turtle	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Loggerhead turtle – North Pacific DPS	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Olive ridley turtle	Training	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	NLAA	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Marine Mammals	Training/Testing	**LAA**	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Blue whale	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	**LAA**	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Fin whale	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA

ESA-Listed Resource	Activity	Overall Determination	Acoustic Stressors: Sonar & Other Transducers	Acoustic Stressors: Air Guns	Acoustic Stressors: Pile Driving	Acoustic Stressors: Vessel Noise	Acoustic Stressors: Aircraft Noise	Acoustic Stressors: Weapons Noise	Explosive Stressors: Explosions	Energy Stressors: In-Water Electromagnetic Devices	Energy Stressors: High Energy Lasers	Physical Disturbance and Strike Stressors: Vessels & In-Water Devices	Physical Disturbance and Strike Stressors: Military Expended Material	Physical Disturbance and Strike Stressors: Seafloor Devices	Entanglement Stressors: Wires & Cables	Entanglement Stressors: Decelerators / Parachutes	Entanglement Stressors: Biodegradable Polymer	Ingestion Stressors: Military Expended Materials – Munitions	Ingestion Stressors: Military Expended Materials – Other than Munitions	Secondary Stressors
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Gray whale - Western North Pacific DPS	Training	**LAA**	**LAA**	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Humpback whale - Mexico DPS	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Humpback whale – Central America DPS	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Sei whale	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Sperm whale	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	**LAA**	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
False killer whale - Main Hawaiian Islands Insular DPS	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Guadalupe fur seal	Training	**LAA**	**LAA**	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Hawaiian monk seal	Training	**LAA**	**LAA**	-	-	NLAA	NLAA	NLAA	**LAA**	NLAA	-	NLAA	NLAA	NLAA	NLAA	NLAA	-	NLAA	NLAA	NLAA
	Testing	**LAA**	**LAA**	NLAA	-	NLAA	NLAA	NLAA	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	
Critical Habitat	Training/Testing	NAD	NAD	-	-	NAD	-	-	NAD	-	-	NAD	NAD	NAD	-	-	-	-	-	-
Black abalone	Training	NAD	-	-					NAD	-	-	NAD	NAD	-	-	-	-	-	-	-
	Testing	NAD	-	-	-	-	-	-	NAD	-	-	NAD	NAD	-	-	-	-	-	-	-
Hawaiian Monk Seal	Training	NAD	-	-					NAD	-	-	-	-	NAD	-	-	-		-	
	Testing	NAD	-	-	-	-	-	-	NAD	-	-	-	-	NAD	-	-	-	-	-	-
False killer whale - Main Hawaiian Islands Insular DPS	Training	NAD	NAD	-	-	NAD	-	-	NAD	-	-	NAD	NAD	-	-	-	-	-	-	-
	Testing	NAD	NAD	-	-	NAD	-	-	NAD	-	-	NAD	NAD	-	-	-	-	-	-	-

9.1 Stressors Not Likely to Adversely Affect ESA-Listed Species

Our analysis of the stressors associated with the proposed action led to the determination that some stressors are not likely to adversely affect some or all ESA-listed species because the effect of that stressor would be insignificant or discountable. The following section discusses stressors that are not likely to adversely affect some or all ESA-listed species considered in this opinion. For analysis of effects to ESA-listed species, note that discussion in this section is organized by taxa (i.e., marine mammals, sea turtles, fishes) because the pathways for effects for these stressors is generally the same by taxa and 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 associated with the proposed action.

9.1.1 Marine Mammals

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed blue, fin, Western North Pacific DPS gray, humpback (both Central America and Mexico DPSs), sei, sperm, and MHI IFKWs, or Guadalupe fur and Hawaiian monk seals. Our analysis for these stressors and marine mammals is summarized below.

9.1.1.1 Acoustic Stressors – Marine Mammals

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed marine mammals. The effects of additional acoustic stressors, which NMFS determined are likely to adversely affect marine mammals, are discussed in Section 9.2.1.

9.1.1.1.1 Vessel Noise – Marine Mammals

Additional discussion on vessel noise as a potential stressor is included in Section 6.1.1. Navy vessel movements involve transits to and from ports to various locations within the action area, and many proposed activities within the action area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels), as well as unmanned vehicles. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks. Navy vessel traffic could occur anywhere within the action area, but would be concentrated within the easternmost part of Southern California and around the major Hawaiian Islands, particularly the area surrounding Honolulu (Mintz 2016). During training and testing, vessel speeds generally range from 10 to 15 knots. However, vessels can and will, go faster if required by mission or operation. While the discussion below focuses on the potential effects of vessel noise on marine mammals, it should be noted up front that it is often difficult to differentiate between the influence of sound exposure from vessels and the physical presence of vessels (e.g., Ng and Leung 2003).

Sound emitted from large vessels, such as cargo 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 (Hatch and Wright 2007; Hildebrand 2005; Richardson et al. 1995f). For example, Bassett et al. (2010) measured mean SPLs at Admiralty Inlet from commercial shipping at 117 dB re 1 μPa with a maximum exceeding 135 dB re 1 μPa on some occasions. Similarly, Veirs et al. (2015) found average broadband noise levels in Haro Strait to be 110 dB re 1 μPa that extended up to 40 kHz, well into the hearing range of odontocetes.

Many studies of behavioral responses by marine mammals to vessels have been focused on the short- and long-term impacts of whale watching vessels. In short-term studies, researchers noted changes in resting and surface behavior states of cetaceans in response to whale watching vessels (Aguilar Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000; Christiansen et al. 2010; Erbe 2002b; Noren et al. 2009; Williams et al. 2009). Received sound levels were often not reported so it is difficult to distinguish responses to the presence of the vessel from responses to the vessel noise. Most studies examined the short-term response to vessel sound and vessel traffic (Aguilar Soto et al. 2006; Magalhaes et al. 2002; Richardson et al. 1995f; Watkins 1981a), with behavioral and vocal responses occurring when received levels were over 20 dB greater than ambient noise levels.

Baleen whales demonstrate a variety of responses to vessel traffic and noise, from not responding at all to both horizontal (swimming away) and vertical (increased diving) avoidance (Baker et al. 1983a; Gende et al. 2011; Watkins 1981a). Other common responses include changes in vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Richter et al. 2003b; Williams et al. 2002a).

The likelihood of response may be driven by the distance or speed of the vessel, the animal's behavioral state, or by the prior experience of the individual or population. For example, in one study fin and humpback whales largely ignored vessels that remained 100 m or more away (Watkins 1981a). In another study, minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 NM. However, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al. 1982). Similarly, Bernasconi et al. (2012) observed the reactions of six individual baleen whales of unidentified species at distances of 50 to 400 m from a fishing vessel conducting an acoustic survey of pelagic fisheries, with only a slight change in swim direction when the vessel began moving around the whales. Sei whales have been observed ignoring the presence of vessels entirely and even passing close to vessels (Reeves et al. 1998), and North Atlantic right whales tend not to respond to the sounds of oncoming vessels and continue to use habitats in high vessel traffic areas (Nowacek et al. 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves. This lack of response may be due to habituation to the presence and associated noise of vessels in right whale habitat, or may be due to propagation effects that may attenuate vessel noise near the surface (Nowacek et al. 2004; Terhune and Verboom 1999).

When baleen whales do respond to vessels, responses can be as minor as a change in breathing patterns (e.g., Jahoda et al. 2003a), or can be evidenced by a decrease in overall presence, as was observed during a construction project in the United Kingdom, when fewer minke whales were observed as vessel traffic increased (Anderwald et al. 2013a). Avoidance responses can be as simple as an alteration in swim patterns or direction by increasing speed and heading away from the vessel (Jahoda et al. 2003a), or by increasing swim speed, changing direction to avoid, and staying submerged for longer periods of time (Au and Green 2000). For example, in the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing but otherwise do not exhibit strong reactions (Mckenna et al. 2009). In another study in Hawaii, humpback whales exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 2,000 m and 4,000 m away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were less than 2,000 m away (Baker et al. 1983a). Similarly, humpback whales in Australia demonstrated variable responses to whale watching vessels, including both horizontal avoidance, approaching, and changes in dive and surface behavior (Stamation et al. 2009). Humpback whales avoided a Navy vessel by increasing their dive times and decreasing respiration rates at the surface (Smultea et al. 2009). Williamson et al. (2016) specifically looked at close approaches to humpback whales by small research boats for the purposes of tagging. They found that while dive behavior did not change for any groups, some groups did increase their speed and change their course during or right after the approach, but resumed pre-approach speed and heading shortly thereafter. Only mother-calf groups were found to increase their speed during the approach and maintain the increased speed for longer after the approach, but these groups too resumed normal swim speeds after about 40 minutes. It should be noted that there were no responses by any groups that were approached closely but with no attempts at tagging, indicating that the responses were not due to the vessel presence but to the tagging attempt. In addition, none of the observed changes in behavior were outside the normal range of swim speeds or headings for these migrating whales.

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. An increase in feeding call rates and repetition by humpback whales in Alaskan waters is associated with vessel noise (Doyle et al. 2008), while decreases in singing activity have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). Frequency parameters of fin whale calls also decreased in the presence of increasing background noise due to shipping traffic (Castellote et al. 2012b). Bowhead whales avoided the area around icebreaker ship noise and increased their time at the surface and number of blows (Richardson et al. 1995b). Right whales increase the amplitude or frequency of their vocalizations or called at a lower rate in the presence of increased vessel noise (Parks 2011; Parks et al. 2007), and these vocalization changes may persist over long periods if background noise levels remain elevated.

The long-term consequences of vessel noise are not well understood. In a short-term study, minke whales on feeding grounds in Iceland responded to increased whale watching vessel traffic with a decrease in foraging, both during deep dives and at the surface (Christiansen et al. 2013). They also increased their avoidance of the boats while decreasing their respiration rates, likely leading to an increase in their metabolic rates. Christiansen and Lusseau (2015) followed up this study by modeling the cumulative impacts of whale watching boats on minke whales, but found that although the boats cause temporary feeding disruptions, there were not likely to be long-term consequences as a result. This suggests that short-term responses may not lead to long-term consequences, and that over time animals may habituate to the presence of vessel traffic. Using historical records, Watkins (1986b) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957 to 1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more uninterested reactions towards the end of the study. Fin whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 30 m. Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986b).

Overall baleen whale responses to vessel noise and traffic are varied but are generally minor, and habituation or disinterest seems to be the predominant long-term response. If baleen whales do avoid ships, they do so by altering their swim and dive patterns to move away from the vessel, but no strong reactions have been observed. In many cases, whales do not appear to change their behavior at all. This may result from habituation by the whales, but may also result from reduced received levels near the surface due to propagation, or due to acoustic shadowing of the propeller cavitation noise by the ship’s hull.

Most odontocetes react neutrally to vessels, although both avoidance and attraction behavior have been observed (Hewitt 1985; Wursig et al. 1998a). Wursig et al. (1998a) found that Kogia whales and beaked whales were the most sensitive species to vessels, and reacted by avoiding marine mammal survey vessels in 73 percent of sightings, more than any other odontocetes. Avoidance reactions included a decrease in resting behavior or change in travel direction (Bejder et al. 2006a). Incidents of attraction have also been observed in odontocetes (e.g., Wursig et al. 1998a). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner, and common dolphins) showed evasive behavior when approached; however, populations that lived closer to shore (within 100 NM; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010). The presence of vessels has also been shown to interrupt feeding behavior in delphinids (Meissner et al. 2015; Pirotta et al. 2015b).

Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/chronic displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007). Delphinid behavioral states also change in the presence of tourist boats that often approach animals, with travel increasing and foraging decreasing (Meissner et al. 2015). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (e.g., Gregory and Rowden 2001; Mattson et al. 2005). Steckenreuter et al. (2011) found bottlenose dolphin groups to feed less, become more tightly clustered, and have more directed movement when approached to 50 m than groups approached to 150 m or approached in a controlled manner. Guerra et al. (2014) demonstrated that bottlenose dolphins subjected to chronic noise from tour boats responded to boat noise by alterations in group structure and in vocal behavior but also found the dolphins' reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed. This demonstrates that the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach, and speed of approach seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng and Leung 2003).

Vessels have been shown to affect killer whales as well, such as the Northern and Southern Resident populations on the west coast of North America. These animals are targeted by numerous small whale-watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, had an annual monthly average of nearly 20 vessels of various types within 0.5 miles of their location during daytime hours (Erbe et al. 2014). These vessels have source levels that ranged from 145 to 169 dB re 1 μPa and produce broadband noise up to 96 kHz and 116 dB re 1 μPa. They have the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing capabilities via masking (Erbe 2002b; Veirs et al. 2015). Killer whales foraged significantly less and traveled significantly more when boats were within 100 m of the whales (e.g., Lusseau et al. 2009; Williams et al. 2002a). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; Noren et al. 2009). As with other delphinids, the reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them rather than to the noise of the vessel itself, or to the number of vessels in their proximity. Williams et al. (2014) modeled behavioral responses of killer whales to vessel traffic by looking at their surface behavior relative to the received sound level of three large classes of ships. The authors found that the severity of the response was largely dependent on seasonal data (e.g., year and month) as well as the animal's prior experience with vessels (e.g., age and sex), and the number of other vessels present, rather than the received level of the larger ships (Williams et al. 2014).

Sperm whales generally react only to vessels approaching within several hundred meters. However, some individuals may display avoidance behavior, such as quick diving (Magalhaes et al. 2002; Wursig et al. 1998a) or a decrease in time spent at the surface (Isojunno and Miller 2015). One study showed that after diving, sperm whales showed a reduced timeframe before they emitted the first click than prior to a vessel interaction (Richter et al. 2006). Smaller whale watching and research vessels generate more noise in higher-frequency bands and are more likely to approach odontocetes directly, and to spend more time near an individual whale. Azzara et al. (2013) also found a reduction in sperm whale clicks while a vessel was passing, as well as up to a half hour after the vessel had passed. It is unknown whether the whales left the area, ceased to click, or surfaced during this period.

Some odontocetes have been shown to make short-term changes to vocal parameters such as intensity as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). For example, bottlenose dolphins in Portuguese waters decreased their call rates and changed the frequency parameters of whistles in the presence of boats (Luis et al. 2014), while dolphin groups with calves increased their whistle rates when tourist boats were within 200 m and when the boats increased their speed (Guerra et al. 2014). Likewise, modification of multiple vocalization parameters was shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales are also known to modify their calls during increased noise. For example, the source level of killer whale vocalizations was shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Holt et al. 2008). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2011a). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. This type of change has been observed in killer whales off the northwestern coast of the United States between 1973 and 2003. This population increased the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which is suggested as being a long-term response to increased masking noise produced by the vessels (Foote et al. 2004).

The long-term and cumulative implications of ship sound on odontocetes is largely unknown, although some long-term consequences have been reported (Higham et al. 2007). Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors suggested that repeated interruptions of the dolphins' foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Similar to mysticetes, odontocete responses to vessel noise are varied. Some species, in particular killer whales and porpoises, may be sensitized to vessels and respond at further distances and lower received levels than other delphinids. In contrast, many odontocete species also approach vessels to bowride, indicating either that these species are less sensitive to vessels, or that the behavioral drive to bowride supersedes any impact of the associated noise.

Pinniped reactions to vessels are variable and reports include a wide spectrum of possibilities from avoidance and alert, to cases where animals in the water are attracted, and cases on land where there is lack of significant reaction suggesting habituation to or tolerance of vessels (Richardson et al. 1995c). Specific case reports in Richardson et al. (1995c) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007c), pinniped responses to vessels are affected by the context of the situation and by the animal's experience.

Anderwald et al. (2013b) investigated grey seal reactions to an increase in vessel traffic off Ireland's coast in association with construction activities, and their data suggests the number of vessels had an indeterminate effect on the seals' presence. Harbor seals haul out on tidewater glaciers in Alaska, and most haulouts occur during pupping season. Blundell & Pendleton (2015) found that the presence of any vessel reduces haulout time, but cruise ships and other large vessels in particular shorten haulout times. Another study of reactions of harbor seals hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska, revealed that animals are more likely to flush and enter the water when cruise ships approach within 500 m and four times more likely when the cruise ship approaches within 100 m (Jansen et al. 2010). Karpovich et al. (2015) also found that harbor seal heart rates increased when vessels were present during haulout periods, and increased further when vessels approached and animals re-entered the water. Harbor seals responded more to vessels passing by haul out sites in areas with less overall vessel activity, and the model best predicting their flushing behavior included the number of boats, type of boats, and distance to boats. More flushing occurred to non-motorized vessels (e.g. kayaks), likely because they tended to occur in groups rather than as single vessels, and tended to pass closer (25 – 184 m) to the haul out sites than motorized vessels (55 – 591 m) (Cates and Acevedo-Gutiérrez 2017). Jones et al. (2017) also modeled the spatial overlap of vessel traffic and grey and harbor seals in the United Kingdom, and found most overlap to occur within 50 km of the coast, and high overlap occurring within 5 of 13 grey seal Special Areas of Conservation and within 6 of 12 harbor seal Special Areas of Conservation. They also estimated received levels of shipping noise and found maximum daily M-weighted cumulative SEL values from 170 – 189 dB, with the upper confidence intervals of those estimates sometimes exceeding TTS values. However, there was no evidence of reduced population size in an of these high overlap areas.

Marine mammals may also experience masking due to vessel noises. For example, right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks et al. 2011; Parks et al. 2009). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al. 2009a). Although humpback whales did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected, potentially indicating some signal masking (Dunlop 2016).

Vessel noise can potentially mask vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely on. Potential masking can vary depending on the ambient noise level within the environment, the received level and frequency of the vessel noise, and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 μPa in the band between 10 Hz and 10 kHz due to a combination of natural (e.g., wind) and anthropogenic sources (Urick 1983a), while inshore noise levels, especially around busy ports, can exceed 120 dB re 1 μPa. When the noise level is above the sound of interest, and in a similar frequency band, masking could occur. This analysis assumes that any sound that is above ambient noise levels and within an animal's hearing range may potentially cause masking. However, the degree of masking increases with increasing noise levels; a noise that is just detectable over ambient levels is unlikely to cause any substantial masking.

The ESA-listed marine mammals considered in this opinion will be exposed to noise from Navy vessels during training and testing activities in the action area. As documented above, vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. These reactions are anticipated to be short-term, likely lasting the amount of time the vessel and the whale are in close proximity (e.g., Magalhaes et al. 2002; Richardson et al. 1995e; Watkins 1981a), and not consequential to the animals. Additionally, short-term masking could occur. Masking by passing vessels or other sound sources transiting the action area would be short term and intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic noise sources such as areas around busy shipping lanes and near harbors and ports may cause sustained levels of masking for marine mammals, which could reduce an animal's ability to find prey, find mates, socialize, avoid predators, or navigate. Navy vessels make up a very small percentage of the overall traffic in the action area (See Section

6.1.1), so Navy vessels are not expected to significantly contribute to overall background levels of underwater noise in the marine environment. This minimizes the potential for Navy vessels to contribute to long-term masking in the action area.

In summary, ESA-listed marine mammals 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. Therefore, the effects of vessel noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). Additionally, the effects of any temporary masking specifically from Navy vessels is insignificant 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.

9.1.1.1.2 Aircraft Noise – Marine Mammals

Additional discussion of aircraft overflight noise as a potential stressor is included in Section 6.1.2. Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone (Navy 2017b). Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Marine mammals may respond to both the physical presence and to the noise generated by aircraft, making it difficult to attribute causation to one or the other stimulus. In addition to noise produced, all low-flying aircraft make shadows, which can cause animals at the surface to react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal’s behavior at or near the surface.

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft and helicopters, as well as unmanned aerial vehicles. Thorough reviews of the subject and available information is presented in Richardson et al. (1995f) and elsewhere (e.g., Efroymson et al. 2001; Holst et al. 2011b; Luksenburg and Parsons 2009; Smith et al. 2016a). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping; Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al. 2011b; Manci et al. 1988). Richardson et al. (1995f) noted that marine mammal reactions to aircraft overflights have largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition, it was suggested that variations in the responses noted were generally due to other undocumented factors associated with overflights (Richardson et al. 1995f). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (altitude, centered on the animal, off to one side, circling, level and slow), environmental factors (e.g., wind speed, sea state, cloud cover) and locations where native subsistence hunting continues and animals are more sensitive to anthropogenic impacts, including the noise from aircraft.

Christiansen et al. (2016a) measured the in air and underwater noise levels of two unmanned aerial vehicles. The researchers found that in air the broadband source levels were around 80 dB re 20 μPa, while at a meter underwater received levels were 95 to 100 dB re 1 μPa when the vehicle was only 5 to 10 m above the surface, and were not quantifiable above ambient noise levels when the vehicle was higher. Therefore, if an animal is near the surface and the unmanned aerial vehicle is flying at a low altitude, it may be detected, but in most cases these vehicles are operated at much higher altitudes (e.g. well over 30 m) and so are not likely to be heard.

The impact of aircraft overflights is one of the least well-known sources of potential behavioral response by any species or taxonomic group, and so many generalities must be made based on the little data available. There is some data for each taxonomic group; taken together it appears that in general, marine mammals have varying levels of sensitivity to overflights depending on the species and context.

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998). Richardson et al. (1985a) and Richardson et al. (1995e) found no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft (304.8 m) above sea level, infrequently observed at 1,500 ft (457.2 m), and not observed at all at 2,000 ft (609.6 m) (Richardson et al. 1985a). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 150 m or higher. The bowheads exhibited fewer behavioral changes than did the odontocetes in the same area (Patenaude et al. 2002). It should be noted that bowhead whales in this study may have more acute responses to anthropogenic activity than many other marine mammals because these animals were presented with restricted egress due to limited open water between ice floes. Additionally, these animals are hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

A pilot study was conducted on the use of unmanned aerial vehicles to observe bowhead whales. Flying at altitudes between 120 to 210 m above the surface, no behavioral responses were observed in any animals (Koski et al. 2015; Koski et al. 1998). Similarly, Christiansen et al. (2016a) did not observe any responses to an unmanned aerial vehicle flown 30 to 120 m above the water when taking photos of humpback whales to conduct photogrammetry and assess fitness. Acevedo-Whitehouse et al. (2010) successfully maneuvered a remote-controlled helicopter over large baleen whales to collect samples of their blows, with no more avoidance behavior than noted for typical photo-identification vessel approaches. Unmanned vehicles are much smaller and quieter than typical aircraft and so are less likely to cause a behavioral response, although they may fly at much lower altitudes (Smith et al. 2016a).

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react Richardson et al. (1995e). Wursig et al. (1998a) found that beaked whales were the most sensitive cetacean and reacted by avoiding marine mammal survey aircraft in 89 percent of sightings and at more than twice the rate as Kogia whales, which was the next most reactive of the odontocetes in 39 percent of sightings. These are the same species that were sensitive to vessel traffic.

During standard marine mammal surveys at an altitude of 750 ft, some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters ((Richter et al. 2006; Richter et al. 2003b; Smultea et al. 2008; Wursig et al. 1998a). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995f). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft (fixed-wing airplanes and helicopters) apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003a).

Smaller delphinids generally react to overflights either neutrally or with a startle response (Wursig et al. 1998a). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 150 m. A change in travel direction was noted in a group of pilot whales as the aircraft circled while conducting monitoring (HDR 2011).

Much like mysticetes, odontocetes have demonstrated no responses to unmanned aerial vehicles. For example, Durban et al. (2015) conducted photogrammetry studies of killer whales using a small hexacopter flown 35 to 40 m above the animals with no disturbance noted. However, odontocete responses may increase with reduced altitude, due either to noise or the shadows created by the vehicle (Smith et al. 2016a).

Richardson et al. (1995c) noted that pinniped responsiveness to aircraft overflights generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). In general pinnipeds are unresponsive to overflights, and may startle, orient towards the sound source or increase vigilance, or may briefly re-enter the water, but typically remain hauled out or immediately return to their haulout location (Blackwell et al. 2004b; Gjertz and Børset 1992). Pinniped adult females, calves and juveniles are more likely to enter the water than males, and stampedes resulting in mortality to pups (by separation or crushing) can occur when disturbance is severe, although they are rare (Holst et al. 2011a). Responses may also be dependent on the distance of the aircraft. For example, reactions of walruses on land varied in severity and included minor head raising at a distance of 2.5 km, orienting toward or entering the water at less than 150 m and 1.3 km in altitude, to full flight reactions at horizontal ranges of less than 1 km at altitudes as high as 1,000–1,500 m (Richardson et al. 1995c).

Helicopters are used in studies of several species of seals hauled out and are considered an effective means of observation (Bester et al. 2002; Gjertz and Børset 1992), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). For California sea lions and Steller sea lions at a rocky haulout off Crescent City in northern California, helicopter approaches to landing sites typically caused the most severe response of diving into the water (National Oceanic and Atmospheric Administration 2010). Responses were also dependent on the species, with Steller sea lions being more sensitive and California sea lions more tolerant. Depending on the time between subsequent approaches, animals hauled out in between and fewer animals reacted upon subsequent exposures (National Oceanic and Atmospheric Administration 2010).

Pinniped reactions to rocket launches and overflight at San Nicholas Island were studied from August 2001 to October 2008 (Holst et al. 2011a). California sea lions startled and increased vigilance for up to two minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 4 km of the rocket trajectory leaving their haul-out sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the growing populations of pinnipeds on San Nicholas Island (Holst et al. 2011a).

Pinnipeds may be sensitive to unmanned aerial systems, especially those flying at low altitudes, due to their possible resemblance to predatorial birds (Smith et al. 2016b), which could lead to flushing behavior (Olson 2013). Responses may also vary by species, age class, behavior, and habituation to other anthropogenic noise, as well as by the type, size, and configuration of unmanned aerial vehicle used (Pomeroy et al. 2015). However, in general pinnipeds have demonstrated little to no response to unmanned aerial systems, with some orienting towards the vehicle, other alerting behavior, or short-term flushing possible (Moreland et al. 2015; Sweeney et al. 2015).

It should be noted that many of the observations cited in this section are of marine mammal reactions to aircraft flown for whale-watching and marine research purposes. Marine mammal survey aircraft are typically used to locate, photograph, track, and sometimes follow animals for long distances or for long periods of time, all of which results in the animal being much more frequently located directly beneath the aircraft (in the cone of the loudest noise and potentially in the shadow of the aircraft) for extended periods. In contrast to whale-watching excursions or research efforts, Navy aircraft would not follow marine mammals so would not result in prolonged exposure of marine mammals to overhead noise or encroachment.

To summarize, in most cases, 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. 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. Some sonic booms from aircraft could 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, except for animals that are resident in inshore areas around Navy ports, on Navy fixed ranges, or during major training exercises. Resident animals could be subjected to multiple overflights per day, though most of the ESA-listed marine mammals considered in this opinion have wide rangeing life histories. Additionally, aircraft would pass quickly overhead, typically at altitudes above 3,000 ft, which would make marine mammals unlikely to respond. Due to the short term and infrequent nature of any exposures to fixed-wing and unmanned aircraft flight and the brief responses that could follow such exposure, the effects of fixed-wing aircraft overflight on ESA-listed marine mammals is insignificant.

Low flight altitudes of helicopters during some anti-submarine warfare and mine warfare activities, often under 100 ft, may elicit a somewhat stronger behavioral response due to the proximity to marine mammals, the slower airspeed and therefore longer exposure duration, and the downdraft created by the helicopter's rotor. Marine mammals would likely avoid the area under the helicopter due to the downdraft, noise, and presence of the helicopter. It is unlikely that an individual would be exposed repeatedly for long periods because these aircraft typically transit open ocean areas within the action area. The literature cited above indicates that aircraft noise would cause only small temporary changes in the behavior of marine mammals. Specifically, marine mammals at or near the surface when an aircraft flies overhead at low altitude may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving.

In summary, due to the short-term nature of any exposures to aircraft and the brief responses that could follow such exposure, the effects of aircraft overflight noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effects cannot be meaningfully evaluated).

9.1.1.1.3 Noise from Weapons – Marine Mammals

Activities using weapons and deterrents would be conducted as described in Section 3.3 of this opinion. Additional discussion on weapons noise as a potential stressor is included in section 6.1.4. 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.

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water. Yagla and Stiegler (2003b) found that the average peak sound pressure in the water measured directly below the muzzle of the gun and under the flight path of the shell (assuming it maintains an altitude of only a few meters above the water's surface) was approximately 200 dB re 1 μPa. 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. Many missiles are launched from aircraft, which would 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.[20] Animals 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.

For noise produced by each of these different types of weapons, behavioral reactions would likely be short-term (minutes) and due to the short-duration, transient nature of launch noise, animals are unlikely to be exposed multiple times within a short period. For these reasons, the effects of weapon noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.1.1.4 Pile Driving – Marine Mammals

Activities with pile driving would take place nearshore and within the surf zone, up to two times per year, once at Silver Strand Training Complex and once at Marine Corps Base Camp Pendleton. There are no pile driving activities in the HRC.

Impact hammer pile driving produces an impulsive, broadband sound, primarily in low-frequency ranges. As such, it is within the hearing ranges of marine mammals. Vibratory hammers produce a non-impulsive, continuous sound. Potential effects of underwater sound from pile driving on marine mammals include injury, threshold shift, and behavioral disturbance (e.g., Nowacek et al. 2007; Richardson et al. 1995f; Southall et al. 2007d). These effects are similar to what is described in detail later for marine mammals in response to other acoustic stressors (e.g., see Sections 9.2.1.1.1 and 9.2.1.2.1). One of the primary differences between pile driving and other Navy acoustic stressors is that pile driving is a stationary source whereas most other Navy acoustic stressors move.

[20] Note that the potential for objects to physically strike an ESA-listed marine mammal is discussed in section 9.1.1.3.

Pile driving for the Elevated Causeway System training would occur in shallow water with soft substrates. In general, softer substrates absorb the sound better than hard substrates, thus, pile driving in softer substrates does not typically produce the louder sound signals that driving in hard substrate would. Soft, wetted substrates, may increase ground-borne transmission, meaning a sound wave could propagate further away from the source through the substrate. If ground-borne transmission sound reenters the water column, the intensity and amplitude of the sound wave would likely be lower than the sound wave traveling from the source through the water column and not likely to cause injury but could result in disturbance.

The Navy's acoustic exposure analysis did not indicate any ESA-listed marine mammals would be exposed to sound from impact or vibratory pile driving activities. Most ESA-listed marine mammals in the action area do not occur in nearshore shallow water areas where pile driving is conducted. The only ESA-listed cetacean that could be expected in the relatively shallow water habitats where pile driving occurs is Western North Pacific DPS gray whales. However, this species would be transitory in these areas as the species is migrating through the action area. Additionally, this DPS is rare in southern California waters (i.e., the unlisted Eastern DPS is much more common in the action area) and the likelihood of an individual from this DPS occurring in close proximity to Navy pile driving activities is very low. Guadalupe fur seals also occur in nearshore environments (e.g., when travelling from haulouts to pelagic environments), though available tracking data suggests this species does not typically occur in nearshore environments in the action area (2017 unpublished data from Marine Mammal Center; Sausalito, California). For these reasons, NMFS considers it extremely unlikely that any Western North Pacific DPS gray whales or Guadalupe fur seals would be exposed to sound from Navy pile driving activities. Therefore, the potential effects of pile driving on these species are discountable.

9.1.1.2 Energy Stressors – Marine Mammals

This section analyzes the potential impacts of energy stressors used during training and testing activities within the action area. Additional discussion on energy stressors is included in Section 6.3. This section includes analysis of the potential impacts of: (1) in-water electromagnetic devices and (2) high-energy lasers.

9.1.1.2.1 In-water Electromagnetic Devices

The devices producing an electromagnetic field are towed or unmanned mine countermeasure systems. The electromagnetic field is produced to simulate a vessel's magnetic field. In an actual mine-clearing operation, the intent is that the electromagnetic field would trigger an enemy mine designed to sense a vessel's magnetic field.

Normandeau et al. (2011b) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Fin, humpbacks, and sperm whales have shown positive correlations with geomagnetic field differences. Although none of the studies have determined the mechanism for magneto-sensitivity, the suggestion from these studies is that whales can sense the Earth's magnetic field and may use it to migrate long distances. Cetaceans appear to use the Earth's magnetic field for migration in two ways: as a map by moving parallel to the contours of the local field topography, and as a timer based on the regular fluctuations in the field allowing animals to monitor their progress on this map (Klinowska 1990).

Most of the evidence of marine mammals sensing magnetic fields is indirect evidence from correlation of sighting and stranding locations suggesting that marine mammals may be influenced by local variation in the earth's magnetic field (Kirschvink 1990b; Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas (negative magnetic anomaly; Kirschvink 1990a). Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microteslas (Kirschvink et al. 1986). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond.

Impacts to marine mammals associated with electromagnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. Electromagnetic fields associated with naval training exercises and testing activities are relatively weak (only 10 percent of the earth's magnetic field at 24 m), temporary, and localized. Once the source is turned off or moves from the location, the electromagnetic field is gone. A marine mammal would have to be present within the electromagnetic field (approximately 200 m from the source) during the activity in order to detect it, though detection does not necessarily signify a significant biological response rising to the level of take as defined under the ESA. Given the small area associated with mine fields, the infrequency and short duration of magnetic energy use, the low intensity of electromagnetic energy sources (essentially mimicking the magnetic field of a steel vessel), the density of marine mammals in these areas, and the Navy's procedural mitigation measure to not approach ESA-listed cetaceans within 500 yd or pinnipeds within 200 yd (Table 33), NMFS considers it extremely unlikely that ESA-listed marine mammals would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. Therefore, potential effects from electromagnetic devices are discountable.

9.1.1.2.2 Lasers

High-energy laser weapons activities involve evaluating the effectiveness of an approximately 30-kilowatt high-energy laser 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 a marine mammal underwater), which would not be expected to be common. Additionally, ESA-listed marine mammal densities in the action area are relatively low. The likelihood of a laser missing a target and striking a marine mammal at or near the surface of the water is remote. For example, the Navy conducted a probability analysis to determine the potential for marine mammals to be directly hit by a high-energy laser beam (Navy 2017b). The marine mammal species with the highest average seasonal density (short beaked common dolphin) in the location with the greatest number of training activities involving high-energy lasers (SOCAL Range Complex) was used as a surrogate for ESA-listed marine mammals in the statistical probability analysis. Even using this density, the likelihood that an individual would be struck by a laser was extremely low (i.e., probability of 0.000693). The probability of striking any ESA-listed marine mammal species was even lower (i.e., highest probability was 0.000032 for Guadalupe fur seals). For these reasons, NMFS considers it extremely unlikely that ESA-listed marine mammals would be exposed to high energy lasers. Therefore, potential effects from lasers are discountable.

9.1.1.3 Physical Disturbance and Strike Stressors – Marine Mammals

Additional discussion on physical disturbance and strike stressors is included in Section 6.4. This section analyzes 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: in-water devices; military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions; and seafloor devices. The potential for vessel strike of marine mammals is discussed in Section 9.2.1.3.

9.1.1.3.1 In-water devices

In-water devices are used in both offshore and inshore areas of the action area. 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. 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 that have been trained to identify marine mammals (See Section 3.4.2) and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified distance from marine mammals (See Section 3.4.2.1.15). 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 mammal species 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 insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) to the animal. Therefore, potential effects on ESA-listed marine mammals from in-water devices discountable or insignificant.

9.1.1.3.2 Military Expended Materials

This section analyzes the strike potential to ESA-listed marine mammals from the following categories 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. While no strike of marine mammals from military expended materials has ever been reported or recorded, the possibility of a strike still exists. However, given the large geographic area involved and the relatively low densities of ESA-listed marine mammals in the action area, we do not believe such interactions are likely (or reasonably certain to occur). For example, the Navy conducted a probability analysis for each ESA-listed marine mammal to be struck by military expended materials while at the surface in both the SOCAL and Hawaii Range Complexes (Navy 2017b). Estimates were made for each of the ESA-listed marine mammal species found in the range complexes. The model output indicated that no ESA-listed marine mammal would be struck by military expended materials in the action area. Specifically, the highest probability for an ESA-listed marine mammal strike was 0.00631 for Guadalupe fur seals in SOCAL. 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 (e.g., guidance wires sink at an estimated rate of 0.7 ft [0.2 m] 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 organisms such as cetaceans. Also important in this conclusion is that animals are unlikely to encounter military expended materials falling through the water column due to the large geographic area involved and the relatively low densities of ESA-listed marine mammals in the action area.

In summary, NMFS considers it extremely unlikely for any ESA-listed marine mammal 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 insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) and does not rise to the level of take. For these reasons, potential effects on ESA-listed marine mammals from physical disturbance and strike with military expended materials are insignificant or discountable.

9.1.1.3.3 Seafloor Devices

Activities that use seafloor devices include items placed on, dropped on, or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed devices, and bottom-crawling unmanned underwater vehicles. Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. Objects falling through the water column will slow in velocity as they sink toward the bottom and would be avoided by ESA-listed marine mammals. The only seafloor device used during training and testing activities that has the potential to strike an ESA-listed marine mammal at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, and the analysis of the potential impacts from those devices are covered in the military expended material strike section. NMFS considers it extremely unlikely for any ESA-listed marine mammals to be struck by a seafloor device. Therefore, potential effects on ESA-listed marine mammals from seafloor device strike are discountable. Any individuals encountering seafloor devices are likely to behaviorally avoid them. Given the slow movement and relatively small size of seafloor devices, the effort expended by individuals to avoid them will be minimal and temporary, and will not have fitness consequences. Therefore, behavioral avoidance of seafloor devices by ESA-listed marine mammals is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.1.4 Entanglement Stressors – Marine Mammals

Additional discussion of entanglement stressors is included in Section 6.5. Some expended materials from U.S. Navy activities may pose a risk of entanglement to marine mammals in the action area. These interactions 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 military expended materials have the potential to result in negative sub-lethal effects, mortality, or result in no impact. Expended materials from Navy activities that may pose an entanglement risk include wires and cables and decelerators/parachutes. Though there is a potential for ESA-listed marine mammals to encounter military expended material, for the reasons described below, we believe such interactions are extremely unlikely to occur.

There has never been a reported or recorded instance of a marine mammal entangled in military expended materials. NOAA (2014a) conducted a review of entanglement of marine species in marine debris with an emphasis on species in the United States. The review did not document any known instances where military expended material had entangled a marine mammal. Instead, the vast majority of entanglements have been from actively fished or derelict fishing gear. For example, Knowlton et al. (2012), as cited in NOAA (2014a), conducted a 30-year comprehensive review of entanglement rates of North Atlantic right whales using photographs. Much of the habitat occupied by North Atlantic right whale is coextensive with Navy training and testing activities (i.e., almost identical to activities conducted in the HSTT action area) using military expended materials in the western Atlantic (Navy 2018c). In the report, 626 individuals were observed and the vast majority showed evidence of entanglement involving non-mobile pot gear and nets used for fishing. Baulch and Perry (2012), as cited in NOAA (2014a), reported that nearly 98% of documented cetacean entanglements worldwide were from abandoned, lost, or derelict fishing gear. NOAA (2014a) summarized available information on pinniped entanglement and found that pinnipeds (including Hawaiian monk seals) are generally observed entangled in net fragments, monofilament line, packing straps, rope, and rubber products.

Goldstein et al. (1999) studied human-related injuries to pinnipeds in Calfiornia (some caused by marine debris including fishing nets and monofilament line, packing straps, plastic bags, rope, and rubber o-rings) and documented two cases of marine debris entanglement for the species. Hanni et al. (1997) also reported on observed entanglement of Guadalupe fur seals and documented entanglement with polyfilament line around the neck, net markings, and one with hook and line. Military expended material has not been shown to entangle ESA-listed marine mammals despite the Navy expending materials in the action area (and other range complexes) for decades.

If encountered, it is extremely unlikely that an animal would get entangled in a fiber optic cable, sonobuoy wires, or guidewire while these were sinking or settling on the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled, and given the properties of the expended cables and wires (low breaking strength and a design to resit coiling or the forming of loops) the likelihood of entanglement from cables and wires is extremely low. Additionally, as noted above, though there are numerous documented cases where marine mammals have been entangled in anthropogenic materials (e.g., fishing gear), but there have been no documented instances where a marine mammal has been entangled in military expended cables and wires despite decades of training and testing activities being conducted in the action area and elsewhere utilizing wires and cable. For these reasons, it is extremely unlikely that ESA-listed marine mammals will become entangled in military expended wires and cables in the action area and effects from entanglement are therefore discountable.

Decelerators/parachutes also may pose a risk of entanglement, though for the reasons described below, we believe such incidences are extremely unlikely to occur. The Navy uses a variety of sizes of decelerators in the action area (Table 57).

Table 57. Size categories for decelerators/parachutes expended during training and testing activities (Navy 2018d).

Size Category	Diameter (ft)	Associated Activity
Small	1.5 to 6	Air-launched sonobuoys, lightweight torpedoes, and drones (drag parachute)
Medium	19	Illumination flares
Large	30 to 50	Drones (main parachute)
Extra-large	82	Drones (main parachute)

The majority of the decelerators/parachutes used are in the small size category and are associated with sonobuoys. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon and have weights attached to their short attachment lines (i.e., from 1 to 19 ft) to speed their sinking. According to the Navy's BA, small and medium parachutes with weights may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Group 2005). Therefore, the majority of parachutes/decelerators would not remain suspended in the water column for more than a few minutes as most have weights that speed the sinking of the materials to the seafloor. Some large and extra large decelerators/parachutes are also proposed for use in the action area. In contrast to small and medium parachutes, large and extra large parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor. However, a limited number of these items are proposed for use each year (i.e., 36 large parachutes in both the Hawaii and SOCAL range complexes; 3 extra large parachutes in Hawaii). The small number of large and extra large parachutes proposed for use annually reduces the potential for ESA-listed marine mammals to encounter and become entangled in these items.

As noted above, the vast majority of large whale entanglements have been associated with fishing gear, some of which has been actively fishing, and some of which is derelict NOAA (2014a). For example, Baulch and Perry (2012), as cited in NOAA (2014a), reported that nearly 98% of documented cetacean entanglements worldwide were from abandoned, lost, or derelict fishing gear. In contrast, as noted previously, there has never been a documented instance where a large whale was observed entangled in military expended material, including decelerators/parachutes. There are a number of key differences between parachutes/decelerators and fishing gear that result in the likelihood of entanglement in parachutes being significantly lower than it is for fishing gear. First, as noted above, most decelerators/parachutes used by the Navy sink quickly to seafloor and do not remain suspended in the water column for extended periods of time. This is in contrast to fishing gear which can be left in the water 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 in the water column (Figure 62), whereas fishing gear may consist of some buoys and traps that are visible, but also many hundreds of feet of rope in between these items that is not. Finally, the cords associated with parachutes are, at most, 80 ft long. In contrast, typical gear associated with some fisheries (e.g., the U.S. west coast Dungeness crab fishery; the American lobster fishery on the east coast of the U.S. in which large whales are regularly entangled) has hundreds of feet of rope suspended in the water column.

Figure 62. Aerial target with deployed parachute (Navy 2018d).

It is also possible that a bottom feeding animal (e.g., sperm whale) could become entangled when they are foraging in areas where parachutes have settled on 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 extremely unlikely and therefore, discountable. Further, and as noted previously, there has never been a documented instance where a bottom feeding marine mammal was entangled in a Navy parachute.

In conclusion, for the reasons described above, NMFS considers it extremely unlikely for any marine mammals to become entangled in military expended materials. Therefore, potential effects on ESA-listed marine mammals from entanglement in military expended materials are discountable.

9.1.1.5 Ingestion Stressors – Marine Mammals

Additional discussion on ingestion stressors is included in Section 6.6. The munitions and other materials small enough to be ingested by ESA-listed marine mammals 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 too large for marine mammals to consume and/or are made of metal a marine mammal would not be able to break-apart to ingest. Most expendable materials will be used over deep water of both the Hawaii and Southern California portions of the action area and most items will sink quickly and settle on 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 will be accidentally ingested by ESA-listed marine mammals that do not typically forage on the sea floor.

There have been no general surveys to investigate marine debris on the seafloor in Hawaii. Watters et al. (2010) conducted a visual survey of the seafloor that included a portion of the Navy's Southern California range complex as part of a 15-year quantitative assessment of marine debris on the seafloor off the California coast. The authors found plastic was the most abundant material and along with recreational monofilament fishing line, dominate in the debris documented on the seafloor (note that, according to the Navy's BA (Navy 2018d), U.S. Navy vessels have a zero-plastic trash discharge policy and return all plastic waste to appropriate disposal sites on shore). There was only one item found that was potentially "military" in origin. Keller et al. (2010) characterized the composition and abundance of man-made marine debris during groundfish bottom trawl surveys in 2007 and 2008 along the U.S. west coast at 1,347 randomly selected stations. This including some sample sites that were within the Southern California portion of the action area and within that subset, some that included historically used post-World War II dump sites. The evidence that post-World War II dump sites were sampled was indicated by items recovered that included equipment described as "helmets," "gas masks," "uniforms," and other miscellaneous and diverse items including "plastic," "file cabinets," and "buckets" that are not (since approximately the 1970s) disposed of at sea and are not military expended material associated with the activities in the proposed action. For this reason, the "military debris" discovered by Keller et al. (2010) is not the same as the material expended during proposed training and testing activities in the action area. Based on this information, military expended material is not expected to be commonly encountered on the seafloor of the action area.

Sperm whales are capable of foraging along the sea floor in deep water. 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 2003). However, the relatively low density of both sperm whales and expended materials along the vast sea floor suggests ingestion would be rare. Gray whales and humpback whales are the only mysticetes likely to occur in the action action that 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 one of these species were to accidentally ingest expended materials small enough to be eaten, it is likely the item will pass through the digestive tract and not result in an injury (e.g., Wells et al. 2008a) or 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. Since baleen whales feed by filtering large amounts of water, they could encounter and consume debris at higher rates than other marine animals (NOAA 2014b). 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). In a comprehensive review of documented ingestion of debris by marine mammals by Laist (1997), there are two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag. This effort was followed up by a comparative summary of the earlier review with additional information and the number of mysticete species with documented records of ingestion increased to seven species, including right whales, pygmy right whales, gray whales, and four rorqual species (Bergmann et al. 2015). Information compiled by Williams et al. (2011) listed humpback whale, fin whale, 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 material has not been documented as having been consumed.

Some Styrofoam, plastic endcaps, and other small military expended materials 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. For example, chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to their light weight and small size they float and 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). Given the small size, low densities, and low toxicity of chaff, 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 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 end caps would eventually sink to the seafloor where they would be less likely to be ingested by marine mammals. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur.

In conclusion, ingestion of military expended material of sufficient size to cause on adverse effect by ESA-listed marine mammals is extremely unlikely and thus make the effect of this stressor discountable.

9.1.2 Sea Turtles

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles. As noted above, our analysis for these stressors is organized on the taxa level (i.e., sea turtles) because the pathways for effects for these stressors is generally the same for all sea turtles and we would not expect different effects at the species level. While there is variation among species within each taxa, the sea turtle species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Our analysis for these stressors and sea turtles is summarized below.

9.1.2.1 Acoustic Stressors – Sea Turtles

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed sea turtles. The effects of explosives, another acoustic stressor, which NMFS determined was likely to adversely affect sea turtles, is discussed in Section 9.2.2.1.

9.1.2.1.1 Sonar and Other Transducers – Sea Turtles

Under the Navy's proposed action, training and testing activities using sonar and other transducers could occur throughout the action area, although use would generally occur within 200 NM of shore in Navy Operating Areas, on Navy range complexes, on Navy testing ranges, or around inshore locations (Navy 2018d). Use of sonar and other transducers would typically be transient and temporary. The number of major training exercises and civilian port defense activities would fluctuate annually. Some anti-submarine warfare tracking exercises and ship unit level training activities would also be conducted using simulators in conjunction with other training exercises (See the Description of the Proposed Action, Section 3 for more specifics on Navy sonar types and hours of use). Low-frequency sources are operated more frequently under testing activities than under training activities. Therefore, although the general impacts from sonar and other transducers under testing would be similar in severity to those described under training, there may be slightly more impacts under testing activities (Navy 2018d). The use of sources within sea turtle hearing range would be greater in the Southern California portion of the action area compared to the Hawaii Range complex or the transit corridor (Navy 2018d).

Potential Effects of Sonar and Other Transducers

The potential effects of sea turtle sonar exposure include hearing impairment, an observable behavioral response, a stress response that may not be detectable, or masking. These potential effects are discussed below, with reference to Section 2.2.1 as appropriate, which describes the criteria and thresholds for estimating potential effects from sonar.

Hearing Impairment

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. The Navy evaluated sea turtle susceptibility to hearing loss (from sonar exposure) based upon what is known about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species such as marine mammals and fishes. The criteria and thresholds used to evaluate the potential for hearing impairment in sea turtles from Navy sonar is in Section 2.2.1.3.

Physiological stress

Stress caused by acoustic exposure has not been studied for sea turtles. As described for marine mammals, 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 these other anthropogenic stressors, and including what is known about cetacean stress responses, we assume that some sea turtles will exhibit a stress response if exposed to a detectable sound stressor. Compared to other 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 tutles is more expected to be more limited compared other taxa that are more sensitive to acoustic stresors.

Animals often respond to anthropogenic stressors in a manner that resembles a predator response (Beale and Monaghan 2004b; 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

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009b; Erbe et al. 2016). 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.

Compared to other 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. 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 vibratory pile extraction or vessel noise affecting natural background and ambient sounds). Other intermittent, short-duration sound sources with low-frequency components (e.g., low-frequency sonar, or air guns) would have more limited potential for masking, depending on how frequently the sound occurs.

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

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. 2014d), qualitative risk factors were developed to assess the potential for sea turtles to respond to various underwater sound sources. The guidelines state that there is a low likelihood that sea turtles would respond within tens of meters of low-frequency sonars, and that it is highly unlikely that sea turtles would respond to mid-frequency sonar sources. The risk that sea turtles would respond to other broadband sources, such as vessel noise, air guns, and pile driving, is considered high within tens of meters of the sound source, but moderate to low at farther distances.

To date, very little research has been conducted on sea turtle behavioral responses relative to sonar exposure. Because of this, the working group that prepared the ANSI Guidelines (Popper et al. 2014d) provide parametric descriptors of sea turtle behavioral responses to sonar and other transducers. The working group estimate that the risk of a sea turtle responding to a low-frequency sonar (less than 1 kHz) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (1 to 10 kHz). For purposes of our effects analysis, we requested the Navy estimate the number of sea turtles that could be exposed to sonar within their hearing range at received levels of 175 dB rms re: 1 μPa SPLor greater. This level is based upon work by McCauley et al. (2000c), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. The authors 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. 2000c). 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. Because data on sea turtle behavioral responses to non-impulsive sounds, such as sonars, is limited, the air gun data set was used to inform potential risk. We considered that the relative risk of a sea turtle responding to air guns would be higher than the risk of responding to sonar, so it is likely that potential sea turtle behavioral responses to sonar exposures are a sub-set of sea turtles exposed to received levels of 175 dB rms (re: 1 μPa) or greater.

Exposure and Response Analysis

The Navy's quantitative analysis (discussed above in Section 2.2) predicts that no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that could cause PTS or TTS during a maximum year of training and testing activities under the proposed action. Only a limited number of sonar and other transducers with frequencies within the range of sea turtles' hearing (less than two kHz) and high source levels have the potential to cause TTS and PTS. The quantitative analysis, also predicts no sea turtles of any species are likely to be exposed to received levels from sonars in their hearing range at or exceeding 175 dB re 1 μPa SPL (rms), the received level associated with onset of avoidance behavior in air gun studies. Therefore, no sea turtles are expected to exhibit avoidance or any other higher severity behavioral response to sonars or other transducers during a maximum year of training and testing activities. Although masking of biologically relevant sounds by the limited number of sonars and other transducers operated in sea turtle hearing range is possible, this may only occur in certain circumstances. Sea turtles most likely use hearing to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach. The use characteristics of most sonars, including limited bandwidth, beam directionality, limited beam width, relatively low source levels, low duty cycle, and limited duration of use, would both greatly limit the potential for a sea turtle to detect these sources and limit the potential for masking of broadband, continuous environmental sounds. In addition, broadband sources within sea turtle hearing range, such as countermeasures used during anti-submarine warfare, would typically be used in off-shore areas, not in near-shore areas where detection of beaches or concentrated vessel traffic is relevant. Implementation of mitigation may further reduce the already low risk of auditory impacts on sea turtles. Depending on the sonar source, mitigation includes powering down the sonar or ceasing active sonar transmission if a sea turtle is observed in the mitigation zone, as discussed in Section 3.4.2 (Mitigation Measures).

Due to the short term and infrequent nature of any exposures to sonar and transducers and the brief responses that could follow such exposure, the effects of sonar and transducers on ESA-listed sea turtles are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). In summary, we find that the likely effects from exposure to sonar and transducers are insignificant for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.1.2 Pile Driving – Sea Turtles

Sea turtles could be exposed to sounds from impact pile driving and vibratory pile extraction during the construction and removal phases of the elevated causeway system. This training activity involves the use of an impact hammer to drive 24-inch steel piles into the sediment to support an elevated causeway to the shore and a vibratory hammer to later remove the piles that support the causeway structure (Navy 2018d). Impact pile driving operations to install the piles would last about ten days, and extraction of the piles at the end of the exercise takes approximately three days. Pile driving would take place nearshore and within the surf zone, up to two times per year at either the Silver Strand portion of the SOCAL Range Complex in San Diego, California, or Marine Corps Base Camp Pendleton, California (Navy 2018d).

Impact pile driving produces repetitive, impulsive sounds potentially over multiple minutes, similar to repeated air gun shots. The broadband range of frequencies generated from impact hammering of piles are within the range of sea turtle hearing, especially since most energy is within the lower frequencies. For this analysis, NMFS requested that the Navy estimate the number of sea turtles that could be exposed to impact pile driving and vibratory removal at received levels of 175 dB re 1 μPa SPL (rms) or greater. 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.

Underwater noise effects from pile driving and vibratory pile extraction were modeled using actual measures of impact pile driving and vibratory removal during construction of an elevated causeway (Rodkin 2015; Rodkin 2017). A conservative estimate of spreading loss of sound in shallow coastal waters (i.e., transmission loss = $16.5*\text{Log}_{10}[\text{radius}]$) was applied based on spreading loss observed in actual measurements. Inputs used in the model include source levels, the number of strikes required to drive a pile and the duration of vibratory removal for a pile, the number of piles driven or removed per day, and the number of days of pile driving and removal.

The Navy modeled ranges to the onset of hearing impairment for sea turtles exposed to impact pile driving are 19 m and 2 m for TTS and PTS, respectively. The ranges to effect are short due to sea turtles' relatively high thresholds for any auditory effects compared to the source levels of impact pile driving conducted during Navy training. Ranges are based on driving one pile since turtles are unlikely to spend more than a few minutes within about 20 m of a pile that is being actively driven. NMFS calculated distances to sea turtle hearing impairment based upon a scenario of exposure to all six piles driven in a single day requiring between 3,150 and 4,500 strikes. This results in a large zone of impact with PTS possible at distances ranging from 61-76 m from the pile (depending on number of strikes) and TTS possible for sea turtles at distances ranging from 497-617 m from the pile.

Ranges to behavioral response are based on the criteria requested by NMFS of a sea turtle exposed to air gun firing(s) equal to or greater than 175 dB re 1 μPa SPL (rms), the received level associated with onset of avoidance behavior in air gun studies. Based on this criteria, the Navy's modeled range to a possible behavioral response from impact pile driving is 107 m.

Given the proposed location of this activity, the sea turtle species that would most likely be exposed to the effects of pile driving from the proposed action is the green sea turtle East Pacific DPS. During a maximum year of training activities, the Navy's exposure model estimates no TTS or PTS for green sea turtles and no behavioral responses (i.e., no green turtles are predicted to be exposed to received levels from pile driving at or exceeding 175 dB re 1 μPa SPL (rms)). For this analysis, the Navy assumed the minimum exposure scenario (only one minute of pile driving of one pile) which predicts PTS if a turtle is located within two meters of a pile, and TTS within 19 m of a pile. The Navy will implement specific mitigation zones for sea turtles during pile driving events. These mitigation zones include an area of 100 yds (approximately 91 m) around a pile being driven. Pile driving will not commence if any sea turtles are seen in the 100 yd zone, and will be halted if a sea turtle is observed entering the zone. For these reasons, it is unlikely that a sea turtle would be exposed for a full day's accumulation period of pile driving. Moreover, the mitigation zone extends beyond the range to effects for permanent hearing loss, and likely temporary hearing loss if the animal is avoided or allowed to exit the area before an entire accumulation period occurs. Thus, the calculated ranges to PTS (up to 76 m) and TTS (up to 617 m) for sea turtles exposed to impact pile driving from multiple piles over an extended period of time may not apply given the anticipated pile driving scenarios and associated turtle mitigation measures described in the proposed action.

In summary, based on the Navy's quantitative analysis, the low frequency and limited areas where pile driving would occur, and the Navy's proposed mitigation measures, we find that the likely effects from exposure of East Pacific DPS green sea turtles to pile driving are so minor that the they cannot be meaningfully evaluated. . Due to the short term and infrequent nature of any exposures to pile driving and the brief responses that could follow such exposure, the effects of pile driving on this DPS are considered insignificant.

Given the locations where pile driving would occur, and the low expected sea turtle densities in these locations, we find that the probability of the following ESA-listed species overlapping spatially with this activity to be extremely low: hawksbill; leatherback; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for any of these sea turtle species to be exposed to pile driving as part of the proposed action. Therefore, potential effects on these sea turtles species from pile driving are considered discountable.

9.1.2.1.3 Air Guns – Sea Turtles

Under the proposed action, small air guns (12–60 cubic inches) would be fired at off-shore locations in the Hawaii and SOCAL Range Complexes (Navy 2018d). This activity would only occur during testing activities (training activities do not use air guns). Air guns use bursts of pressurized air to create broadband, impulsive sounds. Any use of air guns as part of the proposed action would typically be transient and temporary. Assessing whether these sounds may adversely affect sea turtles involves understanding the characteristics of the sound source produced by an impulsive sound (e.g. air gun) and how that source may be detected and responded to by sea turtles present in the vicinity of the sound. In general, sea turtles are not considered as sensitive to some anthropogenic sound sources as other species such as marine mammals, primarily due to what is known about sea turtle hearing and their use of sound; albeit very little is understood compared to other species. Because we know much less about how sea turtles detect and respond to sound, the impacts of impulsive sounds such as air guns are difficult to assess. Nonetheless, depending on the circumstances, we assume exposure to air guns, as with other acoustic stressor could result in auditory impairment, masking of biologically relevant sounds, behavioral responses, as well as other physiological stress responses of sea turtles.

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by seismic air guns that would be expected to result in sound-induced hearing loss (i.e., TTS or PTS), we relied on acoustic thresholds for PTS and TTS for impulsive sounds developed by Navy for Phase III activities. These thresholds were developed from the most current literature, and recommendations made by the Working Group that developed thresholds for fishes and sea turtles (Popper et al. 2014d). We consider these to be the best available data since they rely on all available information on sea turtle hearing and employ the same statistical methodology to derive thresholds as in NMFS' recently revised technical guidance for auditory injury of marine mammals (NOAA 2018). McCauley et al. (2000c) estimated that sea turtles would begin to exhibit avoidance behavior when the received level of air gun firings was around 175 dB re 1 μPa, based on several studies of sea turtle exposures to air guns. The few studies of sea turtle reactions to sounds suggest that a behavioral response could consist of temporary avoidance, increased swim speed, or changes in depth, or that there may be no observable response. There is no evidence to suggest that any behavioral response would persist after a sound exposure. It is assumed that a stress response could accompany any behavioral responses.

The small air guns proposed lack large pressures that could cause non-auditory injuries. In addition, the broadband impulsive sounds produced by the small air guns proposed for use could only cause PTS and TTS for sea turtles within a short distance. Ranges to the onset of hearing loss for the air guns used in Navy activities are 10 m and 1 m for TTS and PTS, respectively. These ranges are based on the SEL metric for PTS and TTS for 10 firings of an air gun, a conservative estimate of the number of air gun firings that could occur over a single exposure duration at a single location. Ranges to behavioral response based on a received level of 175 dB re 1 μPa SPL (rms) are shown in Table 58 .

Table 58. Ranges to behavioral response for sea turtles exposed to air gun firing(s).

Range to Effects for Air Guns	
Source Depth (m)	**Behavioral Response (m)**
3	Average: 194 Range: 190—200
5	Average: 123 Range: 100—140

The Navy's quantitative analysis, using a maximum year of testing activities, predicts that no PTS or TTS to sea turtles (any species) would occur due to testing of air guns as part of the proposed action (Navy 2018d). The quantitative analysis also predicts no sea turtle of any species are likely to be exposed to received levels from air guns in their hearing range at or exceeding 175 dB re 1 μPa SPL (rms), the received level associated with onset of avoidance behavior in air gun studies. Therefore, no sea turtles are expected to exhibit avoidance, diving or any other higher severity behavioral response to air guns during testing. While sea turtles may be exposed and respond to lower received levels (i.e., less than 175 dB re 1 μPa SPL [rms]), any responses to such level would likely be minor, with no resulting effect on individual fitness. Due to the short term and infrequent nature of any exposures to air guns and the brief responses that could follow such exposure, the effects of air guns on ESA-listed sea turtles are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). In summary, we find that the effects from exposure to air guns are insignificant for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.1.4 Vessel Noise – Sea Turtles

ESA-listed turtles could be exposed to a range of vessel noises within their hearing abilities. The Navy vessels used during training and testing activities will produce low-frequency, broadband underwater sound below 1 kHz for larger vessels, and higher-frequency sound between 1 kHz to 50 kHz for smaller vessels, although the exact level of sound produced varies by vessel type. Depending on the context of exposure, potential responses of the ESA-listed sea turtle species in the action area to vessel noise disturbance would likely include startle responses, avoidance, or other behavioral reactions, and physiological stress responses.

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to 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 endure while the vessel transits through the area where the sea turtle encountered it. Sea turtle responses to the vessel noise disturbance are considered insignificant, and a sea turtle would be expected to return to normal behaviors and baseline stress levels shortly after the vessel passes. In summary, we find that the likely effects from exposure to vessel noise are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.1.5 Aircraft Noise – Sea Turtles

Training and testing activities with aircraft would occur near Navy airfields, installations, and in special use airspace within Navy range complexes. In the action area, aircraft flights associated with training and testing would be concentrated in the SOCAL Range Complex compared to the HRC and transit corridor.

As with vessel disturbance above, little information is available on how ESA-listed sea turtles respond to aircraft. For the purposes of this consultation, we assume all ESA-listed sea turtles in the action area may exhibit similar short-term behavioral responses such as diving, changes in swimming, etc., which is also 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.

The working group that developed the 2014 ANSI Guidelines for fishes and sea turtles (Popper et al. 2014d) did not consider this specific acoustic stressor for sea turtles, in part because it is not considered to pose a great risk. Although the aircraft used by the Navy can produce extensive airborne sounds (e.g., turbofan or turbojet engines, and sonic booms), depending on the altitude some sounds would not be transmitted into the water. Any low-flying aircraft would only likely transmit low levels of sound within one meter into the water column. Sea turtles located at or near the water surface may exhibit startle reactions to certain aircraft overflights if the aircraft is flying at a low altitude and the turtle can see it or detect it through sound or water motion generated from wind currents on the surface. This would most likely occur when helicopters are hovering (other aircraft are mostly flying at higher altitudes) and might be visually detected by a sea turtle. The currents and waves the helicopter produces on the water's surface may also cause sea turtles to respond to the disturbance along with the sound. 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. 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 aircrafts and the brief responses expected to the noise or visual disturbance produced, the effects of aircraft overflight noise on ESA-listed sea turtles is considered temporary and insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). In summary, we find that the likely effects from exposure to aircraft overflight noise are insignificant for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.1.6 Weapons Noise – Sea Turtles

Individual sea turtles from all of the ESA-listed species may be exposed to sounds caused by the 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 propagate across a large expanse of surface waters. This 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 2018d).

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 could cause 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 2018d). 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 will 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. Most of these activities will typically occur more than 12 NM from the coast; therefore, sea turtles would still be able to detect biologically relevant sounds near the coastal areas they inhabit or need to detect near nesting beaches.

In addition, as described in the proposed mitigation measures (Section 3.4.2) for these activities, the Navy will not commence with weapons firing if mats of floating vegetation are observed, or if a sea turtle is observed within the mitigation zone. These measures will help reduce the likelihood of impacts on hatchling and pre-recruitment juveniles of all sea turtle species and leatherback turtles of all age classes because these species and age classes are known to congregate around mats of floating vegetation. For these reasons, 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 behavioral patterns. Sea turtle responses to weapons noise are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated), and a sea turtle would be expected to return 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 are insignificant for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.2 Energy Stressors – Sea Turtles

This section analyzes the potential impacts of energy stressors used during training and testing activities within the action area on sea turtles. This section includes analysis of the potential impacts of in-water electromagnetic devices and high-energy lasers.

9.1.2.2.1 In-water Electromagnetic Devices – Sea Turtles

Magnetic fields and other cues (e.g., visual cues), are known to be important for sea turtle orientation and navigation (Lohmann et al. 2000; Putman et al. 2015). Sea turtles use geomagnetic fields to navigate at sea, and therefore changes in those fields could impact their movement patterns (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Turtles in all life stages orient to the earth's magnetic field to position themselves in oceanic currents and directional swimming presumably aided by magnetic orientation has been shown to occur in some sea turtles (Christiansen et al. 2016b). This life strategy enables them to locate seasonal feeding and breeding grounds and return to their nesting sites (Lohmann and Lohmann 1996; Lohmann and Lohmann 1998). Sea turtles have been shown able to detect changes in magnetic fields, which may cause them to deviate from their original direction. For example, Liboff (2016) determined that freshly hatched sea turtles are able to detect and use the local geomagnetic field as a reference point before embarking a post-hatchling migration. This study suggests that the information is transferred from the mother to the egg through some undetermined geomagnetic imprinting process.

Sea turtles may also use nonmagnetic cues for navigation and migration, and these additional cues may compensate for variations in magnetic fields. Putman et al. (2015) conducted experiments on loggerhead hatchlings and determined that electromagnetic fields may be more important for sea turtle navigation in areas that may constrain a turtle's ability to navigate by other means (cold temperatures or displacement from a migration route). The findings of this study suggest that the magnetic orientation behavior of sea turtles is closely associated with ocean ecology and geomagnetic environment.

The in-water electromagnetic devices that the Navy proposes to use during training and testing activities include towed or unmanned mine warfare systems that mimic the electromagnetic signature of a vessel passing through the water. A full description of these devices is provided in 6.3.1 of this biological opinion. In general, the voltage used to power these devices is approximately 30 volts, with just 35 volts (capped at 55 volts) in saltwater, required to generate a current. These levels are considered safe for marine species due to the low charge relative to salt water. The static magnetic field generated by the mine neutralization devices is of relatively minute strength. The maximum strength of the magnetic field is approximately 2,300 μT, with the strength of the field decreasing further from the device (Navy 2018d). At a distance of four meters from the source of a 2,300 μT magnetic field, the strength of the field is approximately 50 μT, which is within the range of the Earth's magnetic field (25 to 65 microteslas). At eight meters from a 2,300 μT magnetic field the strength of the field is approximately 40 percent of the Earth's magnetic field, and at 24 m away only 10 percent (Navy 2018d). Therefore, at a distance of 200 m (the maximum predicted distance of the magnetic field proposed for use by the Navy) the strength of the magnetic field would be approximately 0.2 microteslas (Navy 2018d), which is less than one percent of the strength of the Earth's magnetic field. This is likely within the range of detection for sea turtle species, but at the lower end of their sensitivity to the field.

For any sea turtles located in the immediate area (within about 200 m) where in-water electromagnetic devices are being used, adult, sub-adult, juveniles, and hatchling sea turtles could be temporarily disoriented and could deviate from their original movements, but the extent of this disturbance is likely to be inconsequential given the brief duration of the potential disorientation (seconds or minutes). These brief behavioral disruptions are expected to be limited and minor, and not anticipated to result in any effect, beyond what would be similar to natural stressors regularly occurring in the animal's life cycle. The effects from exposure to in-water electromagnetic devices for sea turtles are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). In summary, we find that the likely effects from exposure to in-water electromagnetic devices are insignificant for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.2.2 Lasers – Sea Turtles

As discussed above, high-energy laser (lasers) weapons training and 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 2018d). Lasers would only be used in open ocean areas of the action area, and would therefore not affect species located nearshore.

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. 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: for turtles located deeper in the water column, the probability of being struck by a laser decreases. 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.

Within the action area, the use of lasers would occur within the HRC and SOCAL Range Complex. Draft HSTT EIS/OEIS Appendix F (Military Expended Material and Direct Strike Impact Analyses) includes a conservative approach for estimating the probability of a direct laser strike on a sea turtle during testing and training activities. The Navy analysis assumes: (1) that all sea turtles would be at or near the surface 100 percent of the time, and would not account for the duration of time a sea turtle would be diving; and (2) that sea turtles are stationary, which does not account for any movement or any potential avoidance of the training or testing activity in response to other stressors (e.g., vessel noise). Similar to the modeling for acoustics and explosives impacts, the sea turtle guild is used as a conservative proxy for individual sea turtle species. The Navy's modeling results show a probability of 0.000064 strikes per year on a sea turtle. Based on this extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for any sea turtles to be struck by a high-energy laser. Therefore, potential effects on sea turtles from lasers are considered discountable. In summary, we find that the probability of exposure to effects of lasers is discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.3 Physical Disturbance and Strike Stressors – Sea Turtles

Additional discussion on physical disturbance and strike stressors is included in Section 6.4. This section analyzes 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: in-water devices; military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions; and seafloor devices. The potential for vessel strike of sea turtles is discussed in Section 9.2.2.2.

9.1.2.3.1 Military Expended Materials – Sea Turtles

Navy activities involving military expended materials occur both nearshore and offshore within the HSTT action area, but the majority of materials would be expended in offshore areas (Navy 2018d). During Navy activities that produce military expended materials, the potential for a strike of ESA-listed sea turtles exists from all sizes of non-explosive practice munitions, fragments from high-explosive munitions, expendable targets, and expended materials other than munitions; such as sonobuoys, expended bathythermographs, and torpedo accessories. Most of the expended materials that may enter the water column are expected to only cause temporary, localized impacts when they strike the surface of the water (Navy 2018d). Current Navy gunnery exercises, include firing a variety of weapons and using a variety of non-explosive training and testing rounds, including 5-in. naval gun shells, and small-, medium-, and large-caliber projectiles. The larger-caliber projectiles are only used in the open ocean beyond 20 NM (Navy 2018d). The chance of a turtle being hit is related to the sea turtle life history and likelihood of presence in the action area when materials are expended. The primary concern with these materials is for a sea turtle located at or near the water surface to be struck. If this occurs, a turtle could be harmed. The chances of this occurring depend on several factors discussed below.

Under the proposed action, training and testing activities in offshore waters that involve military expended materials would occur in the HRC, SOCAL Range Complex, and the transit corridor. For training activities occurring in the offshore waters, the species and age classes most likely to be impacted are hatchlings and pre-recruitment juveniles of all sea turtle species, adult loggerhead turtles, and leatherback turtles of all age classes. Adult sea turtles in these areas could be located at the surface of the water, but generally spend most of their time submerged. Thus, adult sea turtles are expected to be at the surface for brief periods of time compared to hatchlings and juveniles; as these early life stages spend more time at the surface while in ocean currents. However, all life stages do spend some time at the surface basking. Because the Navy will not commence activities that expend materials (e.g. weapons firing) near concentrated mats of floating vegetation (e.g., kelp paddies), the chances of these life stages (i.e., hatchlings and juveniles) being affected is low. Moreover, sea turtles are expected to be widely distributed in offshore waters, decreasing the chances of a single or repeated exposure to sea turtles since these offshore areas do not have sea turtle presence year-round.

While no strike from military expended materials has ever been reported or recorded for sea turtles, the possibility of a strike exists, although it is unlikely. For this reason, the Navy conservatively estimated the probability of a direct strike to a sea turtle based upon the distribution and density estimates they have for the species and the number of activities that would pose a risk occurring throughout the action area. To estimate potential direct strike exposures, a worst-case scenario was calculated using the sea turtle with the highest average year-round density in areas with the highest military expended material expenditures in the Hawaii and Southern California portions of the HSTT action area (Navy 2018d). The green turtle was used as a proxy for all sea turtle species because it had the highest density when averaged over the the range complex, which would provide the most conservative modeling output results. The Navy analysis assumes the following. The Navy analysis assumes the following:

- The model is two-dimensional and assumes that all sea turtles would be at or near the surface 100 percent of the time and does not consider any time a sea turtle would be submerged.
- The model does not take into account the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small number of those would hit the water at a maximum velocity and force.
- The model assumes the animal is stationary and does not account for any movement of the sea turtle or any potential avoidance of the training or testing activity.

In the HRC, the model estimates approximately 0.008 exposures per year (Navy 2018d). Only density estimates in the HRC were used because in these waters green sea turtles occur in the highest numbers year round (in contrast to waters off southern California, where sea turtle occurrence is more seasonal). Presumably, sea turtle exposures in the SOCAL Range Complex and transit corridors would be even lower than those estimated for the HRC. Based on a worst-case scenario, the Navy's model results indicate with a reasonable degree of certainty that sea turtles would not be struck by non-explosive practice munitions, expendable targets, and expended materials during training activities. Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for any sea turtles to be exposed to military expended materials as part of the proposed action. Therefore, potential effects on sea turtles from military expended materials are considered discountable. In summary, we find that the probability of exposure to effects of military expended materials is discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.3.2 Seafloor Devices – Sea Turtles

Offshore activities that use seafloor devices would primarily occur in the Hawaii and SOCAL Range Complexes. The types of activities that use seafloor devices include items placed on, dropped on, or that move along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles (Navy 2018d). The likelihood of any sea turtle species encountering seafloor devices is considered low because these items are either stationary or move very slowly along the bottom. Sea turtles would be expected to ignore or avoid any slowly moving or stationary device. Based on the Navy model that estimated the number of sea turtles present when military materials are expended (described above), which also takes into account the use of seafloor devices, the probability of an individual sea turtle being struck by a seafloor device is extremely low (Navy 2018d). Considering the extremely low probability of occurrence, NMFS considers it extremely unlikely for any sea turtles to be exposed to seafloor devices as part of the proposed action. Therefore, potential effects on sea turtles from seafloor devices are considered discountable. In summary, we find that the probability of exposure to effects of seafloor devices is discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.4 Entanglement Stressors – Sea Turtles

All of the ESA-listed sea turtles present within the action area could encounter materials that may entangle them such as wires and cables, and decelerators and parachutes that are used during Navy activities. Sea 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 fishing gear that float or are suspended at the ocean's surface for long periods of time.

9.1.2.4.1 Cables and Wires

Expended fiber optic cables, which range in size up to 3,000 m in length, can pose a potential entanglement risk for sea turtles. However, because expended fiber optic cables are not expected to remain suspended in the water column for long periods and are expected to sink rapidly, the likelihood of a turtle at the surface or in the water column encountering them is low. In addition, the material from these cables is very brittle and breaks easily if bent or twisted, which also decreases the likelihood that a turtle would become ensnared. Furthermore, because most of the Navy activities that use fiber optic cables occur in deeper waters, most cables would ultimately settle in deep ocean substrates beyond the diving depth range for the sea turtle species and life stages considered here (Navy 2018d).

In addition to expended fiber optic cables, the Navy proposes to temporarily deploy slightly negatively buoyant fiber optic cables at depths of approximately 600 to 850 ft up to approximately 60 miles in length. Since these longer cables would be recovered immediately following their use there is very little risk of sea turtle entnaglement.

Similar to fiber optic cables, guidance wires may pose an entanglement threat to sea turtles either in the water column or after the wire has settled to the seafloor. However, the likelihood of a sea turtle encountering and becoming entangled in a guidance wire is low. The sink rate to the seafloor (at an estimated rate of 0.7 ft per second) is fast, and the probability of a sea turtle encountering a wire as it descends is lower than encountering it after it has settled. Also similar to fiber optic cables, the guide wires have a relatively low tensile breaking strength (between 10 and 42 lb) which further reduces the entanglement risk for sea turtles. Guidance wires may also degrade after settling along the substrate. The Navy estimates they would break down within one to two years and therefore no longer pose an entanglement risk after that time (Navy 2018d).

Sonobuoy wires, consist of a thin-gauge, hard draw copper strand wire, wrapped by a hollow rubber tubing or bungee. The tensile breaking strength of the sonobuoy wire and rubber tubing is no more than 40 lb. Operationally, sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor, which would increase the likelihood that a sea turtle could encounter a sonobuoy wire either while it is suspended or as it sinks (Navy 2017). However, as with fiber optic wires, sonobuoys are weak and likely to break if wrapped around a sea turtle. Bathythermographs wires are similar to sonobuoys, and expected to have the same fate, as such are expected to pose little risk for sea turtles.

Any ESA-listed sea turtles that occurs within the action area could at some time encounter expended cables or wires. Based upon the numbers and geographic locations of where the Navy will use these materials, they pose a higher risk of entanglement for sea turtles located at the waters surface or in the water column rather than those foraging along the seafloor. Because of this, hatchlings and pre-recruitment juveniles of all sea turtle species, and leatherback turtles of all age classes are more likely to encounter these materials in offshore areas. Due to their size, adult sea turtles may have a higher risk of entanglement than smaller turtles such as hatchlings and juveniles, since larger turtles are considered less able to disentangle from loops that may form in lines. However, since this material has different tensile strength and breaks easier than fishing gear (which is more commonly the cause of sea turtle entanglement), the risk of a larger seas turtle remaining entangled in wires or cables is low.

In shallow, nearshore waters, wires and cables may pose a slight risk to juvenile, sub-adult, and adult loggerhead, green, hawksbill, and olive ridley who forage along the substrate. However, most cables from sonobuoys would be expended in waters too deep for benthic foraging, so bottom foraging sea turtles would not interact with them once they sink, thereby decreasing any risk of entanglement for these species and life stages. Moreover, the sink rates of cables and wires would minimize the potential for these items to drift into nearshore and coastal areas from offshore, where these species and life stages are more likely to occur in benthic foraging areas.

Given the low concentration of expended wires and cables, the rapid sink rates, and likely distribution of sea turtles in the action area that may be concurrent where cables and wires are expended, the likelihood of a sea turtle encountering a wire or cable and becoming entangled is extremely low. For these reasons, the potential effects from these stressors on sea turtles are discountable. Based on the extremely low probability of occurrence, coupled with the other assumptions described above, NMFS considers it extremely unlikely for any sea turtles to be exposed to entanglement in cables and wires as part of the proposed action. Therefore, potential effects on sea turtles from entanglement in cables and wires are considered discountable. In summary, we find that the probability of exposure to effects of entanglement in cables and wires is discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.4.2 Decelerators and Parachutes

Training and testing activities that introduce decelerators and parachutes into the water column can occur anywhere in the HSTT action area and may pose an entanglement risk to sea turtles. Decelerators and parachutes used during the proposed training and testing activities range in size from 18 inches up to 19 ft in diameter (Navy 2018d). The vast majority of expended decelerators and parachutes are small (18 inches), cruciform shaped, and are used with sonobuoys. Illumination flares and targets use large parachutes, up to 19 ft in diameter. Small decelerators and parachutes have short attachment cords and upon water impact may remain at the surface for 5-15 seconds before they sink to the seafloor, where they become flattened. Sonobuoy decelerators and parachutes are designed to sink within 15 minutes, but the rate of sinking depends upon sea conditions and the shape of the decelerator or parachute, and the duration of the descent would depend on the water depth (Navy 2018d). The likelihood for entanglement is higher for the large and extra-large chutes due to their size and length of the attachment cords, and because some of the large and extra-large decelerators and parachutes have the potential to be expended nearshore, where sea turtle densities are likely higher. Additionally, these larger parachutes and decelerators are not weighted with anything to help them sink rapidly, thus could potentially remain suspended in the water column for an extended period of time, increasing the chance of sea turtles encountering them in the water column (Navy 2018d). However, significantly fewer large and extra-large decelerators and parachutes are expended annually during Navy activities, and therefore the chance for a sea turtle to encounter them is low given sea turtle distributions and densities throughout the portions of the action area where these devices are used (Navy 2018d).

Based on the numbers and geographic locations of their use in training and testing activities, decelerators and parachutes pose a risk of entanglement for all sea turtle species considered in this opinion. The high sink rates of small and medium decelerators and parachutes would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom.

Once these smaller chutes reach the substrate, they will likely flatten and are not expected to billow up from the bottom. Any decelerators or parachutes that do settle have some small degree of risk to become resuspended, however it is more likely that these items would become buried in sediments and degrade over time as ocean currents move sediment around along the seafloor or organisms colonize them. The leatherback is more likely to co-occur where decelerators and parachutes would be deployed given this species' preference for offshore, open-ocean habitats. Since leatherback 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. Overall, given the low probability of a sea turtle being near a deployed decelerator or parachute, as well as the general behavior of sea turtles, we find the likelihood of entanglement to be very low. Therefore, the potential effects from entanglement of sea turtles in decelerators and parachutes are considered extremely unlikely and thus discountable. In summary, we find that the probability of exposure to effects of entanglement in decelerators and parachutes is discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.4.3 Biodegradable Polymer

Navy testing activities that involve vessel entanglement systems include the use of a biodegradable polymer. A biodegradable polymer is a high molecular weight polymer that degrades to smaller compounds as a result of microorganisms and enzymes. Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will break down into small pieces within a few days to weeks (Navy 2018d). The small pieces will then break down further and dissolve into the water column within weeks to a few months. The final products, which are all environmentally benign, will be dispersed quickly to undetectable concentrations (Navy 2018d). Unlike other entanglement stressors, biodegradable polymers only retain their strength for a relatively short period of time, therefore the potential for entanglement by a sea turtle would be limited (Navy 2018d). Furthermore the longer the biodegradable polymer remains in the water, the weaker it becomes making it more brittle and likely to break. A sea turtle would have to encounter the biodegradable polymer immediately after it was expended for it to be a potential entanglement risk. The risk of biodegradable polymers to hatchlings could extend for days to weeks since a lower tensile strength would be required to cause entanglement. Due to the wide dispersion and low numbers of the proposed biodegradable polymer use, and the distribution of sea turtle adults, juveniles and hatchlings in the action area, there is a low likelihood of any sea turtle interacting with biodegradable polymers. In summary, we find that the probability of exposure to effects of entanglement in in biodegradable polymers is extremely unlikely and thus discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.2.5 Ingestion Stressors – Sea Turtles

The munitions and other materials NMFS considers small enough to be ingested by ESA-listed 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 (Navy 2018d). Most expendable materials will be used over deep water, and these items will sink quickly and settle on the seafloor with the exception of chaff and some firing target materials (Navy 2018d). In inshore waters, training activities would concentrate small-caliber shell casings in areas that may potentially be over benthic foraging areas. Life stages of sea turtles potentially affected in these areas would be juvenile, sub-adult, and adult green, loggerhead, olive ridley, and hawksbill sea turtles. These species are more likely to encounter munitions of ingestible size that settle on the substrate. Because leatherback sub-adult and adult sea turtles forage in coastal surface waters, they would be less likely to ingest expended materials that sink to the bottom.

Types of munitions that can result in fragments include demolition charges, projectiles, missiles, and bombs. The size of these fragments would vary depending on the net explosive weight size and munitions type. Metal materials are expected to quickly sink and settle on the seafloor. Fragments that could be encountered by sea turtles would most likely be those that have settled on the seafloor. Other munitions and munitions fragments such as large-caliber projectiles or intact training and testing bombs are too large for sea turtles to consume and since they are made of metal a sea turtle would not be able to break it apart and ingest it (Navy 2018d). 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 material. If this occurs, chaff is not expected to impact sea turtles due to the low concentration that would be ingested and the small size of the fibers (Navy 2018d). Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to their light weight and small size, chaff float and can be carried great distances in both air and water currents (Navy 2018d). Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Given the small size, low densities, and low toxicity of chaff, any accidental ingestion by ESA-listed sea turtles 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. Firing target materials are normally retrieved before sinking so it is not reasonable to expect ingestion of these items to occur (Navy 2018d).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, during Navy activities, where they may persist for long periods and therefore could be ingested by sea turtles while initially floating on the surface and sinking through the water column (Navy 2018d). However, these end caps would eventually sink to the seafloor where they would be less likely to be ingested by sea turtles that forage at or near the surface (i.e., hatchlings and pre-recruitment juveniles of all sea turtle species and all life stages of leatherbacks). Green, hawksbill, olive ridley, and loggerhead sea turtles could be at an increased risk of ingesting chaff cartridge plastic end caps and pistons that settle in potential benthic feeding habitat.

Should a sea turtle encounter military expended materials, it is unlikely that it would ingest every fragment. Sea turtles may attempt to ingest a projectile and then reject it, after realizing it is not a food item. It is likely that most ingested material would pass through the digestive tract of the animal. NMFS is also unaware of any data indicating these items 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). 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. The likelihood of this occurring would be low. 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. The probability of this occurring would partially be 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 2018d).

If a sea turtle were to ingest any of the military expended material, short-term or long-term effects could occur such as disruption in feeding behavior or digestive processes. 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. Therefore, a sea turtle could have reduced growth, survival, or reproductive success. However, munitions used in training and testing activities are generally not expected to cause such reactions in sea turtles. Sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended (beyond the foraging depths of bottom feeding turtles). If material is ingested, most ingestible-sized items would likely be spit out or passed through the digestive tract without significantly impacting the individual. In addition, given the limited geographic area where materials other than munitions are expended during a given event, 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. Therefore, potential exposures to military expended material that may result in risk to sea turtles from ingestion of these materials is considered extremely unlikely and thus discountable. In summary, we find that the probability of exposure to effects from ingestion of military expended materials is discountable for the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley.

9.1.3 Fishes

We determined that several of the acoustic stressors, all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect

ESA-listed Southern California DPS steelhead trout, giant manta ray, oceanic whitetip shark, and Eastern Pacific DPS scalloped hammerhead shark. As noted above, our analysis for these stressors is organized on the taxa level (i.e., fishes) because the pathways for effects for these stressors is generally similar for all fishes and we would not expect different effects at the species level. While there is variation among species within each taxa, the fish species considered in this opinion share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors associated with the proposed action. Where species-specific information is relevant, this information is provided in this section. Our analysis for these stressors and fishes is summarized below.

9.1.3.1 Acoustic Stressors – Fishes

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. NMFS determined that these acoustic stressors are not likely to adversely affect ESA-listed sea turtles. The effects of explosives and pile driving, other acoustic stressors, which NMFS determined was likely to adversely affect ESA-listed fishes, is discussed in Section 9.2.3.

9.1.3.1.1 Vessel Noise – Fishes

As described above for marine mammals, Navy vessel movements involve transits to and from ports to various locations within the action area, and many proposed activities within the action area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels), as well as unmanned vehicles. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks. Navy vessel traffic could occur anywhere within the action area, but would be concentrated within the easternmost part of Southern California and around the major Hawaiian Islands, particularly the area surrounding Honolulu (Mintz 2016).

Individuals from all ESA-listed fishes considered in this biological opinion may be exposed to sound from vessel movement during Navy training and testing activities. In general, information regarding the effects of vessel noise on fish hearing and behaviors is limited. Although some TTS has been observed in fishes exposed to elevated background noise and other white noise, a continuous sound source similar to noise produced from vessels. Caged studies on sound pressure sensitive fishes show some TTS after several days or weeks of exposure to increased background sounds, although the hearing loss appeared to recover (e.g., Scholik and Yan 2002; Smith et al. 2006; Smith et al. 2004b). Smith et al. (2004b) and Smith et al. (2006) exposed goldfish (a fish with hearing specializations, unlike any of the ESA-listed species considered in this opinion) to noise with an SPL of 170 dB re 1 μPa and found a clear relationship between the amount of TTS and duration of exposure, until maximum hearing loss occurred at about 24 hours of exposure. A short duration (e.g., 10-minute) exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure baseline levels (Smith et al. 2004b). Recovery times were not measured by researchers for shorter exposure durations, so recovery time for lower levels of TTS was not documented.

Vessel noise may also affect fish behavior by causing them to startle, swim away from an occupied area, change swimming direction and speed, or alter schooling behavior (Engas et al. 1998; Engas et al. 1995; Mitson and Knudsen 2003). Physiological responses have also been documented for fish exposed to increased boat noise. Nichols et al. (2015a) demonstrated physiological effects of increased noise (playback of boat noise) on coastal giant kelpfish. The fish exhibited acute stress responses when exposed to intermittent noise, but not to continuous noise. These results indicate variability in the acoustic environment may be more important than the period of noise exposure for inducing stress in fishes. However, other studies have also shown exposure to continuous or chronic vessel noise may elicit stress responses indicated by increased cortisol levels (Scholik and Yan 2001; Wysocki et al. 2006). These experiments demonstrate physiological and behavioral responses to various boat noises that could affect species' fitness and survival but may also be influenced by the context and duration of exposure. It is important to note that most of these exposures were continuous, not intermittent, and the fish were unable to avoid the sound source for the duration of the experiment because this was a controlled study. In contrast, wild fish are not hindered from movement away from an irritating sound source, if detected, so are less likely to subjected to accumulation periods that lead to the onset of hearing damage as indicated in these studies. In other cases, fish may eventually become habituated to the changes in their soundscape and adjust to the ambient and background noises.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Navy vessels produce moderate to low-level passive sound sources (larger Navy ships would produce low-frequency, broadband underwater sound below 1 kHz; and smaller vessels emit higher-frequency sound between 1 kHz to 50 kHz). Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from Navy vessels is unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Plus, in the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors. Auditory masking due to vessel noise can potentially mask vocalizations and other biologically important sounds that fish may rely on. However, impacts from Navy vessel noise would be intermittent, temporary and localized, and such responses would not be expected to compromise the general health or condition of individual fish from continuous exposures. Instead, the only impacts expected from exposure to Navy vessel noise for fishes may include temporary auditory masking, physiological stress, or minor changes in behavior.

Therefore, similar to marine mammals and sea turtles, exposure to vessel noise for fishes could result in short-term behavioral or physiological responses (e.g., avoidance, stress). Vessel noise would only result in brief periods of exposure for fishes and would not be expected to accumulate to the levels that would lead to any injury, hearing impairment or long-term masking of biologically relevant cues. For these reasons, exposure to vessel noise is not expected to significantly disrupt normal behavior patterns of fishes in the action area. Therefore, the effects of vessel noise on ESA-listed fishes is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.1.2 Aircraft Noise – Fishes

All ESA-listed fish species considered in this biological opinion (Southern California DPS steelhead, Eastern Pacific DPS scalloped hammerhead shark, giant manta ray, and oceanic whitetip shark) could be exposed to aircraft-generated overflight noise throughout the action area. Should sound transmit from aircraft tracel into the water column, it would likely only be to a shallow depth and would be below the range of any injury criteria for fishes. Furthermore, aircraft quickly pass overhead, with helicopters potentially hovering for a few minutes or up to a few hours over the water's surface. As described above, sound transmission into deep depths of the water column is not likely, and sound that is transferred into the water from air is only within a narrow cone under the aircraft. Therefore, only fishes located at or near the surface of the water and within the limited area where transmission of aircraft noise is expected to occur have the potential to detect any noise produced from low-flying aircraft.

Direct injury and hearing impairment in fishes is unlikely to occur from aircraft overflight noise, because sounds from aircraft noise, including occasional sonic booms, lack the amplitude or duration to cause any physical damage to fishes underwater. Furthermore, due to the brief and dispersed nature of aircraft overflights, masking of biologically relevant sounds for fishes is also extremely unlikely. In the rare circumstance a fish detects sound produced from an aircraft overhead, only very brief startle or avoidance responses would be expected. Additionally, due to the short-term, transient nature of aircraft noise, ESA-listed fishes are unlikely to be exposed multiple times within a short period of time that could lead to ongoing behavioral disruptions or stress. Any physiological stress and behavioral reactions would likely be short-term (seconds or minutes) and are expected to return to normal shortly after the aircraft disturbance ceases. Therefore, the effects on fishes from aircraft overflight noise are anticipated to be minor, temporary and will not lead to a significant disruption of normal behavioral patterns. As such the effects from aircraft overflight noise on fishes are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.1.3 Weapons Noise – Fishes

ESA-listed fishes at the surface of the water could be exposed to weapons noise, albeit in a narrow footprint under a weapons trajectory, as described previously. In addition, any objects that are dropped and impact the water with great force could produce a loud broadband sound at the water's surface from large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets (Mclennan 1997).

Naval gunfire could also elicit a brief behavioral reaction such as startle reactions or avoidance and could expose fishes to multiple shots within a few seconds. The sound produced from missile and target launches is typically at a maximum during initiation of the booster rocket, but rapidly fades as the missile or target travels downrange; therefore this noise is unlikely to affect fishes underwater. These are launched from aircraft which would produce minimal sound in the water due to the altitude of the aircraft when these are fired.

For exposed fishes, most of the weapons noise produced from these activities lack sound characteristics such as duration and high intensity that would accumulate or cause mortality, injury, or hearing impairment. The average peak levels of 200 dB are also below the peak levels for impulsive sound sources that could lead to onset of injury for fishes. Additionally, because these activities are brief in duration and widely dispersed throughout the action area, accumulation of levels high enough to cause TTS or masking of biologically relevant sound for fishes is also extremely unlikely. As with the other stressors for fishes discussed in this section, exposure to the sound produced from weapons would only be expected to cause brief behavioral or stress responses should they detect the noise. Fish may react by exhibiting startle responses, rapid bursts in movement, changes in swimming direction or orientation, or leaving the immediate area of the sound. Concurrent with these behavioral responses, fishes could also experience temporary increases in heart rate or stress hormones. However, any behavioral reactions and physiological stress would likely be brief, and are expected to return to normal shortly after the weapons noise ceases. Therefore, the effects on fishes from weapons noise are anticipated to be minor, temporary, and are not expected to lead to a significant disruption of normal behavioral patterns. As such, the effects from weapons noise on fishes are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.1.4 Sonar and Transducers – Fishes

General categories and characteristics of Navy sonar systems proposed for use during activities considered in this biological opinion are described in Section 6.1.3. All ESA-listed fishes considered in this opinion have the potential to be exposed to sonar and other transducers during Navy activities in the action area. However, direct injury from sonar and other transducers is considered unlikely. These types of sound sources are considered to pose less risk to fish species because the sound produced from sonar characteristically has lower peak pressures and slower rise times than other acoustic stressors that are known to injure fish such as impulsive sounds from pile driving, or the strong shock waves produced from detonation of explosives. Direct injury from sound levels produced from the type of sonar the Navy uses has not been documented in fishes (Halvorsen et al. 2012e; Kane et al. 2010; Popper et al. 2014a; Popper et al. 2007; Popper et al. 2013). However, some hearing impairment could occur, as well as behavioral and stress responses which are discussed below.

As described previously, fishes are not equally sensitive to noise at all frequencies. Some species of fishes have specialized adaptations which increases their ability to detect sounds at higher frequencies. However, none of the ESA-listed fishes that may be affected by Navy activities possess any hearing specializations. For these reasons, grouping fish according to the presence of a swim bladder and whether or not that swim bladder is involved in hearing and their known hearing frequency ranges (audiograms) is considered the best approach for the purposes of our analyses. All of the ESA-listed fish species that have a swim bladder considered in this opinion do not have a swim bladder associated with hearing, thus the sound criteria used for fishes are based upon fishes with swim bladders not involved in hearing (steelhead) and fishes that do not possess a swim bladder (Oceanic whitetip shark, Giant manta ray, and scalloped hammerhead sharks).

Exposure to SURTASS low-frequency active sonar has been tested at maximum received levels of 193 dB re 1 μPa (218 dB SELcum) and has not been shown to cause mortality or any injury in fish with swim bladders (Kane et al. 2010; Popper et al. 2007). The researchers exposed three freshwater species of fish, the rainbow trout (*Oncorhynchus mykiss*), channel catfish (*Ictalurus punctatus*), and the hybrid sunfish (*Lepomis sp*.), to both low- and mid-frequency sonar. Low-frequency active sonar exposures with received SPLs of 193 dB re 1 μPa occurred for either 324 or 648 seconds. This study exposed the fish to low-frequency active sonar pulses for time intervals that would be substantially longer than what would occur in nature (e.g., unconfined fishes), but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Hearing was measured both immediately post-exposure and for several days thereafter. Catfish and some specimens of rainbow trout showed 10 to 20 dB of hearing loss immediately after exposure to the low-frequency active sonar when compared to baseline and control fish; however, another group of rainbow trout showed no hearing loss. Recovery in trout took at least 48 hours, but studies on recovery were not completed. The reason for the different results between rainbow trout groups is not known. But the researchers speculated it may be due to developmental or genetic differences in the various groups of fish. Catfish hearing returned to, or close to, normal within about 24 hours after exposure to low-frequency active sonar. Furthermore, examination of the inner ears of the fish during necropsy revealed no differences from the control groups in ciliary bundles or other inner ear features indicative of hearing loss (Kane et al. 2010). Lesser potential for injurious effects would be expected for fish without swim bladders, because the presence of a swim bladder increases risk of injury as the sound wave passes through a fish’s body and causes the swim bladder to resonate with the sound frequency.

No studies have indicated any physiological damage to adult fish from mid-frequency sonar. However, studies on juvenile herring survival following intense sonar exposures affected less than 0.3 percent of the total juvenile stock (Kvadsheim and Sevaldsen 2005). Similarly, Jorgensen et al. (2005) exposed larvae and juvenile fishes of Atlantic herring (*Clupea harengus*) Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) to sounds that were designed to simulate mid-frequency active sonar transmissions (1 to 6.5 kHz) to study the effects of the exposure on the survival, development, and behavior. The fish were placed in plastic bags three meters from the sound source and exposed to between four and 100 pulses of one-second duration of pure tones at 1.5, 4, and 6.5 kHz. The fish in only two groups out of the 42 tested exhibited adverse effects beyond a behavioral response. These two groups were both composed of herring (a fish with hearing specializations), and were tested with SPLs of 189 dB re 1 µPa, which resulted in a post-exposure mortality of 20 to 30 percent. In the remaining 40 tests, there were no observed effects on behavior, growth (length and weight), or the survival of fish that were kept as long as 34 days post exposure. While statistically significant losses were documented in the two groups impacted, the researchers only tested that particular sound level once, so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors. It is also important to note, that none of the ESA-listed fish species considered in this biological opinion have the hearing specializations similar to herring, as such are not considered as sensitive to sound exposures and associated hearing damage as herring.

In another mid-frequency active sonar experiment, Halvorsen et al. (2012e) exposed rainbow trout to simulated mid-frequency active (2.8 to 3.8 kHz) sonar at received SPLs of 210 dB re 1 uPa, resulting in cumulative SELs of 220 dB re 1 uPa. The researches did not observe any mortality or hearing sensitivity changes in rainbow trout and suggested that the frequency range of mid-frequency active sonar may be above the most sensitive hearing range of the species.

Some studies have suggested that there may be some loss of sensory hair cells due to high intensity sources; however, none of these studies concurrently investigated effects on hearing. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following 1 to 5 hours of exposure to pure tone sounds between 50 and 400 Hz with an SPL of 180 dB re 1 µPa. Similarly, Hastings (1995) found auditory hair-cell damage in a species with notable anatomical hearing specializations, the goldfish (*Carassius auratus*) exposed to 250 Hz and 500 Hz continuous tones with maximum peak levels of 204 dB re 1 µPa and 197 dB re 1 µPa, respectively. Compared to Navy sonar exposures anticipated, these were long duration exposures of about 2 hours in laboratory settings, much longer than any exposure a fish would encounter in the wild during the Navy's proposed activities (i.e., due to the transient nature of Navy sonar use and that fishes are not confined in the wild as they are in a laboratory setting). The fish exposed in the lab were held in a cage for the duration of the exposure, unable to avoid the source.

Hastings et al. (1996) also demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) following a 1-hour exposure to a pure tone at 300 Hz with a peak pressure level of 180 dB re 1 µPa. Although in none of the studies was the hair cell loss more than a relatively small percent (less than a maximum of 15 percent) of the total sensory hair cells in the hearing organs.

Hastings (1990b) and Hastings (1995) also demonstrated 'acoustic stunning' (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an 8-minute exposure to a 150 Hz pure tone with a peak SPL of 198 dB re 1 µPa. However, this species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. The researchers also found that goldfish exposed to two hours of continuous wave sound at 250 Hz with peak pressures of 204 dB re 1 µPa, and fathead minnows exposed to 0.5 hours of 150 Hz continuous wave sound at a peak level of 198 dB re 1 µPa did not survive. The only study on the effect of exposure of the lateral line system to continuous sound was conducted on a freshwater species, and suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

The research described above, and the most recent literature review and summary completed by Popper et al. (2014a) regarding fish response to low-frequency active and mid-frequency active sonar indicate that those species tested to date can be used as viable surrogates for estimating injury in other species exposed to similar sources. However, the research conducted to date has not provided evidence that injury or mortality could occur from the sonar used by the Navy. Although fishes have been injured and killed due to intense, long duration, non-impulsive sound exposures, fish exposed under more realistic conditions have shown no signs of injury. Exposures would need to be of a much longer duration than those that would realistically occur with the Navy's proposed activities. Moreover, if injury or mortality occurs, it is thought to begin at higher sound levels than have been tested to date. In addition, the relative risk of injury or mortality to fish with no swim bladders exposed to low and mid-frequency sonar is lower than fish with swim bladders, no matter the distance from the source.

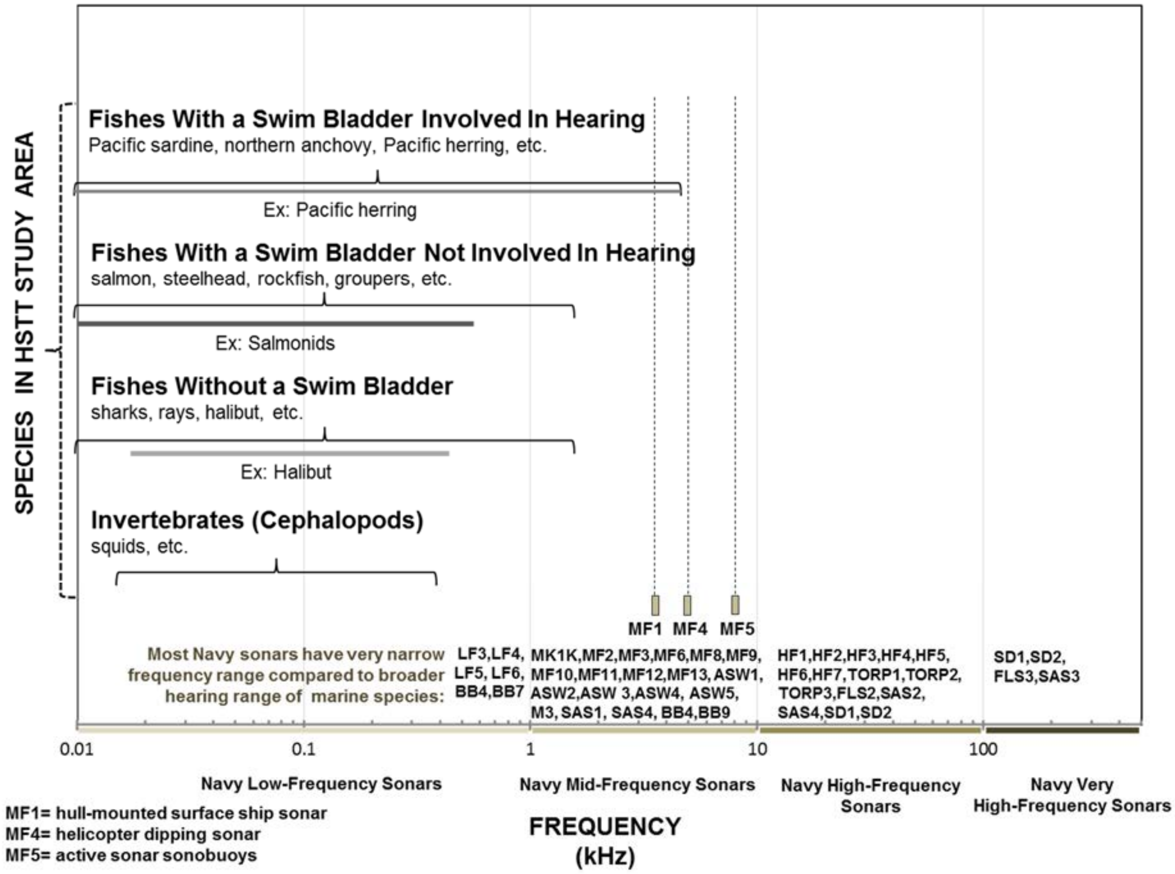
For these reasons, the recommended criteria and thresholds in the 2014 ANSI Guidelines are used to predict potential impact to fishes from sonar and transducers (described in Section 2.0). Since it is common practice for hearing thresholds to be based upon SEL_{cum}, to account for the duration of the exposure, the Navy converted the recommended levels to SEL based on the signal duration reported in the original research cited in the 2014 ANSI Guidelines, and described above. For low-frequency active sonar, only fishes with a swim bladder are likely to develop TTS from low-frequency active sonar exposure. Therefore, the recommended threshold for onset of TTS in this fish hearing group would be low frequency sonars exposure levels greater than 210 dB SEL_{cum} (re 1 μPa^2-s). TTS has not been observed in fishes with a swim bladder that is not involved in hearing exposed to mid-frequency active sonar. Fishes within this hearing group do not sense pressure well and typically cannot hear at frequencies above 2 kHz (Halvorsen et al. 2012e; Popper et al. 2014a). Therefore, no criteria were proposed for fishes with a swim bladder that is not involved in hearing from exposure to mid-frequency active sonars. Fishes without a swim bladder (elasmobranchs) are even less susceptible to noise exposure, therefore TTS is also unlikely to occur, and no criteria are proposed. These criteria are provided below in Table 59.

Table 59. Sound exposure criteria for TTS from sonar for fishes.

Fish Hearing Group	TTS from Low-Frequency Sonar (SEL_{cum})	TTS from Mid-Frequency Sonar (SEL_{cum})
Fishes without a swim bladder	NC	NC
Fishes with a swim bladder not involved in hearing	> 210	NC

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sonar is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

Because of the sheer number and diversity of fishes, only a limited amount have had hearing capabilities tested. Figure 63 below, provides a summary of hearing threshold data from available literature (e.g., Casper and Mann 2006; Deng et al. 2013; Mann et al. 2001; Navy 2018c) to demonstrate the potential overall range of frequency detection for each hearing group. However, these estimated hearing ranges may be overly conservative in that they may extend beyond actual species hearing capabilities for a particular group. The upper bounds of each fish hearing group frequency range are outside of the range of best sensitivity for all fishes within that group. As a result, fishes within each group would only be able to detect those upper frequencies from sources with relatively high source levels. Figure 63 is not intended as a composite audiogram, but rather displays the basic overlap in potential detectable frequencies for each fish hearing group associated with the Navy's defined sonar classes (i.e., low-, mid-, high- and very high-frequency) as discussed in Section 6.1 and above.



Notes: For fish hearing ranges, brackets indicate general frequency detection across the widest range known for each fish hearing group after review of scientific literature on freshwater and marine fish hearing. The science of fish hearing studies is evolving and not all studies are as robust as others. Therefore, as a conservative consideration accounting for the variation in hearing research study design, the lowest and highest values are used to define the fish hearing group brackets. Overall, any fish that falls within a given hearing group may or may not be able to detect the full range of frequencies in a given hearing group range. Because of this, narrow bars underneath a bracket represent example species within the study area that fit into a hearing group. These narrow bars show the minimum and maximum measured hearing thresholds from specific species regardless of testing methodology or study limitations. For US Navy sonars, although each sonar bin is represented graphically (e.g., low-frequency sonars less than 1 kHz, mid-frequency sonars between 1-10 kHz, etc.), not all sources within each bin would operate at all the displayed frequencies. Example mid-frequency sources are provided to further demonstrate this. SD1 and SD2 bins can use either mid- or very-high frequency depending on the given system. BB4 and SAS4 are more broad band source bins. (Fish hearing citations supporting this figure include Hawkins and Johnstone 1978; Fay 1988, Astrup and Mohl 1993; Popper and Carison 1998; Astrup 1999; Popper et al. 2003; Ladich and Popper 2004; Nedwell et al. 2004; Jorgensen et al. 2005; Lovell et al. 2005; Mann et al. 2005; Popper 2008; Popper 2009; Popper and Hastings 2009a, 2009b; Popper and Fay 2011; Ladich and Fay 2013; Popper et al. 2014, Sivle et al. 2015).

Figure 63. Fish hearing groups and Navy sonar frequency ranges (Navy 2018e).

Based upon the fish hearing and frequency overlap, the ESA-listed fishes considered in this biological opinion would be able to detect most of the Navy sonars within the low-frequency active sonar ranges, and would have limited ability to detect mid-frequency active sonar frequencies. For example, both fish groups (with and without swim bladders) would not be able to detect mid-frequency active sonar sources within bins MF1, MF4 and MF5. Also, it is anticipated that most ESA-listed fishes would not be able to hear Navy sonars or other transducers with operating frequencies greater than about 1 to 2 kHz. None of the ESA-listed fish species considered in this opinion can detect high- and very high-frequency sonars and other transducers. Therefore, these species will not be affected by these Navy sonar sources. As described above, mortality or injury from exposure to sonar is highly unlikely for the fish species potentially present in areas where the Navy will use sonar or other transducers. Thus, the most probable effects would be TTS, masking, physiological stress and behavioral responses. However, as stated above, if TTS occurred it would likely only occur for fishes with swim bladders (i.e., just steelhead). No elasmobranchs are expected to sustain TTS from sonar exposure.

In order to estimate the range to effects for fish exposed to sonar, the Navy calculated the range to effects based upon their NAEMO and the respective hearing criteria. Although ranges to effect are predicted, the density data for fish species within the action area are not available, therefore estimates of the total number of fishes that could be affected by sonar and other transducers was not possible. Sonar durations of 1, 30, 60 and 120 seconds were used in the calculations. Due to the relatively low source levels from this sonar source level and duration of sonar exposures, a range of zero meters was predicted for TTS. Therefore, it is unlikely that any fishes with a swim bladder not involved in hearing would experience TTS or any injury from exposure to Navy activities using sonar and other transducers.

Fishes that are able to detect low-frequency active sonar and perhaps some mid-frequency active sonar, could experience brief periods of masking, or exhibit brief behavioral reactions and stress responses. Fish located closer to the sonar sound source would likely experience more significant responses, whereas fish located further away from the source are less likely to react to the sound levels. However, because the Navy’s sonar is moving, and fish are also capable of moving away from the disturbance, the overall exposure duration is expected to be brief and if masking did occur, it would not occur for a significant amount of time and not prevent fish from detecting biologically relevant cues at meaningful levels. Additionally, any physiological stress responses or behavioral reactions would also be expected to be temporary, lasting only a few seconds or minutes during sonar pings. For these reasons, no long-term consequences for any exposed steelhead are expected. The effects described above are not anticipated to lead to a significant disruption of normal behavior patterns such as breeding, feeding or sheltering, and as such are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) for Southern California DPS steelhead, Giant manta ray, Oceanic whitetip shark, and Eastern Pacific DPS scalloped hammerhead shark.

9.1.3.1.5 Impulsive Sound Sources (Air Guns and Pile Driving) – Fishes

Because the impulsive sound produced from air guns and pile driving have similar characteristics and associated effects on fishes, a general description of the research regarding these effects is included below, with more detail regarding the specific sound source effects on fishes in Sections 9.1.3.1.5.2 and 9.1.3.1.5.3.

9.1.3.1.5.1 Potential Effects of Impulsive Sound Sources – Fishes

Impulsive sounds such as those produced by seismic air guns and impact pile driving are known to affect fishes in a variety of ways, and have been shown to cause mortality, auditory injury, barotrauma and behavioral changes. As described in Section 6.1, impulsive sound sources produce brief, broadband signals that are atonal transients (e.g., high amplitude, short-duration sound at the beginning of a waveform; not a continuous waveform). They are generally characterized by a rapid rise from ambient sound pressures to a maximal pressure followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures. For these reasons, they generally have an increased capacity to induce physical injuries in fishes, especially those with swim bladders (Casper et al. 2013a; Halvorsen et al. 2012b; Popper et al. 2014a). These types of sound pressures cause the swim bladder in a fish to rapidly and repeatedly expand and contract, and pound against the internal organs. This pneumatic pounding may result in hemorrhage and rupture of blood vessels and internal organs, including the swim bladder, spleen, liver and kidneys. External damage has also been documented, evident with loss of scales, hematomas in the eyes, base of fins, etc. (e.g., Casper et al. 2012b; Gisiner 1998; Halvorsen et al. 2012b; Wiley et al. 1981; Yelverton et al. 1975a). Fishes can survive and recover from some injuries, but in other cases, death can be instantaneous, occur within minutes after exposure, or occur several days later.

Hearing impairment

Research is limited on the effects of seismic air guns on fishes, however some research on seismic air gun exposure has demonstrated mortality and potential damage to the lateral line cells in fish larvae, fry, and embryos after exposure to single shots from a seismic air gun near the source (0.01 to 6 m; Booman et al. 1996; Cox et al. 2012). Popper et al. (2005a) examined the effects of a seismic air gun array on a fish with hearing specializations, the lake chub (*Couesius plumbeus*), and two species that lack notable hearing specializations, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*), a salmonid species. In this study the average received exposure levels were a mean peak pressure level of 207 dB re 1 μPa; SPL of 197 dB re 1 μPa; and single-shot SEL of 177 dB re 1 μPa^2-s. The results showed temporary hearing loss for both lake chub and northern pike to both 5 and 20 air gun shots, but not for the broad whitefish. Hearing loss was approximately 20 to 25 dB at some frequencies for both the northern pike and lake chub, and full recovery of hearing took place within 18-24 hours after sound exposure. Examination of the sensory surfaces of the showed no damage to sensory hair cells in any of the fish from these exposures (Song et al. 2008). Popper et al. (2006) also indicated exposure of adult fish to a single shot from an air gun array (consisting of four air guns) within close range (six meters) did not result in any signs of mortality, seven days post-exposure. Although non-lethal injuries were observed, the researchers could not attribute them to air gun exposure as similar injuries were observed in controlled fishes. Other studies conducted on fishes with swim bladders did not show any mortality or evidence of other injury (Hastings et al. 2008; McCauley and Kent 2012; Popper et al. 2014a; Popper et al. 2007; Popper et al. 2005a).

McCauley et al. (2003) showed loss of a small percent of sensory hair cells in the inner ear of the pink snapper (*Pagrus auratus*) exposed to a moving air gun array for 1.5 hours. Maximum received levels exceeded 180 dB re 1 μPa^2-s for a few shots. The loss of sensory hair cells continued to increase for up to at least 58 days post-exposure to 2.7 percent of the total cells. It is not known if this hair cell loss would result in hearing loss since TTS was not examined. Therefore, it remains unclear why McCauley et al. (2003) found damage to sensory hair cells while Popper et al. (2005a) did not. However, there are many differences between the studies, including species, precise sound source, and spectrum of the sound that make it difficult speculate what the caused hair cell damage in one study and no the other.

Hastings et al. (2008) exposed the pinecone soldierfish (*Myripristis murdjan*), a fish with anatomical specializations to enhance their hearing and three species without notable specializations: the blue green damselfish (*Chromis viridis*), the saber squirrelfish (*Sargocentron spiniferum*), and the bluestripe seaperch (*Lutjanus kasmira*) to an air gun array. Fish in cages in 16 ft (4.9 m) of water were exposed to multiple air gun shots with a cumulative SEL of 190 dB re 1 μPa^2-s. The authors found no hearing loss in any fish following exposures. Based on the tests to date that indicated TTS in fishes from exposure to impulsive sound sources (air guns and pile driving) the recommended threshold for the onset of TTS in fishes is 186 dB SEL_{cum} re 1 μPa^2-s, as described in the 2014 ANSI Guidelines.

Elasmobranchs (Giant manta rays, oceanic whitetip sharks, and scalloped hammerhead sharks), like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity) and thus are unable to detect sound pressure (Casper et al. 2012b), and therefore are also likely less susceptible to non-auditory injuries compared to fish with swim bladders. Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper and Mann 2006; Casper and Mann 2009b; Casper et al. 2012b; Ladich and Fay 2013a; Myrberg 2001; Yan et al. 2003). Myrberg (2001) stated that sharks have demonstrated highest sensitivity to low frequency sound (40 to 800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity, thus resembling struggling fish. These signals, some “pulsed,” are not substantially different from the air gun array signals. Myrberg et al. (1978) reported that silky shark withdrew 10 m from a speaker broadcasting a 150 to 600 Hz sound with a sudden onset and peak source level of 154 dB re: 1 μPa. These sharks avoided a pulsed low frequency attractive sound when its sound level was abruptly increased by more than 20 dB re: 1 μPa. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. The pelagic oceanic whitetip shark also showed a withdrawal response during limited tests, but less so than other species (Myrberg et al. 1978). These results do not rule out that such sounds may have been harmful to the fish after habituation; but the tests were not designed to examine that point. Thus, given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency sound from an air gun array if exposed, but TTS is not known to occur for these species.

Physiological Stress

Physiological effects to fishes from exposure to anthropogenic sound include increases in stress hormones or changes to other biochemical stress indicators (e.g., D'amelio et al. 1999; Sverdrup et al. 1994; Wysocki et al. 2006). Fishes may have physiological stress reactions to sounds that they can detect. For example, a sudden increase in sound pressure level or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response. Studies have demonstrated elevated hormones such as cortisol, or increased ventilation and oxygen consumption (Hastings and C. 2009; Pickering 1981; Simpson et al. 2015; Simpson et al. 2016; Smith et al. 2004a; Smith et al. 2004b). Although results from these studies have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous anthropogenic sounds can lead to a reduction in embryo viability (Sierra-Flores et al. 2015) and decreased growth rates (Nedelec et al. 2015). Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of loud and impulsive sound signals. Stress responses are typically considered to be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or have previous experience with the sound. However, exposure to chronic noise sources may lead to more severe effects leading to fitness consequences such as reduced growth rates, decreased survival rates, reduced foraging success, etc. Although physiological stress responses may not be detectable on fishes during sound exposures, NMFS assumes a stress response occurs when other physiological impacts such as injury or hearing loss occur.

Some studies have been conducted that measure changes in cortisol levels in response to sound sources. Cortisol levels have been measured in fishes exposed to vessel noises, predator vocalizations, or other tones during playback experiments. Nichols et al. (2015b) exposed giant kelpfish (*Heterostichus rostratus*) to vessel playback sounds, and fish increased levels of cortisol were found with increased sound levels and intermittency of the playbacks. Sierra-Flores et al. (2015) demonstrated increased cortisol levels in fishes exposed to a short duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 Hz. The levels returned to normal within one hour post-exposure, which supports the general assumption that spikes in stress hormones generally return to normal once the sound of concern ceases. Gulf toadfish (*Opsanus beta*) were found to have elevated cortisol levels when exposed to low-frequency dolphin vocalization playbacks (Remage-Healey et al. 2006). Interestingly, the researchers observed none of these effects in toadfish exposed to low frequency snapping shrimp "pops.", indicating what sound the fish may detect and perceive as threats. Not all research has indicated stress responses resulting in increased hormone levels. Goldfish exposed to continuous (0.1 to 10 kHz) sound at a pressure level of 170 dB re 1 μPa for one month showed no increase in stress hormones (Smith et al. 2004b). Similarly, Wysocki et al. (2007b) exposed rainbow trout to continuous band-limited noise with an SPL of about 150 dB re 1 μPa for nine months with no observed stress effects. Additionally, the researchers found no significant changes to growth rates or immune systems compared to control animals held at an SPL of 110 dB re 1 μPa.

Masking

As described previously in this biological opinion, masking generally results from a sound impeding an animal's ability to hear other sounds of interest. The frequency of the received level and duration of the sound exposure determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the area becomes within which an animal can detect biologically relevant sounds such as those required to attract mates, avoid predators or find prey (Slabbekoorn et al. 2010). Because the ability to detect and process sound may be important for fish survival, anything that may significantly prevent or affect the ability of fish to detect, process or otherwise recognize a biologically or ecologically relevant sound could decrease chances of survival. For example, some studies on anthropogenic sound effects on fishes have shown that the temporal pattern of fish vocalizations (e.g., sciaenids and gobies) may be altered (Parsons et al. 2009) when fish are exposed to sound-masking. This may indicate fish are able to react to noisy environments by exploiting "quiet windows" (e.g., Lugli and Fine 2003) or are moving from affected areas and congregating in areas less disturbed by nuisance sound sources. In some cases, vocal compensations occur, such as increases in the number of individuals vocalizing in the area, or increases in the pulse/sound rates produced (Picciulin et al. 2012). Fish vocal compensations could have an energetic cost to the individual which may lead to a fitness consequence such as affecting their reproductive success or increase detection by predators (Amorin et al. 2002; Bonacito et al. 2001).

Behavioral Responses

In general, NMFS assumes that most fish species would respond in similar manner to both air gun and impact pile driving. As with explosives, these reactions could include startle or alarm responses, quick bursts in swimming speeds, diving, or changes in swimming orientation. In other responses, fish may move from the area or stay and try to hide if they perceive the sound as potential threat. Other potential changes include reduced predator awareness and reduced feeding effort. The potential for adverse behavioral effects will depend on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected.

Fish that detect an impulsive sound may respond in "alarm" detected by Fewtrell (2003), or other startle responses may also be exhibited. The startle response in fishes is a quick burst of swimming that may be involved in avoidance of predators. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. A study in Puget Sound, Washington suggests that pile driving operations disrupt juvenile salmon behavior (Feist et al. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to piledriving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. The results are not conclusive but there is a suggestion that pile-driving operations may result in a disruption in the normal migratory behavior of the salmon in that study, though the mechanisms salmon may use for avoiding the area are not understood at this time.

Because of the inherent difficulties with conducting fish behavioral studies in the wild, data on behavioral responses for fishes is largely limited to caged or confined fish studies, mostly limited to studies using caged fishes and the use of seismic air guns (Lokkeborg et al. 2012).

In an effort to assess potential fish responses to anthropogenic sound, NMFS has historically applied an interim criteria for onset injury of fish from impact pile driving which was agreed to in 2008 by a coalition of federal and non-federal agencies along the West Coast (FHWG 2008). These criteria were also discussed in Stadler and Woodbury (2009), wherein the onset of physical injury for fishes would be expected if either the peak SPL exceeds 206 dB (re 1 μPa), or the SEL_{cum}, (re 1 μPa^2-s) accumulated over all pile strikes occurring within a single day, exceeds 187 dB SEL_{cum} (re 1 μPa^2-s) for fish two grams or larger, or 183 dB re 1 μPa^2-s for fishes less than two grams. The more recent recommendations from the studies conducted by Halvorsen et al. (2011a), Halvorsen et al. (2012b), and Casper et al. (2012b) and summarized in the 2014 ANSI Guidelines are similar to these levels, but also establishes levels based upon fish hearing abilities, the presence of a swim bladder as well as severity of effects ranging from mortality, recoverable injury, to TTS. The interim criteria developed in 2008 were developed primarily from air gun and explosive effects on fishes (and some pile driving) because limited information regarding impact pile driving effects on fishes was available at the time. For these reasons, the interim criteria are broadly applied to other impulsive sound sources such as air guns, thus the impacts associated with these sound sources could be similar.

9.1.3.1.5.2 Pile driving – Fishes

As described in Section 6.1.6, impact pile driving and vibratory pile removal would occur during construction of an Elevated Causeway System. This is a temporary pier that will be constructed in sandy shallow water coastal areas at Silver Strand Training Complex and at Camp Pendleton, both in the Southern California Portion of the action area (Figure 15).

Pile driving for the Elevated Causeway System training would occur in shallower water and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. The impact wave travels through the steel pile at speeds faster than the speed of sound in water, producing a steep-fronted acoustic shock wave ("mach wave") in the water (Reinhall and Dahl 2011). In general, softer substrates absorb the sound better than hard substrates, thus, pile driving in softer substrates does not typically produce the louder sound signals that driving in hard substrate would. Soft, wetted substrates, may increase ground-borne transmission, meaning a sound wave could propagate further away from the source through the substrate. If ground-borne transmission sound reenters the water column, the intensity and amplitude of the sound wave would likely be lower than the sound wave traveling from the source through the water column and not likely to cause injury but could result in disturbance.

As explained in more detail below, Southern California DPS steelhead, Eastern Pacific DPS scalloped hammerhead sharks, and giant manta rays have the potential to be exposed to sound produced by impact pile driving and vibratory pile extraction activities during the construction and removal phases of the Elevated Causeway System.

In general, the acoustic frequency of the sound produced during piles installation (and removal) is generally below 1,000 Hz. The size, type, sound source levels of piles anticipated to be installed for construction of the Elevated Causeway are provided in Table 60.

Table 60. Underwater sound levels for elevated causeway system pile driving and removal (Navy 2017).

Pile Size and Type	Method	Average Sound Levels at 10 m (SEL per individual pile)
24-in. Steel Pipe Pile	Impact[1]	192 dB re 1 μPa SPL rms 182 dB re 1 μPa²s SEL (single strike) 211 dB re 1 re 1 μPa SPL peak
24-in. Steel Pipe Pile	Vibratory[2]	146 dB re 1 μPa SPL rms 145 dB re 1 μPa²s SEL (per second of duration)

[1] Illingworth and Rodkin (2016), [2] Illingworth and Rodkin (2015)
Notes: in. = inch, SEL = Sound Exposure Level, SPL = Sound Pressure Level, rms = root mean squared, dB re 1 μPa = decibels referenced to 1 micropascal

As previously described, the Elevated Causeway may require up to 119 supporting piles. No more than six piles are expected to be driven within a 24-hour period thus a total of 20 days of intermittent impact pile driving is expected to occur. The Navy estimates each pile could take about 15 minutes to drive, requiring between 35 to 50 strikes per minute. Each pile could require from 525 to 750 strikes per pile, with between 3,150 to 4,500 strikes total in a 24-hour period. When training events that use the Elevated Causeway are complete, the pier would be dismantled and removed, requiring pile extraction with a vibratory hammer. The Navy anticipates this will take approximately 10 days. 12 piles will be removed per 24-hour period. Each pile will require approximately six minutes to remove, for a total of 72 minutes per day. Pile driving is expected to occur over the course of up to 30 days (20 days for construction and 10 days for removal) at either location in any given year.

The impulsive sound produced from pile driving with an impact hammer is also known to cause auditory and non-auditory (i.e., barotrauma) in fishes (See Section 9.1.3.1.5.1). Barotraumas such as ruptured swim bladders, ruptured blood vessels, and hemorrhaging of other gas-filled organs, have been reported in fish exposed to a large number of simulated impact pile driving strikes. Similarly, dead or injured fish have been collected on site during actual pile driving events. Injuries have been observed both externally and internally. Loss of scales, external hematomas. and distended abdomens have been recorded, indicative of ruptured swim bladders or other internal organ damage.

Controlled laboratory studies exposed fishes to cumulative SELs up to 219 dB re 1 μPa^2-s (Casper et al. 2013a; Casper et al. 2013b; Casper et al. 2012b; Halvorsen et al. 2011a; Halvorsen et al. 2012b). Although single strike peak SPLs were also measured during these experiments, injuries were only observed during exposures to multiple strikes, which is what commonly occurs during most pile driving events. However, there is the potential to have aberrant or high peak single peak pressure levels that can injure or kill fish. Although species with and without swim bladders were included in these studies, the researchers demonstrated that the majority of fish that sustained injuries were those with swim bladders. Halvorsen et al. (2011a) also conclude that the presence of a swim bladder as well as the type of a swim bladder may also determine the degree of injury a fish sustains from these sound exposures. For example, physostomous fishes (e.g. salmon and sturgeon) have an open duct connecting the swim bladder to their esophagus and may be better able to adjust the amount of gas in their body by gulping or releasing air in a more rapid manner than physoclistous fishes. Physoclistous fish do not have this connection and must diffuse or regulate gas pressure in the swim bladder by special tissues or glands. Lake sturgeon (*Acipenser fulyescens*), a physostomous fish, was found to be less susceptible to injury from impulsive sources than Nile tilapia (*Oreochromis niloticus*), a physoclistous fish (Halvorsen et al. 2012a).

Another factor regarding a fish’s susceptibility to injury related to the swim bladder is its state of buoyancy during exposure. In the Halvorsen et al. (2011a) and Halvorsen et al. (2012b) studies, neutral buoyancy was determined in the fishes prior to exposure to the simulated pile driving. Establishing the state of buoyancy for fishes in the wild is not possible, so their response to exposure at the same sound source levels may vary. No mortalities occurred during these experiments and recovery was generally observed to occur within a few days. Other experimental data suggests that fish larvae exposed to pile driving at cumulative SELs up to 206 dB re 1 μPa^2-s and peak SPLs of 210 re 1 μPa are not susceptible to mortality (Bolle et al. 2012).

Another study obtained similar results as described above, but in caged fish exposed to live pile driving operations (Debusschere et al. 2014). Caged juvenile European sea bass (*Dicentrarchus labrax*) showed no differences in mortality between control and experimental groups at similar levels tested in the experiments described by Halvorsen and Casper in the paragraph above (SELs up to 215 to 222 dB re 1 μPa^2-s) and many of the same types of injuries occurred.

In an investigation of another impulsive source, Casper et al. (2013a) found that some fishes may actually be more susceptible to barotrauma (e.g., swim bladder ruptures, herniations, and hematomas) than hearing effects when exposed to simulated impact pile driving. Hybrid striped bass and Mozambique tilapia (*Oreochromis mossambicus*), two species with a swim bladder not involved in hearing, were exposed to SELs between 213 and 216 dB re 1 μPa^{2-}s. The fishes exhibited barotrauma and although researchers began to observe signs of inner ear hair cell loss, these effects were small compared to the other non-auditory injuries. For these reasons, the researchers speculated that injury might occur prior to signs of hearing loss or TTS. This is why understanding at what levels the onset of injury occurs is important.

Vibratory hammers produce a non-impulsive, continuous sound, as such are considered less harmful for fishes than impact hammers. Although it is possible for fish to be injured or killed from exposure to continuous sound sources, the exposure time would be a much longer duration than those that will occur for vibratory hammer pile extraction proposed by the Navy. The duration of pile extraction the Navy proposes for pile removal is not likely to cause any injury or hearing impairment on fishes, but could elicit some type of behavioral response if a fish detects the sound. For these reasons the effects from impact hammering of piles, is the primary consideration here for analyses of potential adverse effects on fishes.

The following section provides calculated distance to the range to effects for fishes exposed to impact pile driving. Ranges are calculated based on the 2014 ANSI Guidelines (Table 120). The Navy based their calculations on the assumption that pelagic species of fishes would be able to move away from the pile driving sound source and therefore not sustain cumulative exposures for an entire pile driving duration. Therefore, the Navy calculated ranges to effect for these species are estimated based on an average of 35 strikes per minute, for a cumulative exposure time of only one minute. These distances are provided in Table 61.

Table 61. Range to effect from impact pile driving for 35 strikes (1 minute); (Navy 2017).

Fish Hearing Group	Range to Effects (meters)				
	Onset of Mortality		Onset of Injury		TTS
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}
Fishes without a swim bladder	1	< 8	1	< 8	NR
Fishes with a swim bladder not involved in hearing	2	< 17	5	< 17	< 57

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NR = no criteria are available and therefore no range to effects are estimated, < indicates that effects would occur below the provided range.

In this minimum exposure scenario, mortality or injury could occur in fishes with swim bladders (i.e., Southern California DPS steelhead) exposed to impact pile driving at distances less than 17 m from the source. These fishes could also experience temporary hearing loss at distances less than 57 m. Fishes without a swim bladder such as giant manta rays and scalloped hammerhead sharks are not likely to experience TTS from pile driving exposure, but could be injured or killed at distances less than 8 m from the pile driving sound source.

Depending on life history patterns, NMFS often conservatively assumes fishes do not always move away from the sound source and may stay in the area during pile driving activities and, therefore, could accumulate sound levels for a longer duration during a pile driving event. This would be particularly true for fish that have high site-fidelity (e.g., a juvenile rearing salmonid). For this reason, NMFS calculated the potential ranges to effects based upon the minimum and maximum pile strikes it may take to drive all six piles in the given day. These include daily total of between 3,150 (minimum) and 4,500 (maximum) number of pile strikes to seat all piles within a 24-hour period. These strike numbers are based upon the Navy's estimates for typical range of strikes required to drive the 24-inch steel pipe piles during previous Navy pile driving activities. NMFS also has established an "effective quiet" SEL for pile driving analysis, which is included in our calculations of the range to injury and TTS. Effective quiet assumes that when the received SEL from an individual pile strike is below a certain level, then the accumulated energy from multiple strikes would not contribute to injury or other adverse effects, regardless of how many pile strikes occur. This is determined to be 150 dB (re: 1 μPa^{2}-sec). Therefore, effective quiet establishes a limit on the maximum distance from the pile where injury to fishes is expected. Beyond this distance, no physical injury is expected, regardless of the number of pile strikes. However, the severity of the injury can increase within this zone as the number of strikes increases.

The respective distances to these ranges are provided below in Table 62.

Table 62. Range to effects from impact pile driving for 3,150 to 4,500 strikes per day.

Fish Hearing Group	***Range to Effects Minimum of 3,150 Strikes (meters)***					
	Onset of Mortality		***Onset of Injury***		***TTS***	***Behavior***
	SEL_{cum}	***SPL_{peak}***	***SEL_{cum}***	***SPL_{peak}***	***SEL_{cum}***	***RMS***
Fishes without a swim bladder	8	8	11	8	NR	3511
Fishes with a swim bladder not involved in hearing	40	17	70	17	755	3511
Fish Hearing Group	***Range to Effects maximum of 4,500 Strikes (meters)***					
	Onset of Mortality		***Onset of Injury***		***TTS***	***Behavior***
	SEL_{cum}	***SPL_{peak}***	***SEL_{cum}***	***SPL_{peak}***	***SEL_{cum}***	***RMS***
Fishes without a swim bladder	9	8	14	8	NR	3511
Fishes with a swim bladder not involved in hearing	50	17	87	17	870	3511

Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NR = no criteria are available and therefore no range to effects are estimated, < indicates that effects would occur below the provided range.

Without knowing the exact timing between subsequent piles being installed within a given day, we assume that there will be a relatively short time between each pile being driven. For this reason, unless a break of 12 hours or longer occurs between pile driving events, NMFS calculates all piles driven in a given day to determine the ispoleths for each fish threshold. [21] Based on the onset of injury criteria and the proposed pile driving scenarios, the maximum range any steelhead could be killed is 50 m from the pile and the maximum range in which any steelhead could suffer injury is 87 m from the pile. The maximum range any scalloped hammerhead shark or giant manta ray could be killed is 9 m from the pile and the maximum

[21] No ESA-listed fishes are expected to be present smaller than two grams during any pile driving event.

range these species could suffer injury is 14 m. TTS could occur up to 870 m from the pile for steelhead (not TTS is expected for the elasmobranchs) and all species could exhibit a behavioral response up to 3,511 m from the pile.

As distance from the pile increases, SPLs decrease and the potential harmful effects to fish also decrease. Hence, the distance to reach the 150 dB rms corresponding to sub-injurious sound levels (i.e., non-lethal, behavioral responses) is not expected to extend beyond a 3,511 m radius from any pile driving event. This larger area defines the total area of potential impact expected from pile driving during Navy construction of the Elevated Causeway. The sections below use the information described above regarding the potential range to effect and species life history information and expected occurrence to assess whether ESA-listed fishes are likely to be affected by sound from pile driving.

Southern California DPS Steelhead

Southern California DPS steelhead have the potential to be exposed to pile driving activities in nearshore areas, including individuals migrating into oceanic waters from the San Mateo Creek or the Santa Margarita River, which are in close proximity to or flow through Camp Pendleton. However, as explained below, exposure would be infrequent, of limited duration, and most likely at low received levels, as the species is migrating to offshore feeding areas or returning to freshwater to spawn.

Steelhead are thought to rely heavily on offshore marine waters for feeding, with high seas tagging programs indicating steelhead make more extensive migrations offshore in their first year than any other Pacific salmonids (Quinn and Myers 2004). Steelhead typically spend approximately 1-3 years in freshwater, then migrate rapidly through estuaries, bypassing coastal migration routes of other salmonids, moving into oceanic offshore feeding grounds (Daly et al. 2014; Quinn and Myers 2004). 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 this life history, we would not anticipate outmigrating steelhead to spend extended periods of time in nearshore habitats of the action area where pile driving is conducted. Instead, any exposure would be extremely brief as the animal transits through the area where pile driving is conducted.

It's possible that adult steelhead returning to spawn could stage in nearshore areas for relatively longer period of time. If pile driving were to occur in these nearshore areas, steelhead could be exposed for longer durations. However, the San Mateo Creek and Santa Margarita estuaries are 6 to 8 miles away from the location where elevated causeway pile driving would be conducted (C. Johnson, Navy, pers. comm to E. MacMillan, NMFS, July 30, 2018). We would not expect adult steelhead returning to spawn to stage in the nearshore beach environment where pile driving is conducted for long periods of time.

Based on the information presented above, neither life stage is anticipated to be exposed to sound from pile driving activities except potentially as the animal is transiting through the action area to either northern offshore feeding areas or freshwater to spawn. Additionally, transit through the nearshore beach environment where pile driving will be conducted would be rare as the pile driving is conducted several miles away from the freshwater or estuarine environments where this species is expected to occur most frequently. For steelhead just travelling through the area of pile driving, the animal would need to be within 17 m of the pile driving activity to experience injury or mortality. NMFS considers it extremely unlikely that Southern California DPS steelhead would be exposed to sound from Navy pile driving in the action area that could cause injury or mortality due to this small range to effect, the infrequent and short term nature of the pile driving conducted, and that only rarely would adult or out-migrating steelhead occur in the nearshore beach environment where pile driving is conducted.

Even though the range to potential behavioral responses is greater than the range for the more serious effects, the likelihood of any significant behavioral disruption is also low because pile driving is infrequent, and because the animals would only be transiting through the area where they may be exposed to this sound source, the duration of exposure would be extremely brief. Masking effects at close distances (likely within hundreds of meters) from the source would also be highly unlikely due to the short duration exposure. For these reasons, the effects of any pile driving exposure on Southern California DPS steelhead are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Eastern Pacific DPS Scalloped Hammerhead Shark

Eastern Pacific DPS scalloped hammerhead sharks have the potential to be exposed to sound or substrate vibration from impact and vibratory pile driving associated with training activities at Silver Strand Training Complex and at Camp Pendleton in the SOCAL Range Complex. However, occurrence of scalloped hammerhead sharks in Southern California is limited due to their preference for warm water temperatures. Scalloped hammerhead sharks are transient and if they do occur in the SOCAL Range Complex, it would only be during times of the year when water temperatures increase or during unusually warm years (e.g., El Nino). Based on the observation of 19 juveniles in 1997, it has been suggested the southern San Diego Bay may serve as a pupping ground and warm water refugium during warm water years (Lea and Rosenblatt 2000, Shane 2001). However, pile driving activities are not proposed for San Diego Bay. Based on the low likelihood of occurrence of this species, and the small range to adverse effects for fish without swim bladders from pile driving (e.g., range to injury/mortality = less than 15 m), it is extremely unlikely that Eastern DPS scalloped hammerhead sharks would be exposed to sound from Navy pile driving in the action area. Therfore, potential effects on Eastern DPS scalloped hammerhead sharks from pile driving are discountable

Giant Manta Ray

Giant manta rays also have the potential to be exposed to sound from pile driving at the Silver Strand Training Complex and at Camp Pendleton. Adult giant manta rays are typically found offshore, but occasionally visit coastal areas where upwelling occurs, and pups (juveniles) typically spend their first few years in nearshore shallow-water environments. However, Southern California is the northern edge of the giant manta rays' distribution and to our knowledge, the species has not been documented in nearshore waters of the Southern California portion of the action area. Based on the low likelihood of occurrence of this species in areas where pile driving will be conducted, and the small range to adverse effects for fish without swim bladders from pile driving (e.g., range to injury/mortality = less than 15 m), it is extremely unlikely that giant manta rays would be exposed to sound from Navy pile driving in the action area. Therfore, potential effects on giant manta rays from pile driving are discountable.

9.1.3.1.5.3 Air Guns – Fishes

Air guns would only be using during testing activities and would be fired at offshore locations in both the SOCAL and Hawaii Range Complexes. All ESA-listed fishes considered in this opinion could be exposed to sounds from air guns during Navy testing activities.

Although air guns produce broadband sounds, the pulse duration of an individual signal is approximately 1/10th of a second, and generally lacks the rapid rise time of impact pile driving, or the strong shock wave produced during an explosion. A thorough description of impulsive sound sources and their effects is provided in Section 9.1.3.1.5.1.

Using the sound pressure criteria for impulsive sound sources described in Section 2.3. The air gun activities in the action area will occur offshore and involve the use of a single shot or 10 shots. Air guns have the potential to cause direct lethal and non-lethal injury to small juvenile or larval fish located nearby the source, or induce some type of auditory impairment for adult fishes. Thus, as a conservative measure, range to effects are calculated assuming a maximum of 10 shots. Table 71 presents the approximate ranges in meters to mortality, onset of injury and TTS for air guns for 10 pulses. Although ranges to effects are presented, density data for fish species within the action area are not available. Therefore, it is not possible to estimate the total number of ESA-listed fishes in the action area that may be affected by sound produced by air guns within the respective zones. We will make a qualitative assessment on the potential effects to ESA-listed fish species from air gun exposures based upon the distance to reach the thresholds that correlate to auditory and non-auditory impairment or injury. The distance to these thresholds for each fish group is presented below in Table 71.

Table 63. Range to effect for fishes exposed to 10 air gun shots (Navy 2017).

Fish Hearing Group	Range to Effects (meters)[1]				
	Onset of Mortality		Onset of Injury		TTS
	SEL_{cum}	SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}
Fishes without a swim bladder	0	< 5 (4–7)	0 (0–0)	< 5 (4–7)	NR
Fishes with a swim bladder not involved in hearing	0	< 10 (8–14)	10 (8–14)	< 10 (8–14)	< 12 (4–30)

[1] Range to effects represent modeled predictions in different areas and seasons within the action area. Each cell contains the estimated average, minimum and maximum range to the specified effect.
Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NR = no criteria are available and therefore no range to effects are estimated, < indicates that the given effect would occur below the reported range(s).

Based upon the distances provided in Table 63, mortality or injury could occur in steelhead (a fish species with a swim bladder not involved in hearing) on average at a distance of less than ten meters away from the air gun sound source (within a maximum of 14 m). These effects would occur for elasmobranchs (oceanic whitetip sharks, scalloped hammerhead sharks, giant manta rays) out to an average distance of less than five meters (maximum of 7 m). Hearing impairment (i.e., TTS) if it occurs, may occur in steelhead within a distance of less than 12 m on average (a maximum of 30 m). As stated above, TTS is not known to occur for elasmobranchs, and therefore is not anticipated from exposure to air guns.

In addition to the ranges presented above, the Navy also estimated ranges to effects based upon the *2008 Interim Pile Driving Criteria* described previously for consideration in the analysis. Based on the these criteria, fishes, regardless of hearing group, exposed to a peak SPL of 206 dB re 1 μPa may show signs of injury within an average of 11 m from the source (minimum and maximum ranges of 9 and 16 m, respectively). In addition, fishes exposed to a cumulative SEL of 187 dB re 1 μPa^2-s may show signs of injury within an average of 22 m from the source (minimum and maximum ranges of 3 and 150 m, respectively). If fishes that are less than two grams occur within the vicinity of air gun activities, it is estimated that injury could occur within an average of 37 m from the source (minimum and maximum ranges of 6 and 270 m, respectively).

As described in Section 2.1, NMFS typically applies a 150 dB rms (dB re 1 μPa) for impulsive sound sources to estimate potential zones where fish may exhibit some degree of a behavioral response. Although this is considered an "informal" criterion, it provides a means of qualitatively assessing potential non-injurious (e.g., sub-injury) response of fishes exposed to impulsive sounds. Based upon the information provided from the Navy, the distance to reach the 150 dB rms is calculated to be 1,778 m from the air gun pulses.

Although injury and mortality is possible for fishes from air gun exposure, air gun activities in offshore areas are transient and may expose ESA-listed fish species only in passing. An ESA-listed fish would have to be in very close proximity to the source to be injured (i.e., within 10 m or less) or experience hearing impairments (i.e., within 12 m or less). The likelihood of an ESA-listed fish species occurring in close enough proximity to Navy air gun activities to experience injury or hearing impairment is extremely unlikely and thus discountable. Even though the range to potential behavioral responses is greater than the range for the more serious effects, the likelihood of any significant behavioral responses is also low because air gun use is transient and the duration of exposure to this sound source is extremely brief. Masking effects at close distances (likely within hundreds of meters) from the source would also be extremely unlikely due to the short duration of the signal pulse. Multiple exposures to individuals (across days) are also extremely unlikely as air guns are not operated in the same areas from day to day, but rather would be utilized in different areas over time. For these reasons, any effects on fishes from air guns are anticipated to be minor, temporary and will not lead to a significant disruption of normal behavioral patterns. As such the effects from airguns on fishes is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.2 Energy Stressors – Fishes

This section analyzes the potential impacts of energy stressors used during training and testing activities within the action area on ESA-listed fish species. Additional discussion on energy stressors is included in Section 6.3. This section includes analysis of the potential impacts of: (1) in-water electromagnetic devices and (2) high-energy lasers.

9.1.3.2.1 In-Water Electromagnetic Devices – Fishes

A synthesis of information provided by Normandeau et al. (2011a) provides a comprehensive review of information regarding the sensitivity of marine organisms to electric and magnetic impulses. Available data suggests that while many fish species (particularly elasmobranchs) are sensitive to electromagnetic fields (Hore 2012), more research is necessary to understand the physiological response and magnitude of the potential impacts from these sources on fishes.

Many fish groups (including elasmobranchs and salmonids) have been demonstrated to have an acute sensitivity to electrical fields, known as electroreception (Bullock et al. 1983; Helfman et al. 2009). Fishes are thought to use the same sensory organs used for near field water motion and sound pressure (e.g., lateral line system) for electroreception. In general, fish possess two types of electroreceptor organs (Helfman et al. 2009). First, these are ampullary receptors within the skin, which are connected to the surface by a canal filled with a conductive gel that is sensitive to electric fields of low-frequency (less than 0.1 to 25 Hz). Second, are tuberous receptors, embedded in the epidermis, and are covered with loosely packed epithelial cells; these receptors detect higher frequency electric fields (50 Hz to greater than 2 kHz). These receptors are typically found in fishes that use electric organs to produce their own electric fields (e.g. eels). In addition, the distribution of electroreceptors on the head of these fishes, especially around the mouth, such as the rostrum of sawfishes, suggests that these sensory organs may be used in foraging and perhaps social communication (Collin and Whitehead 2004).

Each ESA-listed fish potentially exposed to this stressor has some level of electroreception capabilities. Elasmobranchs (including scalloped hammerheads, oceanic whitetip sharks, and giant manta rays) are well known to be sensitive to electromagnetic fields compared to other fish species. Some elasmobranch species have small pores near the nostrils, and around the head and on the underside of the rostrum, called ampullae of Lorenzini, which detect the electromagnetic signature of their prey. Electroreceptors are also thought to aid in navigation, orientation, and migration of sharks and rays (Kalmijn 2000). In elasmobranchs, behavioral and physiological response to electromagnetic stimulus varies by species and age, and appears to be related to foraging behavior (Rigg et al. 2009). These species are known to respond physiologically to electric fields of 10 nanovolts per cm and behaviorally at five nanovolts per cm (Collin and Whitehead 2004). Kajiura and Holland (2002) demonstrated juvenile scalloped hammerhead sharks were able to detect and respond to electric fields of less than one nanovolt per cm. Other studies suggest that sharks are attracted to electromagnetic sources when conditions in the water hinder their other senses such as sight and hearing, so their ability to detect electromagnetic sources helps sharks find prey when in low sensory conditions (Fields 2007).

For teleost fishes (e.g. bony fishes such as steelhead), effects of electromagnetic fields could potentially affect orientation in the water column (Fisher and Slater 2010). Electromagnetic sensitivities of sturgeon species have not been heavily studied; however, the presence of electroreceptive ampullae in all sturgeon strongly supports the assertion that they are sensitive to electromagnetic energy (Bouyoucos et al. 2014). In addition, electromagnetic sensitivity in some marine fishes is known to be well-developed at early life stages (Ohman et al. 2007), although most of the available research data on electromagnetic sensitivity focuses on adults. A study on juvenile Atlantic sturgeon showed a behavioral avoidance of electropositive metals when food was present (Bouyoucos et al. 2014). Zhang et al. (2012) studied electroreception on Siberian sturgeon (*Acipenser baerii*) and suggested that electroreception plays a role in the feeding behavior of most sturgeon species. Ohman et al. (2007) also indicate some species appear to be attracted to undersea cables, while others show avoidance, likely due to the electromagnetic fields.

Many species of fish use the Earth's magnetic field for navigation, as is documented for salmon, which use this as well as the odor of their natal stream to migrate back to their original spawning grounds (Groot and Margolis 1998; Quinn and Groot 1983). The mechanism for direct sensing of magnetic fields is unknown; however, the presence of magnetite (a magnetic mineral) in the tissues of some fishes such as tunas and salmon, or other sensory systems such as the inner ear and the lateral line system may be responsible for electromagnetic reception (Helfman et al. 2009). Some species of salmon, tuna, eels and stargazers have been shown to respond to magnetic fields and may also contain magnetite in their tissues (Helfman et al. 2009). Crystals of magnetite have been found in four species of Pacific salmon (Mann et al. 1988; Walker et al. 1988), which are believed to serve as a compass that orients to the Earth's magnetic field. Putnam et al. (2013a) provided empirical evidence that salmon use cues from the magnetic field to navigate in the open ocean. Quinn and Brannon (1982) conclude that while salmon can apparently detect B-fields (e.g. magnetic field) their behavior is likely governed by multiple stimuli as demonstrated by the ineffectiveness of artificial B-field stimuli. Supporting this, Yano et al. (1997) found no observable effect on the horizontal and vertical movements of adult chum salmon that had been fitted with a tag that generated an artificial B-field around the head of each fish. Furthermore, research conducted by Ueda et al. (1998) on adult sockeye salmon suggests that, rather than magnetoreception, this species relies on visual cues to locate natal stream and on olfactory cues to reach its natal spawning channel. Blockage of magnetic sense had no effect on the ability of the fish to locate their natal stream.

In a controlled laboratory study, the scalloped hammerhead *(Sphyrna lewini*) and sandbar sharks (*Carcharhinus plumbeus*) exhibited altered swimming and feeding behaviors in response to very weak electric fields (less than 1 nanovolt per cm; Kajiura and Holland 2002). Five Pacific sharks were shown to react to magnetic field strengths of 2,500 to 234,000 μT at distances ranging between 0.26 and 0.58 m and avoid the area (Rigg et al. 2009). Similarly, southern stingrays (*Dasyatis americana*) and nurse sharks (*Ginglymostoma cirratum*) have been demonstrated to detect and avoid a fixed magnetic field producing a flux of 95,000 μT (O'connell et al. 2010). White sharks (*Carcharodon carcharias*) have also been shown to alter behavior when approaching a towed prey item with an active electromagnetic field (Huveneers et al. 2013). For comparison, the researchers also exposed sharks to static prey items and no behavioral alterations were observed, indicating the sharks were able to detect the electromagnetic field of the towed prey.

Potential effects of electromagnetic activity on adult fishes may not be the same as early life stages (e.g., eggs, larvae, juveniles) due to lifestage-based shifts in habitat utilization (Botsford et al. 2009; Sabates et al. 2007). For example, some skates and rays produce egg cases that lay on the bottom of the seafloor, while many neonate and adult sharks occur in the water column or near the water surface. The exposure of eggs and larvae to electromagnetic fields during Navy activities would be low since the distributions of the devices are patchy.

Although some individual fish species may exhibit a response to electromagnetic exposure, the fields generated are typically well below physiological and behavioral responses of magnetoreceptive fishes. The strength of the electromagnetic devices used by the Navy is relatively minute and quickly dissipates at short distances away from the source. The devices work by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The magnetic field away from the device is comparable to the Earth's magnetic field (see sea turtle section above). Based on the small area around each electromagnetic device that will have an altered magnetic field, we assume that any potential disruption in an individual fish's orientation ability in the action area would only occur very close to the source. Additionally, this disruption would be temporary and last only as long as the fish remains within the area where the magnetic field is altered, which is likely to be very brief. Furthermore, most fishes would be expected to avoid the device prior to entering the area where the magnetic field would be altered. NMFS considers it extremely unlikely that ESA-listed fish would be exposed to electromagnetic energy at sufficient intensities to create an adverse effect through behavioral disruption or otherwise. Therefore, potential effects from electromagnetic devices are discountable.

9.1.3.2.2 Lasers – Fishes

High-energy laser weapons would be used for testing activities in the action area. Fish could be exposed to a laser only if the beam missed the target. Should the laser strike the sea surface, individual fish at or near the surface could be exposed. The potential for exposure to a high-energy laser beam decreases as the water depth increases. Most fish are unlikely to be exposed to laser activities because these species primarily occur more than a few meters below the sea surface.

Oceanic whitetip sharks and giant mantas are found in offshore locations and occur near the surface of the water column so may pose a higher risk of being exposed to high-energy lasers. However, it is extremely unlikely that an individual would surface at the exact moment in the exact place that the laser misses its target and hits the surface. ESA-listed fishes are extremely unlikely to be exposed to high-energy lasers based on (1) the relatively low number of events (360 per year throughout the entire action area), (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, and (5) the low probability of a laser missing its target, (6) the low density of ESA-listed fish species in the marine areas where activities using lasers are conducted. Therefore, potential effects from high-energy lasers are discountable.

9.1.3.3 Physical Disturbance and Strike Stressors – Fishes

Additional discussion on physical disturbance and strike stressors is included in Section 6.4. This section analyzes 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 and in-water devices; military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions; seafloor devices; and vessels.

9.1.3.3.1 Vessels and In-water Devices

Vessel traffic and in-water device use during Navy training and testing activities would primarily occur in certain portions of the action area such as areas near ports or naval installations and ranges (e.g., Pearl Harbor, San Diego, San Diego Bay, and San Clemente Island), but could occur throughout the action area. Each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Oceanic whitetip sharks can be found at the ocean surface and down to at least 152 m deep, but most frequently stay between depths of 25.5 and 50 m (Carlson and Gulak 2012; Young et al. 2017). Tagging and diet studies indicate that adult and juvenile steelhead are surface oriented, spending most of their time in the upper portions of the water column (Daly et al. 2014). Walker et al. (2007) summarized information from a series of studies off British Columbia looking at the vertical distribution of steelhead and found the species spends 72 percent of its time in the top 1 m of the water column, with few movements below 7 m. Scalloped hammerhead sharks may occur in the upper portions of the water column as well. Though tagging studies indicate Giant manta rays are capable of descending to depths of hundreds of meters, they are also known to occur in surface waters and be susceptible to vessel strike[22] (82 FR 3694).

Despite these species' utilization of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate the ESA-listed fishes considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 160–490 ft (50–350 m). When the vessel passed over them, some fish responded with sudden escape responses that movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations.

Regardless of the response, there is the potential for some type of stress or energetic cost as an individual fish must stop its current activity and divert its physiological and cognitive attention to responding to the vessel (Helfman et al. 2009). Potential implications of behavioral avoidance response to vessels was addressed in Section 9.1.3.1.1.

Given the low abundance of the ESA-listed fish species in the action area, particularly around Navy ports or Naval installations, the ability of these species to maneuver to avoid any oncoming vessels, the low number of vessels associated with HSTT activities relative to non-military traffic in the area, and the lack of documented cases of Navy vessels striking these species (or any other fish species) in the action area, it is extremely unlikely that a Navy vessel associated with HSTT activities will strike a Southern California DPS steelhead, Eastern Pacific DPS scalloped

[22] Note that as explained in the proposed rule, vessel strikes are thought to be the result of tourist boats in Hawaii. In these cases, a relatively large number of boats concentrates in an area where manta rays are also congregating. This would not occur during Navy training and testing activities in Hawaii or elseware.

hammerhead shark, giant manta ray, or oceanic whitetip shark. The effects of strike on these fish species are thus discountable.

9.1.3.3.2 Military Expended Materials

This section analyzes the strike potential to ESA-listed fish species from military expended materials including the following: (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. While no strike of ESA-listed fish species from military expended materials has ever been reported or recorded, the possibility of a strike still exists. However, given the large geographic area involved and the relatively low densities of ESA-listed fish species in the action area, we do not believe such interactions are likely (or reasonably certain to occur).

For marine mammals, the Navy was able to conduct a probability analysis for each marine mammal species in the action area to estimate the likelihood that an individual from each species would be struck at the surface in both the SOCAL and Hawaii Range Complexes. As documented in Section 9.1.1.3.2, the analysis estimated a very low (i.e., discountable) probability of striking any marine mammal species in the action area. A similar analysis could not be conducted for ESA-listed fish species due to the lack of density data for these species in the action area. However, ESA-listed fish species are not common in the action area and are anticipated to occur in very low densities, similar to ESA-listed marine mammals. For this reason, we anticipate a similarly low likelihood that Navy military expended materials would directly strike an ESA-listed fish species in the action area. Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is not likely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.7 ft [0.2 m] 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 organisms such as ESA-listed fish.

In summary, it is extremely unlikely that an ESA-listed fish will be struck by military expended materials and the effects are therefore discountable. 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 insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.3.3 Seafloor Devices

Activities that use seafloor devices include items placed on, dropped on, or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed devices, and bottom-crawling unmanned underwater vehicles. Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. Objects falling through the water column will slow in velocity as they sink toward the bottom and would be avoided by ESA-listed fishes. The only seafloor device used during training and testing activities that has the potential to strike an ESA-listed fishes at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, and the analysis of the potential impacts from those devices are covered in the military expended material strike section. It is extremely unlikely that a mobile ESA-listed fish will be struck by a slow moving seafloor device and the effects of such a strike are thus discountable. Any individuals encountering seafloor devices are likely to behaviorally avoid them. Given the slow movement of seafloor devices, the effort expended by individuals to avoid them will be minimal, temporary, and will not have fitness consequences. Therefore, behavioral avoidance of seafloor devices by ESA-listed fish is insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.1.3.4 Entanglement Stressors – Fishes

Some of the ESA-listed fish species are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. For example, the shape of the body of some elasmobranchs such as manta rays, increase their risk of entanglement compared to fishes with smoother, more streamlined bodies such as steelhead. For these reasons, Giant manta ray have a higher degree of risk associated with entanglement from decelerators and parachutes, therefore is discussed in more detail below.

For most of the pelagic species of ESA-listed fish species including steelhead, oceanic whitetip sharks, and scalloped hammerhead sharks, the risk of entanglement is unlikely given their body shape and ability to avoid materials that could entangle them in the water column. Steelhead are very strong swimmers, with a streamlined body that is unlikely to become entangled in decelerators and parachutes or lines. Oceanic whitetip or scalloped hammerhead sharks occurring offshore could come into contact with a decelerator and parachute. However, as with salmon, these sharks are highly mobile and visual predators that could easily avoid floating or suspended materials or break free if entangled. Moreover, the small and medium sized parachutes that would most likely be encountered by sharks would sink fairly quickly and therefore would not pose as significant of a threat to these species.

Although some species of fishes could also become entangled in the guidance wires and fiber optic cables, the risk for most of the fish species is considered low. A portion of the fiber optic cable may be recovered, but some used for remotely operated mine neutralization activities would not. The length of this expended tactical fiber would vary (See Section 6.5.1) depending on the activity. Tactical fiber has an 8 μm (0.008 mm) silica core and acylate coating and looks and feels like thin monofilament fishing line; tactical fiber is relatively brittle and breaks if knotted, kinked, or abraded against a sharp object (Navy 2018d). Therefore, if this becomes looped around an underwater object or animal, it is unlikely to tighten. Although this material will not be recovered, it is expected to only remain in the water column for a short duration, and ultimately sink. Similarly, once a guidance wire is released it is expected to rapidly sink, settle and remain on the seafloor. If a wire were to snag or be partially resuspended, in theory a fish could swim through loops in the wire that may entangle the fish. However, because of their rigidity and size, loops are less likely to form in a guidance wire or sonobuoy wire (Environmental Sciences Group 2005). Torpedo guidance wire is resistant to looping and coiling suggesting it has a low entanglement potential compared to other entanglement hazards (Swope & McDonald, 2013. Similarly, fiber optic wire material is more resistant to forming loops and would easily break when tightly kinked or bent at a sharp angle. This is in contrast to fishing gear materials which are more common entanglement threats for fishes and have breaking strengths much greater than that of guidance wire and fiber optic cables used during Navy activities. Because very few of these types of wires would be expended, the risk of entanglement from the wires is very low.

Similarly, sonobuoy surface antenna, float unit, and subsurface hydrophone are attached through a thin gauge, dual-conductor, and hard-draw copper strand wire; which is wrapped by a hollow rubber tubing or bungee. The tensile breaking strength of the wire and rubber tubing is no more than 40 lb. The length of the cable is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. This nylon fabric is very thin and can be broken by hand; therefore, it does not pose a risk of entanglement for fish. Sonobuoys may remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor. Sonobuoy wires may be expended within any of the range complexes throughout the action area. However, the wire that runs through the stabilizing system and leads to the hydrophone components of the sonobuoy hangs vertically in the water column, reducing the risk of ESA-listed fishes becoming entangled.

Parachutes and decelerators could potentially be encountered by ESA-listed fishes 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 encouters them.

Throughout the action area, the vast majority of expended decelerator and parachutes are small (18 inches) cruciform shaped decelerators used with sonobuoys. They have short attachment lines and, upon water impact, may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor. Entanglement of an animal in a parachute assembly at the surface or within the water column would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. For the large and extra-large decelerator and parachutes, that are unweighted and have multiple long lines attached to them, the chance of an entanglement is greater for giant manta rays, which are discussed below.

Manta rays are know to be susceptible to entanglement (83 FR 2916). A study in Hawaii found 10% of manta rays (28 individuals out of a sample of 290) had cephalic fins (fins on either side of the mouth) amputated, disfigured, or were 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. However, manta rays are highly mobile species that are expected to be able to avoid the small or medium-sized floating or suspended decelerators and parachutes, which comprise the majority of the decelerators and parachutes used in the action area. Furthermore, these small and medium decelerators and parachutes have weights attached, causing a more rapid sink rate, thereby decreasing the amount of time materials float at the surface, reducing the risk of a giant manta ray encountering them.

As with marine mammals, the large and extra-large decelerators and parachutes may pose a higher degree of risk for manta rays because these parachutes are larger, have long lines (large chutes have 28 cords, approximately 40 to 70 ft long; extra-large chutes have 64 cords, up to 82 ft long), associated with them. Additionally, parachutes are not weighted with anything to help them sink rapidly, and could potentially remain suspended in the water column for an extended period of time. However, the chance of an encounter is remote given the small number of the large and extra-large chutes proposed to be deployed (i.e., annually, 36 large parachutes in both the Hawaii and SOCAL range complexes; 3 extra large parachutes in Hawaii) and the anticipated low abundance of this species 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 giant manta ray encountering them and becoming entangled is low.

Additionally, available data indicates the entangelments 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 some period of time and ultimately settle on the seafloor. Monofilament lines are hard to see for fishes 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 and likely more difficult for animal to release itself from should it become ensnared in a mooring line. Furthermore, no cases of fish entanglement have been reported for parachutes (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. This is expected to result in a minor behavioral response. Therefore due to the low probability of a gianta manta ray becoming entangled in paracahute and decelerators, it is extremely unlikely that effects from entanglement will occur and NMFS consideres the effects from this stressor discountable for giant mant rays.

In summary, the likelihood of ESA-listed fish species becoming entangled with material such as parachutes and decelerators, fiber optic cables, and lines is extremely low. Therefore, NMFS considers the effect from these stressors to be discountable for all ESA-listed fish species considered in this opinion.

9.1.3.5 Ingestion Stressors – Fishes

For ESA-listed fishes occurring in the action area, it is reasonable to assume that any item of a size that can be swallowed by a fish could be eaten at some time. Given the life histories and foraging strategies of the fish species considered in this opinion, ingestion of materials could occur at water surface or in the water column. The potential for ESA-listed fish species to encounter and ingest expended materials is also evaluated with respect to their physical size and geographic range, which could also influence the probability that they would consume military expended materials.

Fish are known to ingest a variety of small items in the marine environment, including metal and plastics. Metal items eaten by marine fish are generally small (such as fish hooks, bottle caps, and metal springs), suggesting that small and medium caliber projectiles, pistons, or end caps (from chaff canisters or flares) are more likely to be ingested. Both physical and toxicological impacts could occur as a result of consuming metal or plastic materials (Dantas et al. 2012; Davison and Asch 2011; Possatto et al. 2011). Plastics in particular have been shown to increase hazardous toxic burden in fish leading to organ (e.g., liver) toxicity (Rochman et al. 2013). Of these military expended materials that could potentially impact pelagic species that feed at or just below the surface or 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).

As previously described, 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). In the Navy's analysis and in this biological opinion, only small- and medium-caliber munitions (or small fragments from larger munitions), chaff, and end caps and pistons from flares and chaff cartridges are considered to be of ingestible size for a fish. Small- and medium-caliber projectiles include all sizes up to and including 2.25-in diameter. These solid metal materials would quickly move through the water column and settle to the seafloor. Ingestion of non-explosive practice munitions in the water column is possible when shiny fragments of the munitions sink quickly and could be ingested by fast, mobile predators that chase moving prey. Small-caliber projectiles would likely be more prevalent throughout the action area and thus more likely to be encountered and potentially ingested by ESA-listed fishes. For many small fish species and juvenile fishes, many of these items (with the exception of chaff) are too large to be ingested. If a larval or juvenile fish swallows chaff, studies have shown it to have limited effects on fishes due to the concentration levels at which it is released (Arfsten et al. 2002; Force 1997; Spargo 1999). No ingestion potential impacts on early life stages of fishes are likely to occur, with the exception of large juveniles that may be large enough to ingest military expended materials. Therefore, the discussion in this section focuses on those ESA-listed fish species large enough to potentially ingest these materials.

Open-ocean, pelagic fish such as steelhead and oceanic whitetip sharks, and open-ocean planktivores such as giant manta rays are more likely to ingest materials floating in the water column. However, because giant manta rays are filter-feeders, they are not expected to intentionally ingest munitions. Due to the size and composition of material expended, the munitions and fragments would sink fairly rapidly to the seafloor. This would limit the time available for encounter and ingestion by pelagic species. While the most likely scenario would be for steelhead to ignore these objects, if a salmonid such as a steelhead did ingest a fragment or other munition, it would most likely taste the item, then spit it out (Felix et al. 1995). Oceanic whitetip sharks are considered scarce in the action area, which would decrease their chance of encountering sinking material in the water column. Once the item sinks to the seafloor, it would be unavailable to oceanic whitetip sharks. As with the other pelagic species, if an item were accidentally ingested by a shark, it would likely expel the item after it was determined to not be a prey item.

For the reasons provided above, we consider it extremely unlikely that ESA-listed fish species would ingest materials resulting in adverse effects to the fish's normal behavior, growth, survival, or reproductive success. Therefore, the risk of ingestion of expended materials is considered discountable for all ESA-listed fish species considered in this biological opinion.

9.1.4 Secondary Stressors – Marine Mammals, Sea Turtles, and Fish

This section analyzes potential impacts to ESA-listed marine mammals, sea turtles, and fish exposed to stressors indirectly through impacts to their habitat or prey or through the introduction of parasites or disease. The stressors evaluated in this section include (1) explosives 2) explosive byproducts and unexploded munitions, (3) metals, (4) chemicals, and (5) transmission of disease and parasites.

Explosives

Underwater explosions could impact other species in the food web, including prey species that marine mammals, sea turtles, and fish 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. Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. 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. For this reason, the effects of explosive on marine mammal, sea turtle, and fish prey are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

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 potentially affect marine species or their habitats. On the other hand, 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 marine organisms. The authors concluded that degradation products of this explosive are not toxic at realistic exposure levels. 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 background beyond 3 to 6 ft from the degrading munitions. Taken together, it is possible that ESA-listed marine mammals, sea turtles, and fish could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1 to 6 ft).

A series of 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 Mariana Islands) has been used as a target area since 1971. 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 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.

These findings are consistent with other assessments such as that done for the Potomac River Test Range at Dahlgren, Virginia which was established in 1918 and is the nation’s largest fully instrumented, over-the-water gun-firing range. Munitions tested at Naval Surface Warfare

Center, Dahlgren have included rounds from small-caliber guns up to the Navy's largest (16-in. guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (Navy 2013f). Results from the assessment indicate that munitions expended at Naval Surface Warfare Center, Dahlgren have not contributed to significant concentrations of metals to the Potomac River water and sediments given those contributions are orders of magnitude less than concentrations already present in the Potomac River from natural and other manmade sources (Navy 2013f).

The concentration of munitions/explosions, expended material, or devices in any one location in the action area are expected to be a small fraction of that from the sites described above. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects on water quality or prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on marine mammals, sea turtles, and fish are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

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 2013f) indicate metal contamination is very 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 since comparison of metals in sediment next to munitions show relatively little difference in comparison to other "clean" marine sediments used as a control/reference (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 adverse effects on ESA-listed marine mammal, sea turtle, or fish prey or habitat. For these reasons, the metals introduced into seawater and sediments would have an insignificant effect (i.e., so minor that the effect cannot be meaningfully evaluated) on these species.

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, sea turtles, fish, 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. 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). Perchlorate from failed expendable items is therefore unlikely to compromise water quality to that point that it would act as a secondary stressor to marine mammals, sea turtles, and fish. For these reasons, the effects of chemicals used during Navy training and testing are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated) and not likely to adversely affect ESA-listed marine mammals, sea turtles, or fish.

Transmission of Disease and Parasites

The primary vector through which parasites or disease would be transferred to new locations and the ESA-listed species there would be through the deployment of marine mammals used by the Navy's Marine Mammal Systems. Navy animals receive regular veterinarian care, including predeployment exams, regular deworming, and regional screening for specific pathogens of interest (Navy 2018d). The animals are fed restaurant-quality fish to minimize the likelihood of parasite ingestion and animal waste is collected and managed to control the potential spread of parasites. Prior to animal deployment Navy personnel observe the surrounding area and if wild marine mammals are spotted animal deployment is delayed. Contact between Navy animals and wild animals is minimized to the greatest extent possible. In the 40 years the Marine Mammal Program has been operating there has been no known disease or parasite transmissions from Navy animals to wild animals (Navy 2018d). Given the care Navy animals receive, the waste disposal protocols, the minimal time Navy animals are in contact with wild animals, it is extremely unlikely that parasites or diseases will be transferred to ESA-listed marine mammals. Thus, the effect of this stressor is discountable.

9.2 Stressors Likely to Adversely Affect ESA-Listed Species

We determined that the following stressors from the proposed action are likely to adversely affect ESA-listed species:

1) Acoustic stressors from sonar and other transducers, air guns – marine mammals;
2) Acoustic stressors from air guns – marine mammals;
3) Explosive stressors in water – marine mammals, sea turtles, and fishes;
4) Physical disturbance and strike stressors from vessels – marine mammals and sea turtles.

The following sections describe the effects of these stressors on ESA-listed species. We first describe the potential adverse effects of the stressor, then we summarize the exposure analysis which estimated the number of individuals of each ESA-listed species that may be exposed to the stressor (where possible). Next, we provide our assessment of the likely responses these species will exhibit to this exposure. Finally, in our risk analysis, we assess the likely consequences of the responses to the individuals that have been exposed.

Additionally, as described previously in Section 3, 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 assumed that the training and testing activities proposed by the Navy during the 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. Note that while the analysis assumes Navy activities, along with the associated impacts, will continue into the reasonably foreseeable future, the reinitiation triggers described in Section 15 apply such that if any of the following criteria are met, reinitiation of formal consultation is required:

(1) The amount or extent of taking 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 ESA-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.

9.2.1 Marine Mammals

This section discusses the effects of acoustic (i.e., from sonar and other transducers), explosive, and vessel strike stressors on ESA-listed marine mammals.

9.2.1.1 Sonar and Other Transducers – Marine Mammals

As described further in Section 6.1.3, sonar and other transducers includes a variety of acoustic devices used to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track submarines; high-frequency small object detection sonars used to detect mines; high-frequency underwater modems used to transfer data over short ranges; and extremely high-frequency (greater than 200 kHz) Doppler sonars used for navigation, like those used on commercial and private vessels.

9.2.1.1.1 Potential Effects of Sonar and Other Transducers for Marine Mammals

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

The potential effects of acoustic exposure range from physical injury or trauma, to an observable behavioral response, to a stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Hearing loss is a noise-induced decrease in hearing sensitivity, which can either be temporary or permanent. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Masking can occur when the perception of a biologically-important sound is interfered with by a second sound (e.g., noise from Navy training and testing). 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 sonar and other transducers on marine mammals. In the exposure, response, and risk analyses below (i.e., Sections 9.2.1.1.2, 9.2.1.1.3, and 9.2.1.1.4, respectively), we use this information to discuss the likely effects of Navy sonar use on ESA-listed marine mammals.

9.2.1.1.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to exposure to pressure waves. The potential for injury due to exposure to non-explosive acoustic stressors such as active sonar that is proposed for use in the action area is discussed below.

Nitrogen decompression

Marine mammals are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al. 2012). Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could result in nitrogen off-gassing in super-saturated tissues, possibly to the point of deleterious vascular and tissue bubble formation (Hooker et al. 2012; Jepson et al. 2003; Saunders et al. 2008) with resulting symptoms similar to decompression sickness (also known as "the bends" in humans). The process has been under debate in the scientific community (Hooker et al. 2012; Saunders et al. 2008), although analyses of by-caught and drowned animals has demonstrated that nitrogen bubble formation can occur once animals are brought to the surface and tissues are supersaturated with nitrogen (Bernaldo De Quiros et al. 2013; Moore et al. 2009b). Deep diving whales, such as beaked whales (not listed under the ESA), normally have higher nitrogen loads in body tissues, which may make them more susceptible to decompression for certain modeled changes in dive behavior (Fahlman et al. 2014b; Fernandez et al. 2005a; Hooker et al. 2012; Jepson et al. 2003).

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernandez et al. 2005a; Jepson et al. 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al. 2005a; Jepson et al. 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Hooker et al. 2012; Tyack et al. 2006; Zimmer and Tyack 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (Fahlman et al. 2014b). However, Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins, contributing to tissue gas loads. To examine the potential for gas bubble formation, a bottlenose dolphin was trained to dive repetitively to depths shallower than lung collapse to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2009). To estimate risk of decompression sickness, Kvadsheim (2012) modeled gas exchange in the tissues of sperm, pilot, killer, and beaked whales based on actual dive behavior during exposure to sonar in the wild. Results indicated that venous supersaturation was within the normal range for these species, which have naturally high levels of nitrogen loading. Researchers have also considered the role of accumulation of carbon dioxide produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, may facilitate the formation of bubbles in nitrogen saturated tissues (Bernaldo De Quiros et al. 2012; Fahlman et al. 2014b). Garcia Parraga et al. (2018) suggest that diving marine mammals have physiological and anatomical adaptations to control gas uptake above the depth of lung collapse, favoring oxygen uptake while minimizing nitrogen uptake. Under the hypothesis of Garcia Parraga et al. (2018), elevated activity due to a strong evasive response could lead to increased uptake of nitrogen, resulting in an increased risk of nitrogen decompression.

Modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (i.e., tissues that take longer to give off nitrogen, e.g., fat and bone lipid) to the point that they are supersaturated when the animals are at the surface (Fahlman et al. 2014b; Hooker et al. 2009; Saunders et al. 2008). The presence of osteonecrosis (bone death due to reduced blood flow) in deep diving sperm whales has been offered as evidence of chronic supersaturation (Moore and Early 2004). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation in these tissues has been demonstrated in marine mammals drowned at depth as fisheries bycatch and brought to the surface (Moore et al. 2009b). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation may be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al. 2009).

A fat embolic syndrome (out of place fat particles, typically in the bloodstream) was identified by Fernandez et al. (2005b) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream.

Dennison et al. (2011) reported on investigations of dolphins stranded in 2009 to 2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the liver of two of the 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed could be tolerated since the majority of stranded dolphins released did not re-strand.

The appearance of extensive bubble and fat emboli in beaked whales (not listed under the ESA) is unique to strandings associated with certain high intensity sonar events. The phenomenon has not been observed in other stranded marine mammals, including beaked whale strandings not associated with sonar use. It is not clear whether there is some mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Because of the lack of evidence for extensive nitrogen bubble formation while diving, NMFS believes that the probability of ESA-listed marine mammals getting "the bends" following acoustic exposure to be extremely low, and thus, discountable.

Acoustically-induced bubble formation due to sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors including the SPL and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that an immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lungs without negative consequence to the animal.

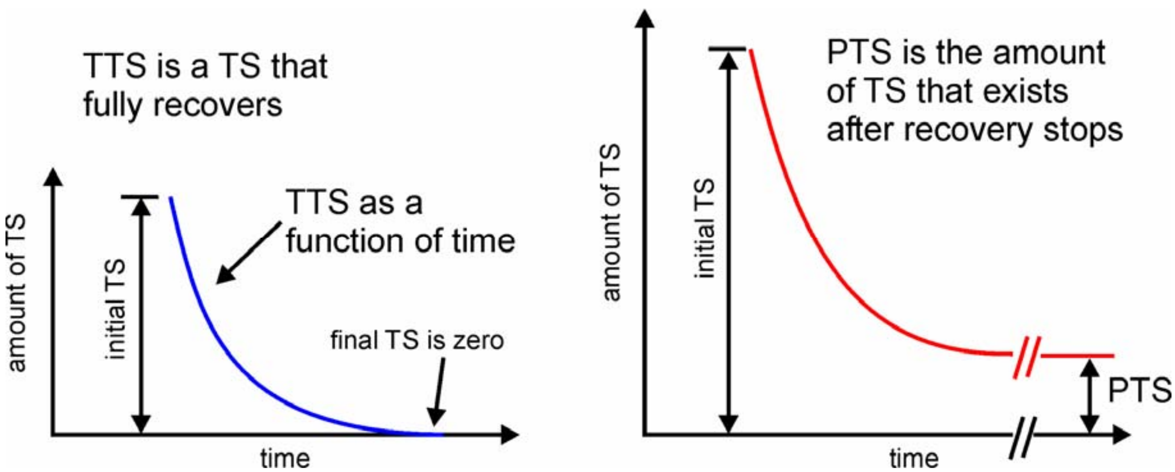
Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway and Howard 1979). The dive patterns of some marine mammals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

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

9.2.1.1.1.2 Hearing Loss and Auditory Injury

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss will vary depending on the frequency of the noise, with frequencies at and above the noise frequency most strongly affected. 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 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 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 called a temporary threshold shift. If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is called a permanent threshold shift. Figure 64 shows two hypothetical threshold shifts: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. By definition, TTS is a function of the recovery time, therefore comparing the severity of noise exposures based on the amount of induced TTS can only be done if the recovery times are also taken into account. For example, a 20-dB TTS measured 24 hr post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only 2 min after exposure; if the TTS is 20 dB after 24 hr., the TTS measured after 2 min would have likely been much higher. Conversely, if 20 dB of TTS was measured after 2 min, the TTS measured after 24 hr would likely be much smaller.



Note: TTS is temporary threshold shift; PTS is permanent threshold shift.

Figure 64. Two hypothetical threshold shifts.

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). (Liberman and C. 2009) found that noise exposures sufficient to produce a TTS in neural thresholds of 40 dB, measured 24 hr. post-exposure, resulted in acute loss of nerve terminals and delayed degeneration of the cochlear nerve in mice. Lin et al. (2011b) found a similar result in guinea pigs with a TTS in auditory-evoked potential up to approximately 50 dB, measured 24 hr 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 hr after exposure) — but no PTS — may result in auditory injury.

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

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40 to 50 dB may be induced without PTS and that 40 dB is a precautionary upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al. 1965; 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. 2015b; Ketten 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately 4 min 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 4 min 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 Liberman and C. (2009) and Lin et al. (2011b) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in marine mammals (See Finneran et al. 2015b). 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. 2015b).

- The amount of TTS varies with the hearing test frequency. As the exposure SPL increases, the frequency at which the maximum TTS occurs also increases (Kastelein et al. 2014b). For high level exposures, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Mooney et al. 2009a; Nachtigall et al. 2004; Popov et al. 2013; Popov et al. 2011; Schlundt et al. 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range; i.e., narrowband exposures can produce broadband (greater than one octave) TTS.
- The amount of TTS increases with exposure SPL and duration, and is correlated with SEL, especially if the range of exposure durations is relatively small (Kastak et al. 2007; Kastelein et al. 2014b; Popov et al. 2014). As the exposure duration increases, 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 marine mammal experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.
- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the region of best sensitivity (Finneran and Schlundt 2013). The onset of TTS — defined as the exposure level necessary to produce 6 dB of TTS (i.e., clearly above the typical variation in threshold measurements) — also varies with exposure frequency. At low frequencies onset-TTS exposure levels are higher compared to those in the region of best sensitivity.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al. 2010; Kastelein et al. 2015c; Kastelein et al. 2014b; Mooney et al. 2009b). This means that TTS predictions based on the total, cumulative SEL will overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., approximately 40 dB) may require several days or longer for recovery. 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. 2014b; Kastelein et al. 2014c; 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., 6 dB recovery per doubling of time).

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

TTS in mid-frequency cetaceans exposed to non-impulsive sound (e.g., active sonar) 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) from two species, bottlenose dolphins (*Tursiops truncates*) and beluga whales (*Delphinapterus leucas*). Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al. 2012b) and the finless porpoise (*Neophocaena phocaenoides*) (Popov et al. 2011). TTS from non-impulsive sounds has also been investigated in three pinniped species: harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), and Northern elephant seal (*Mirounga angustirostris*) (e.g., Kastak et al. 2005). These data are reviewed in detail in Finneran (2015).

9.2.1.1.1.3 Physiological Stress

The growing field of conservation physiology relies in part on the ability to monitor stress hormones in populations of animals, particularly those that are threatened or endangered. The ability to make predictions from stress hormones about impacts to individuals and populations exposed to various forms of stressors, natural and human-caused, relies on understanding the linkages between changes in stress hormones and resulting physiological impacts. At this time, the sound characteristics that correlate with specific stress responses in marine mammals are poorly understood, as are the ultimate consequences due to these changes. Efforts are underway to try to improve understanding of and the ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al. 2015b; New et al. 2013a; New et al. 2013b; Pirotta et al. 2015a). With respect to acoustically-induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound (e.g., prior experience with a stressor may result in a reduced response due to habituation; Finneran 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 such things as fishery interactions, pollution, and ocean noise. Rolland et al. (2017) studied glucocorticoid hormones in North Atlantic right whales, evaluating healthy whales, those that had been struck by vessels, and those chronically entangled in fishing gear. The authors found that stress hormones in the entangled whales were elevated compared to those of healthy whales and those struck by vessels. 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 gluticosteroids (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).

The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor (Moberg 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). 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.

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. The endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al. 2015). For example, due to the necessity of breath-holding while diving and foraging at depth, the physiological role of the epinephrine and norepinephrine (the catecholamines) may 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. 1990a) 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. (2010a) 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, Thompson et al. (1998; cited in Gordon et al., 2003) observed a rapid but short-lived decrease in heart rates in harbor and gray seals exposed to seismic air guns. Williams et al. (2017b) 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.

Similarly, a limited amount of work has addressed how chronic exposure to acoustic stressors affect stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure in marine mammals associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly 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 (e.g., Bain 2002; Erbe 2002b; 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. However, Ayres et al. (2012) investigated southern resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone 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. The work of Rolland et al. (2012) represents the most provocative link between ocean noise and cortisol in cetaceans to date.

9.2.1.1.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al. 2015). Masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency, cessation of vocalization) and behavior changes (e.g., cessation of foraging, leaving an area) on the part of both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al. 2015).

Clark et al. (2009a) 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 (2015) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, and noise-source location, distance relative to each other, and received level of the call.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise and include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin 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 2008b; Holt et al. 2011b; 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 (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks. These findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking could occur as a result of sonar and other transducers. As stated previously, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Because traditional military sonars typically have low duty cycles, the effects of such masking would likely be limited when compared with continuous sources (e.g., vessel noise). Low-frequency active sonar could overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, in the presence of low-frequency active sonar, humpback whales were observed to increase the length of their songs (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., 2 to 10 kHz with harmonics up to 19 kHz, 76 to 77 pings per minute (Culik et al. 2001) also operate at lower source levels. While the lower source levels of these systems limits the range of impact compared to more traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high duty cycle systems operate overlaps the vocalization frequency of a number of mid-frequency cetaceans (e.g., ESA-listed sperm whales).

Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically-mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g. killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g. vessel noise and low-frequency cetaceans), and will likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm and Slabbekoorn 2005; Hotchkin and Parks 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al. 2003a). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al. 2004; Parks et al. 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm and Slabbekoorn 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm and Slabbekoorn 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al. 2003a).

9.2.1.1.1.5 Behavioral Reactions

Any stimuli in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels, sonar, air guns, or pile driving, but could also include the physical presence of a vessel or aircraft. However, these stimuli could also influence how or if a marine mammal responds to a sound such as the presence of predators, prey, or conspecifics. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al. 2011). The distance from the sound source and whether it is approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al. 2003).

For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995f). Other reviews (Gomez et al. 2016; Nowacek et al. 2007; Southall et al. 2007a) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated, and also examined the role of context. Southall et al. (2007a) synthesized data from many behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. Southall et al. (2016) reviewed the range of experimental field studies that have been conducted to measure behavioral responses of cetaceans to sonar. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007a; Southall et al. 2016). Ellison et al. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context" as described, greatly influences the type of behavioral response exhibited by the animal. Forney et al. (2017) also point out that an apparent lack of response (e.g. no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitable for foraging, resting, or socializing.

Behavioral reactions could result from a variety of sound sources, including impulsive sources such as explosives, air guns, and impact pile driving, and non-impulsive sources such as sonar and other active acoustic sources (e.g., pingers), and vessel and aircraft noise. For some of these noise sources numerous studies exist (e.g., sonar), whereas for others the data are sparse (e.g., pile driving), and surrogate sound sources must be relied upon to assess the potential for behavioral response. Similarly, there is data on the reactions of some species in different behavioral states, providing evidence on the importance of context in gauging a behavioral response. However, for most species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred.

Sonar and other transducers can range in frequency from less than 1 kHz (e.g., low-frequency active sonar) to over 200 kHz (e.g., fish finders), with duty cycles that range from one ping per minute to an almost continuous sound. Although very-high-frequency sonars are out of the hearing range of most marine mammals, some of these sources may contain artifacts at lower frequencies that could be detected (Deng et al. 2014; Hastie et al. 2014). High duty-cycle sonar systems operate at lower source levels, but with a more continuous sound output. These sources can be stationary, or on a moving platform, and there can be more than one source present at a time. Guan et al. (2017) also found that sound levels in the mid-frequency sonar bandwidth remained elevated at least 5 dB above background levels for the first 7 to 15 seconds (within 2 km) after the emission of a sonar ping; depending on the length of the sonar ping and the inter-ping interval this reverberation could increase cumulative SEL estimates during periods of active sonar. This variability in parameters associated with sonar and other transducers makes the estimation of behavioral responses to these sources difficult, with observed responses ranging from no apparent change in behavior to more severe responses that could lead to some costs to the animal. Responses may also occur in the presence of different contextual factors regardless of received level, including the proximity and number of vessels, the behavioral state and prior experience of an individual, and even characteristics of the signal itself or the propagation of the signal through the environment.

Behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, United States (e.g., off Southern California, Hawaii, and the east coast), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of cetaceans to controlled exposures of sonar and other sounds to understand their potential impacts better. While controlling for as many variables as possible (e.g., the distance and movement of the source), these studies also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, distances of the sound source from the whales during behavioral response studies were always within 1 to 8 km. Some of these studies have suggested that ramping-up a source from a lower source level would act as a protective measure to mitigate higher order (e.g., TTS or PTS) impacts of sonar.

However, this practice may only be effective for more responsive animals, and for short durations (e.g., 5 min) of ramp-up (von benda-Beckmann et al. 2016; Von Benda-Beckmann et al. 2014). Therefore, while these studies have provided the most information to date on behavioral responses of marine mammals to sonar, there are still many contextual factors to be teased apart and determining what might produce a significant behavioral response is currently difficult to discern.

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2016; Manzano-Roth et al. 2016; Martin et al. 2015; Mccarthy et al. 2011; Mobley and Deakos 2015; Moretti et al. 2014; Tyack et al. 2011b). In addition, extensive aerial, visual, and acoustic monitoring is conducted before, during and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Campbell et al. 2010; Farak et al. 2011; HDR 2011; Navy 2011b; Navy 2013a; Navy 2014b; Navy 2015; Norris et al. 2012; Smultea and Mobley 2009; Smultea et al. 2009; Trickey et al. 2015). During all of these monitoring efforts, only a few behavioral responses were observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event; e.g., Smultea et al., 2011). However, it should be noted that passive acoustic studies are limited to observations of vocally-active marine mammals and visual studies are limited to what can be observed at the surface. These study types do have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies. Furthermore, when visual and passive acoustic data collected during a training event are combined with ship movements and sonar use they provide a unique and realistic scenario for analysis. In addition to these types of observational behavioral response studies, Harris and Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonars and other transducers beyond behavioral response type studies or passive acoustic monitoring, including conducting controlled exposures on captive animals with scaled sources (smaller sized and deployed at closer proximity), on wild animals with both scaled and real but directed sources, and predator playback studies, all of which will be discussed below.

The above behavioral response studies and observations have been conducted on a number of mysticete and odontocete species, which can be extrapolated to other similar species in these taxonomic groups. There are several captive studies on some odontocete species that can provide insight into how these animals may respond in the wild. The captive studies typically represent a more controlled approach, which allow researchers to better estimate the direct impact of the received level of sound leading to behavioral responses, and to potentially link behavioral to physiological responses. However, there are still contextual factors that must be acknowledged, including previous training to complete tasks and the presence of food rewards upon completion.

There are no corresponding captive studies on mysticete whales, therefore some of the responses to higher level exposures must be extrapolated from odontocetes.

Mysticetes

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

Surface feeding blue and humpback whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 μPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (DeRuiter et al. 2017; Goldbogen et al. 2013b; Silve et al. 2015). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al. 2016). However, even when responses did occur, the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al. 2013b; Silve et al. 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al. 2014). Five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives. In this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4500 Hz, was long in duration (lasting several minutes), and was purposely designed to elicit a reaction from the animals as a prospective means of protecting them from ship strikes (Nowacek et al. 2004). Although the animals' received SPL was similar in the latter two studies (133–150 dB re 1 μPa), the frequency, duration, and temporal pattern of signal presentation were different.

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

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

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

Opportunistic passive acoustic based studies have also detected behavioral responses to sonar. Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior, beginning at received levels of 110 to 120 dB re 1 μPa (Melcon et al. 2012). In another example, Risch et al. (2012) determined that humpback whale song produced in the Stellwagen Bank National Marine Sanctuary was reduced, and since the timing was concurrent with an Ocean Acoustic Waveguide Remote Sensing experiment occurring 200 km away, they concluded that the reduced song was a result of the Ocean Acoustic Waveguide Remote Sensing experiment. However, Gong et al. (2014) analyzed the same data set while also looking at the presence of herring in the region, and found that the singing humpbacks were actually located on nearby Georges Bank and not on Stellwagen, and that the song rate in their data did not change in response to the Ocean Acoustic Waveguide Remote Sensing experiment, but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other active acoustic sources (e.g., the single minke whale), for the most part mysticete responses appear to be fairly moderate across all received levels. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the signal stopped. Mysticete responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would not likely occur during real Navy testing and training scenarios. While there is a lack of data on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al. 2004), suggesting that they could have similar responses to high duty cycle sonars. No significant behavioral responses such as panic or stranding have been observed during monitoring of actual training exercises (Navy 2011b; Navy 2014a; Smultea et al. 2009; Watwood et al. 2012a).

Odontocetes

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale (not ESA-listed) responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge and Durban 2009; Claridge et al. 2009; Henderson et al. 2015; Mccarthy et al. 2011; Moretti et al. 2009; Southall et al. 2013; Southall et al. 2012; Southall et al. 2011; Southall et al. 2014). Though below we will discuss results of behavioral response studies on many odontocete species (e.g., beaked whales), sperm whales are the only odontocete in the action area listed under the ESA. Results to date suggest that sperm whales are not as sensitive to anthropogenic sound sources as some other odontocetes, such as beaked whales (Southall et al. 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, and other unusual dive behavior (Boyd et al. 2008; Deruiter et al. 2013a; Miller et al. 2015; Southall et al. 2011; Stimpert et al. 2014; Tyack et al. 2011a). Falcone et al. (2017) modeled deep and shallow dive durations, surface interval durations, and inter-deep dive intervals of Cuvier's beaked whales against predictor values that included helicopter-dipping; mid-power mid-frequency active sonar; and hull-mounted, high-power mid-frequency active sonar along with other, non-mid-frequency active sonar predictors. They found both shallow and deep dive durations to increase as the proximity to both mid- and high-powered sources decreased, and found surface intervals and inter-deep dive intervals to also increase in the presence of both types of sonars, although surface intervals shortened during periods of no mid-frequency active sonar. The responses to the mid-power mid-frequency active sonar at closer ranges were comparable to the responses to the higher source level ship sonar, again highlighting the importance of proximity. This study also supports context as a response factor, as helicopter-dipping sonars are shorter duration and randomly located, so more difficult for beaked whales to predict or track and therefore potentially more likely to cause a response, especially when they occur at closer distances (6 to 25 km in this study). Watwood et al. (2017) found that helicopter-dipping events occurred more frequently but with shorter durations than periods of hull-mounted sonar, and also found that the longer the duration of a sonar event, the greater reduction in detected Cuvier's beaked whale group dives. Therefore, when looking at the number of detected group dives there was a greater reduction during periods of hull-mounted sonar than during helicopter-dipping sonar.

A response was observed in a northern bottlenose whale, which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over 7 hours (Miller et al. 2015). Responses occurred at received levels between 95 and 150 dB re 1 μPa. All of these exposures occurred within 1 to 8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to real Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84 to 144 and 78 to 106 dB re 1 μPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (Deruiter et al. 2013a). Furthermore, recent long-term tagging work has demonstrated that the longer duration dives considered a behavioral response by Deruiter et al. (2013a) fell within the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Schorr et al. 2014). However, the longer inter-deep dive intervals found by Deruiter et al. (2013a) were among the longest found by Schorr et al. (2014) and could indicate a response to sonar. In addition, Williams et al. (2017a) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in Deruiter et al. (2013a), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams et al. (2017a) was higher.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Claridge et al. 2009; Henderson et al. 2015; Mccarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011a). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long term consequences of the sonar activity. Similarly, photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in 1 or more prior years, with re-sightings up to 7 years apart, indicating a possibly resident population on the range (Falcone and Schorr 2014; Falcone et al. 2009a).

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

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

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

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

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to 220 dB re 1 μPa (Bowles et al. 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington exhibited what were believed by some observers to be aberrant behaviors, during which time the *USS Shoup* was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the *USS Shoup* transmissions (Fromm 2009; Navy 2003; NMFS 2005a) estimated a mean received SPL of approximately 169 dB re 1 μPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 μPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that "Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close" (NOAA 2014c). Several odontocete species, including bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and leaving the area, and at the highest received levels animals were not present in the area at all (Henderson et al. 2014). However, these observations were conducted from a vessel off-range, and so any observed responses could not be attributed to the sonar with any certainty. Research on sperm whales in the Caribbean in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins

1985; Watkins and Schevill 1975). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bowride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (HDR 2011; Navy 2011a; Watwood et al. 2012b). During small boat surveys near the Navy's Southern California Offshore Range in southern California, more dolphins were encountered in June compared to a similar survey conducted the previous November after 7 days of mid-frequency sonar activity. It was not investigated if this change was due to the sonar activity or was a seasonal difference that could be observed in other years (Campbell et al. 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the Marianas Islands Range Complex, with the post-activity absence lasting longer than the mean dolphin absence of two days when sonar was not present (Munger et al. 2014; Munger et al. 2015).

Acoustic harassment devices and acoustic deterrent devices have been used to deter marine mammals from approaching fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a 10 kHz tone and one with a broadband 30 to 160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and 40 percent for the tone and, while there was some gradual habituation after the first 2 to 4 exposures, longer term exposures (over 28 days) showed no evidence of additional habituation. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975). Acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 μPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner and Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive either simulate a predator or are otherwise predictive of a threat are those more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases the net pingers may create a "dinner bell effect", where marine mammals have learned to associate the signal with the availability of prey (Jefferson and Curry 1996; Schakner and Blumstein 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales because these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta and Barlow 2008; Schakner and Blumstein 2013). Additional behavioral studies have been conducted with captive harbor porpoises using acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006). These studies have found that high-frequency sources with varied duration, interval, and sweep characteristics can prove to be effective deterrents for harbor porpoises (Kastelein et al. 2017).

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to 3 kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al., 2013), and in another study bottlenose dolphins and beluga whales were presented with 1-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt 2004; Schlundt et al. 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002b; Schlundt et al. 2000). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over 10 trials, and in the TTS study bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa, and beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Behavioral responses to a variety of sound sources have been studied in harbor porpoises, including acoustic alarms (Kastelein et al. 2001; Kastelein et al. 2006), emissions for underwater data transmission (Kastelein et al. 2005), and tones, including 1 to 2 kHz and 6 to 7 kHz sweeps with and without harmonics (Kastelein et al. 2014d), and 25 kHz with and without sidebands (Kastelein et al. 2015a; Kastelein et al. 2015b). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1 to 2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6 to 7 kHz tonal at the same level (Kastelein et al. 2014d). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for 1 to 2 kHz and 6 to 7 kHz sweeps respectively when no harmonics were present, and decreased to 90 dB re 1 μPa for 1 to 2 kHz sweeps with harmonics present (Kastelein et al. 2014d). Harbor porpoises responded broadband signals up to 44 kHz with a slight respiration response at 117 dB re 1 μPa and an avoidance response at 139 dB re 1 μPa, but another source with a fundamental (lowest and strongest) frequency of 18 kHz didn't have an avoidance response until 151 dB re 1 μPa (Kastelein et al. 2014a). Exposure of the same acoustic pinger to a striped dolphin under the same conditions did not elicit a response (Kastelein et al.

2006), again highlighting the importance of understanding species' differences in the tolerance to underwater noise, although sample sizes in these studies was small so these could reflect individual differences as well.

Behavioral responses by odontocetes to sonar and other transducers appear to run the full gamut from no response at all to responses that could potentially lead to long-term consequences for individual animals (e.g., mother-calf separation). This is likely in part due to the fact that this taxonomic group is so broad and includes some of the most sensitive species (e.g., beaked whales and harbor porpoise) as well as some of the least sensitive species (e.g., bottlenose dolphins). This is also the only group for which both field behavioral response studies and captive controlled exposure experiments have been conducted, leading to the assessment of both contextually-driven responses as well as dose-based responses. This wide range in both exposure situations and individual- and species-sensitivities makes reaching general conclusions difficult. However, it does appear as though exposures in close proximity, with multiple vessels that approach the animal, lead to higher-level responses in most odontocete species regardless of received level or behavioral state. In contrast, in more "real-world" exposure situations, with distant sources moving in variable directions, behavioral responses appear to be driven by behavioral state, individual experience, or species-level sensitivities. These responses may also occur more in-line with received level such that the likelihood of a response would increase with increased received levels. However, these "real-world" responses are more likely to be short-term, lasting the duration of the exposure.

Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be "unpleasant" or threatening have been reported, including habituation by captive seals (they did not avoid the sound), and avoidance behavior by wild seals (Götz and Janik 2010). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal tolerates or habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1–7 kHz sonar signals, in part with displacement (i.e., avoidance) to the areas of least SPL, at levels between 160 and 170 dB re 1 μPa (Kvadsheim et al. 2010b); however, the animals adapted to the sound and did not show the same avoidance behavior upon subsequent exposures. Captive harbor seals responded differently to three signals at 25 kHz with different waveform characteristics and duty cycles. The seals responded to the frequency modulated signal at received levels over 137 dB re 1 μPa by hauling out more, swimming faster, and raising their heads or jumping out of the water, but did not respond to the continuous wave or combination signals at any received level (up to 156 dB re 1 μPa) (Kastelein et al. 2015e). Captive California sea lions were exposed to mid-frequency sonar at various received levels (125 – 185 dB re 1 μPa) during a repetitive task (Houser et al. 2013). Behavioral responses included a refusal to participate, hauling out, an increase in respiration rate, and an increase in the time spent submerged. Young animals (less than 2 years old) were more likely to respond than older animals. Dose-response curves were developed both including and excluding those young animals. The majority of responses below

155 dB re 1 μPa were changes in respiration, whereas over 170 dB re 1 μPa more severe responses began to occur (such as hauling out or refusing to participate); many of the most severe responses came from the younger animals.

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source centered at 75 Hz, with received levels between 118 and 137 dB re 1 μPa, were not found to overtly affect elephant seal dives (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Harbor seals exposed to seal scarers (i.e., acoustic harassment devices) used to deter seals from fishing nets did not respond at levels of 109–134 dB re 1 μPa and demonstrated minor responses by occasionally hauling out at 128–138 dB re 1 μPa (Kastelein et al. 2015d). Pingers have also been used to deter marine mammals from fishing nets; in some cases, this has led to the "dinner bell effect" where the pinger becomes an attractant rather than a deterrent (Carretta and Barlow 2011). Steller sea lions were exposed to a variety of tonal, sweep, impulse and broadband sounds. The broadband sounds did not cause a response, nor did the tones at levels below 165 dB re 1 μPa at 1 m, but the 8 kHz tone and 1-4 kHz sweep at source levels of 165 dB re 1 μPa caused the sea lions to haul out (Akamatsu et al. 1996).

The only study on responses of Hawaiian monk seals to Navy training and testing was D'Amico (2013) where animal movements obtained from telemetry tag data was compared to concurrent mid-frequency active sonar activity. Specifically, positional data was collected by 13 global positioning system telemetry tags deployed over a 2-year period (2010–2011) on 11 individual Hawaiian monk seals, for a total of 38,232 hours (1,593 days). By using geo-spatial data bases, it was determined that four of the eight seals were exposed to a total of 14.48 hours (less than 1 day) of mid-frequency sonar activity while the seal was within 36 km of a hull mounted sonar ship. Independently, the tag data were analyzed to identify specific dates where seal behaviors differed from "normal" for each individual. The time periods determined to be outside the "normal" range were compared to those time periods when a monk seal was in the vicinity of a hull mounted sonar ship while it was transmitting. The available data suggest there were no significant impacts from mid-frequency active sonar on the Hawaiian monk seals tagged in HRC during the 2010–2011 time period, as no outlier days occurred on the day of active transmissions.

Similar to the other taxonomic groups assessed, pinniped behavioral responses to sonar and other active acoustic sources seem to be mediated by the contextual factors of the exposure, including the proximity of the source, the characteristics of the signal, and the behavioral state of the animal. However, all pinniped behavioral response studies have been conducted in captivity, so while these results may be broadly applied to real-world exposure situations, it must be done with caution. Based on exposures to other sound sources in the wild (e.g., impulsive sounds and vessels), pinnipeds are not likely to respond strongly to Navy sonar that is not in close proximity to the animal or approaching the animal.

9.2.1.1.1.6 Stranding

Marine mammals are subjected to a variety of natural and anthropogenic factors acting alone or in combination that may cause a marine mammal to strand (Geraci et al. 1999; Geraci and Lounsbury 2005). When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). A stranding can also occur away from the shore if the animal is unable to cope in its present situation (e.g. disabled by a vessel strike, out of habitat; Geraci and Lounsbury, 2005). Under U.S. law, a stranding is an event in the wild in which: (1) a marine mammal is dead and is (a) on a beach or shore of the United States; or (b) in waters under the jurisdiction of the United States (including any navigable waters); or (2) a marine mammal is alive and is (a) on a beach or shore of the United States and is unable to return to the water; (b) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (c) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 U.S.C. section 1421h).

Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, and aging (Bradshaw et al. 2006; Culik 2004; Geraci et al. 1999; Geraci and Lounsbury 2005; Huggins et al. 2015; NRC 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors include pollution (Hall et al. 2006; Jepson et al. 2005a), vessel strike ((Geraci and Lounsbury 2005; Laist et al. 2001), fisheries interactions (Read et al. 2006a), entanglement (e.g., Saez et al. 2013a; Saez et al. 2012), human activities (e.g., feeding, gunshot) (Dierauf and Gulland 2001; Geraci and Lounsbury 2005), and noise (Cox et al. 2006; Richardson et al. 1995f). For some stranding events, environmental factors (e.g., ocean temperature, wind speed, and topographic conditions) can be utilized in predictive models to aid in understanding why marine mammals strand in certain areas more than others (Berini et al. 2015). In most instances, even for the more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for strandings remains undetermined.

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 12,545 cetacean strandings per year (Navy 2018d). Several mass strandings (strandings that involve two or more cetaceans of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment such as naval operations and seismic surveys. An in-depth discussion of strandings is in the Navy's Technical Report on *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (Navy 2017c).

Sonar use during exercises involving the U.S. Navy has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Cox et al.

2006; Fernandez et al. 2006; Navy 2017c). These five mass strandings have resulted in about 40 known cetacean deaths consisting mostly of beaked whales (not ESA-listed) and with potential linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a potential indirect cause of death of the marine mammals (Cox et al. 2006). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather, have typically been attributed to natural or anthropogenic factors other than sonar.

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

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

Data were gathered from stranding networks that operate within and adjacent to the action area in an attempt to better understand the frequency that marine mammal strandings occur and what major causes of stranding's (both human-related and natural) exist in areas around the action area (National Marine Fisheries Service 2015a). From 2010 through 2014, there were 314 cetacean and phocid strandings reported in Hawaii, an annual average of 63 strandings per year. Twenty-seven species stranded in this region. The most common species reported include the Hawaiian monk seal, humpback whale, sperm whale, striped, and spinner dolphin. Although many marine mammals likely strand due to natural or anthropogenic causes, the majority of reported type of occurrences in marine mammal strandings in the action area include fisheries interactions, entanglement, vessel strike and predation.

In 2004, a mass out-of-habitat aggregation of melon-headed whales occurred in Hanalei Bay. It is speculated that sonar operated during a major training exercise may be related to the incident. Upon further investigation, sonar was only considered as a plausible, but not sole, contributing factor among many factors in the event. The Hanalei Bay incident does not share the characteristics observed with other mass strandings of whales coincident with sonar activity (e.g., specific traumas, species composition, etc.) (Southall et al. 2006; U.S. Navy Marine Mammal Program and SPAWAR Systems Center Pacific 2017). Additional information on this event is available in the Navy's Technical Report on Marine Mammal Strandings Associated with U.S. Navy Sonar Activities (U.S. Navy Marine Mammal Program and SPAWAR Systems Center Pacific 2017).

Records for strandings in San Diego County (covering the shoreline for the Southern California portion of the action area) indicate that there were 143 cetacean and 1,235 pinniped strandings between 2010 and 2014, an annual average of about 29 and 247 per year, respectively. A total of 16 different species have been reported as stranded within this time frame. The majority of species reported include long-beaked common dolphins and California sea lions, but there were also reports of pacific white-sided, bottlenose and Risso's dolphins, gray, humpback, and fin whales, harbor seals and Northern elephant seals (National Marine Fisheries Service 2015b; National Marine Fisheries Service 2016). However, stranded marine mammals are reported along the entire western coast of the United States each year. Within the same timeframe, there were 714 cetacean and 11,132 pinniped strandings reported outside of the action area, an annual average of about 142 and 2,226 respectively. Species that strand along the entire west coast are similar to those that typically strand within the action area with additional reports of harbor porpoise, Dall's porpoise, Steller sea lions, and various fur seals. The most common reported type of occurrence in stranded marine mammals in this region include fishery interactions, illness, predation, and vessel strikes (National Marine Fisheries Service 2016). It is important to note that the mass stranding of pinnipeds along the west coast considered part of a NMFS declared Unusual Morality Event are still being evaluated. The likely cause of this event is the lack of available prey near rookeries due to warming ocean temperatures (National Oceanic and Atmospheric Administration 2016). Carretta et al. (2017d; 2016b; 2013b) provide additional information and data on the threats from human-related activities and the potential causes of strandings for the U.S. Pacific coast marine mammal stocks.

9.2.1.1.1.7 Potential for Long-term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. Depending on the severity and duration, temporary impacts to hearing (i.e., TTS) also have the potential to impact the fitness of individual animals, and potentially, populations. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. Of critical importance in discussion on the potential consequences of disturbance is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated disturbance, 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. However, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al. 2003). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al. 2006b; Blackwell et al. 2004a; Teilmann et al. 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984a). Mysticetes in the northwest Atlantic tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986b), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. west coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound including the use of sonar by the U.S. Navy. However, new data has been published raising uncertainties over whether a decline in the beaked whale population occurred off the U.S. west coast between 1996 to 2014 (Barlow 2016). Photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier’s beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to 7 years apart (Falcone and Schorr 2014; Falcone et al. 2009a). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact to population growth rates and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these with her second calf, and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al. 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

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

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

The Population Consequences of Acoustic Disturbance model (NRC 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al. 2016a; Costa et al. 2016b; Harwood et al. 2014; Hatch et al. 2012; King et al. 2015b; New et al. 2014; New et al. 2013a; New et al. 2013b), but 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. For example, Costa et al. (2016b) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, and 100 percent of their foraging behavior was disturbed when the zone was over 25 km. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Similarly, Costa et al. (2016b) placed similar disturbance zones in the foraging and transit areas of northern elephant seals and California sea lions. Again, the location and radius of disturbance impacted how many animals were exposed and for how long, with California sea lions disturbed for a longer period than elephant seals, which extend over a broader foraging and transit area. However, even the animals exposed for the longest periods had negligible modeled impacts to their reproduction and pup survival rates.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the conservative assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts to the population size and no long-term effects on population viability.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy dense prey and high quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival. However, the authors used many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more indicating that temporary displacement from a small area may not preclude finding prey or suitable habitat. Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips. Even with this very high level of disruption which would not be expected to occur due to Navy activities, only a a slight (0.4 percent) population decline was modeled to occur in the following year. It should be noted that in all of these models, assumptions were made, and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population level effects.

The best assessment of long-term consequences from Navy training and testing activities come from monitoring marine mammal populations over time within the action area. A U.S. workshop on marine mammals and sound indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival (Fitch et al. 2011). The Navy has developed and implemented comprehensive monitoring plans since 2009 for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's current mitigation practices. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (e.g., Martin et al. 2017). Preliminary results of this analysis at the Pacific Missile Range Facility in Hawaii indicate no changes in detection rates for several species over the past decade. Continued monitoring efforts over time will help evaluate the long-term consequences of exposure to noise sources.

9.2.1.1.2 Exposure Analysis

Section 2.2.1 presented information on the criteria and thresholds used to estimate impacts to marine mammals from sonar and other transducers. 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). This section presents information on the range to effects for different sonar sources, the estimated number of exposures of ESA-listed marine mammals to sonar and other transducers that are expected to rise to the level of take under the ESA, the expected magnitude of effect from those exposures, and the likely responses of the animals to those effects. The exposure estimates were produced by the Navy's NAEMO modeling. We consider these estimates to be 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.

For sonar and other transducers (and explosives; see Section 9.2.1.2), we considered exposure estimates from the Phase III NAEMO model at two output points for marine mammals (for sea turtles and explosives, see Section 9.2.2.1). First, we estimated the total number of ESA-listed species (animats) that would be exposed to acoustic sources prior to the application of a dose-response curve or criteria. We term these the "unprocessed" estimates. This estimate is the number of times individual animats or animals are likely to be exposed to the acoustic environment that is a result of training or testing activities, regardless of whether they are injured or respond in a way that would significantly disrupt normal behavioral patterns as a result of that exposure. In most cases, the number of animals "taken" (under the ESA) by an action would be a subset of the number of animals that are exposed to the action because (1) in some circumstances, animals might not respond to an exposure or (2) some responses may be negative for an individual animal without constituting a form of "take" under the ESA. A second set of exposure estimates ("model-estimated") of listed species were generated and "processed" using dose-response curves and criteria for TTS and PTS developed by the Navy and NMFS' Permits Division.

Any modeled instances of injury and mortality are further analyzed to account for the mitigation proposed by the Navy to avoid impacts to marine mammals and avoidance responses that would be expected from individual animals once they sense the presence of Navy acoustic stressors (post-processing; see the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g)). Procedural mitigation measures are expected to reduce the likelihood of injury or mortality, but would not further reduce potential behavioral response impacts to lesser impacts due to the potential distance from the source stressor. Consideration of avoidance and mitigation reduces some modeled instances of injury to instances of non-injurious effects (e.g., a significant disruption of normal behavioral patterns), but such impacts are not reduced in the post-processing stage. The final take estimates for marine mammals (for sea turtles and explosives, see Section 9.2.2.1) from acoustic stressors are the result of the acoustic analysis, including acoustic effects analysis, followed by consideration of animal avoidance of multiple exposures and Navy mitigation measures. We consider 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 impacts (e.g., non-auditory injury, PTS, TTS, significant disruption of behavior) resulting from this analysis are reasonably certain to occur.

Range to Effects

The following tables provide range to effects for sonar and other active acoustic sources to these specific criteria, as they were used in NAEMO. Marine mammals within these ranges would be predicted to receive the associated effect. The ranges to the PTS threshold for an exposure of 30 seconds are shown in Table 64 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 m per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to the maximum distance at which PTS is possible for each hearing group. For a SQS-53C (i.e., bin MF1) sonar transmitting for 30 seconds at 3 kHz and a source level of 235 dB re 1 μPa^2-s at 1 m, the average range to PTS for the low-frequency cetaceans extends from the source to a range of 65 m. PTS ranges for all other functional hearing groups are much shorter. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 to 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: 10 knots is the speed used in NAEMO). As a result, there is no overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 m per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

Table 64. Range to PTS for five representative sonar systems (Navy 2018d).

Hearing Group	Approximate PTS (30 seconds) Ranges (m)[1]				
	Sonar bin LF5 (Low Frequency Sources <180 dB Source level)	Sonar bin MF1 (e.g., SQS-53 ASW Hull Mounted Sonar)	Sonar bin MF4 (e.g., AQS-22 ASW Dipping Sonar)	Sonar bin MF5 (e.g., SSQ-62 ASW Sonobuoy)	Sonar bin HF4 (e.g., SQS-20 Mine Hunting Sonar)
Low-frequency Cetacean	0 (0—0)	65 (65—65)	14 (0—15)	0 (0—0)	0 (0—0)
Mid-frequency Cetacean	0 (0—0)	16 (16—16)	3 (3—3)	0 (0—0)	1 (0—2)
Otariids	0 (0—0)	6 (6—6)	0 (0—0)	0 (0—0)	0 (0—0)
Phocids	0 (0—0)	45 (45—45)	11 (11—11)	0 (0—0)	0 (0—0)

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

The tables below illustrate the range to TTS for 1, 30, 60, and 120 seconds from five representative sonar systems (See Table 65 through Table 69). Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to add together, further increasing the range to onset-TTS.

Table 65. Ranges to TTS for sonar bin low frequency (LF) 5 over a representative range of environments within the action area (Navy 2018d).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin LF5 (Low Frequency Sources <180 dB Source Level)			
	1 sec	30 sec	60 sec	120 sec
Low-frequency Cetacean	3 (0—4)	3 (0—4)	3 (0—4)	3 (0—4)
Mid-frequency Cetacean	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
Otariids	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
Phocids	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)

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

Table 66. Ranges to TTS for sonar bin mid-frequency (MF) 1 over a representative range of environments within the action area (Navy 2018d).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin MF1 (e.g., SQS-53 ASW Hull Mounted Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetacean	903 (850—1,025)	903 (850—1,025)	1,264 (1,025—2,275)	1,839 (1,275—3,025)
Mid-frequency Cetacean	210 (210—210)	210 (210—210)	302 (300—310)	379 (370—390)
Otariids	65 (65—65)	65 (65—65)	106 (100—110)	137 (130—140)
Phocids	669 (650—725)	669 (650—725)	970 (900—1,025)	1,075 (1,025—1,525)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the action area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Note: Ranges for 1-sec and 30-sec periods are identical for Bin MF1 because this system nominally pings every 50 seconds, therefore these periods encompass only a single ping.

Table 67. Ranges to TTS for sonar bin MF4 over a representative range of environments within the action area (Navy 2018d).

Functional Hearing Group	**Approximate TTS Ranges (m)[1]**			
	Sonar Bin MF4 (e.g., AQS-22 ASW Dipping Sonar)			
	1 second	**30 seconds**	**60 seconds**	**120 seconds**
Low-frequency Cetacean	77 (0—85)	162 (150—180)	235 (220—290)	370 (310—600)
Mid-frequency Cetacean	22 (22—22)	35 (35—35)	49 (45—50)	70 (70—70)
Otariids	8 (8—8)	15 (15—15)	19 (19—19)	25 (25—25)
Phocids	65 (65—65)	110 (110—110)	156 (150—170)	269 (240—460)

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

Table 68. Ranges to TTS for sonar bin MF5 over a representative range of environments within the action area (Navy 2018d).

Functional Hearing Group	**Approximate TTS Ranges (m)[1]**			
	Sonar Bin MF5 (e.g., SSQ-62 ASW Sonobuoy)			
	1 second	**30 seconds**	**60 seconds**	**120 seconds**
Low-frequency Cetacean	10 (0—12)	10 (0—12)	14 (0—18)	21 (0—25)
Mid-frequency Cetacean	6 (0—9)	6 (0—9)	12 (0—13)	17 (0—21)
Otariids	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
Phocids	9 (8—10)	9 (8—10)	14 (14—16)	21 (21—25)

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

Table 69. Ranges to TTS for sonar bin high frequency (HF) 4 over a representative range of environments within the action area (Navy 2018d).

Functional Hearing Group	Approximate TTS Ranges (m)[1]			
	Sonar Bin HF4 (e.g., SQS-20 Mine Hunting Sonar)			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency Cetacean	1 (0—3)	2 (0—5)	4 (0—7)	6 (0—11)
Mid-frequency Cetacean	10 (4—17)	17 (6—35)	24 (7—60)	34 (9—90)
Otariids	0 (0—0)	0 (0—0)	0 (0—0)	1 (0—1)
Phocids	2 (0—5)	5 (2—8)	8 (3—13)	11 (4—22)

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

The range to received sound levels in 6-dB steps from five representative sonar bins and the percentage of animals that may exhibit a potentially significant behavioral response under each behavioral response function are shown in Table 70 through Table 74. Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group that are therefore not included in the estimated take. Table 70 illustrates the potentially significant behavioral response for low frequency active sonar. Table 71 through Table 73 illustrates the potentially significant behavioral response for mid-frequency active sonar. Table 74 illustrates the range to a potentially significant behavioral response for high-frequency active sonar.

Table 70. Ranges to a potentially significant behavioral response for an example low frequency sonar bin (LF5) over a representative range of environments within the action area (Navy 2018d).

Received Level (dB re 1 μPa)	Mean Range (m) with minimum to maximum values in parentheses	Probability of Behavioral Response		
		Odontocetes	Mysticetes	Pinnipeds
178	1 (0—1)	97%	59%	92%
172	2 (1—2)	91%	30%	76%
166	4 (1—6)	78%	20%	48%
160	10 (1—13)	58%	18%	27%
154	21 (1—25)	40%	17%	18%
148	46 (1—60)	29%	16%	16%
142	104 (1—140)	25%	13%	15%
136	242 (120—430)	23%	9%	15%
130	573 (320—1,275)	20%	5%	15%
124	1,268 (550—2,775)	17%	2%	14%
118	2,733 (800—6,525)	12%	1%	13%
112	5,820 (1,025—18,275)	6%	0%	9%
106	13,341 (1,275—54,525)	3%	0%	5%
100	31,026 (2,025—100,000*)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 km from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 μPa^2 - s: decibels referenced to 1 micropascal squared second; m: meters

Table 71. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF1) over a representative range of environments within the action area (Navy 2018d).

Received Level (dB re 1 µPa)	Mean Range (m) with minimum to maximum values in parentheses	Probability of Behavioral Response		
		Odontocetes	Mysticetes	Pinnipeds
196	109 (100—150)	100%	100%	100%
190	257 (220—370)	100%	98%	99%
184	573 (400—1,000)	99%	88%	98%
178	1,235 (725—3,525)	97%	59%	92%
172	3,007 (875—9,775)	91%	30%	76%
166	6,511 (925—19,525)	78%	20%	48%
160	11,644 (975—36,275)	58%	18%	27%
154	18,012 (975—60,775)	40%	17%	18%
148	26,037 (1,000—77,525)	29%	16%	16%
142	33,377 (1,000—100,000*)	25%	13%	15%
136	41,099 (1,025—100,000*)	23%	9%	15%
130	46,618 (3,275—100,000*)	20%	5%	15%
124	50,173 (3,525—100,000*)	17%	2%	14%
118	52,982 (3,775—100,000*)	12%	1%	13%
112	56,337 (4,275—100,000*)	6%	0%	9%
106	60,505 (4,275—100,000*)	3%	0%	5%
100	62,833 (4,525—100,000*)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 km from the sound source.*

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 µPa^2 - s: decibels referenced to 1 micropascal squared second; m: meters

Table 72. Ranges to potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF4) over a representative range of environments within the action area (Navy 2018d).

Received Level (dB re 1 µPa)	Mean Range (m) with minimum to maximum values in parentheses	Probability of Behavioral Response		
		Odontocetes	Mysticetes	Pinnipeds
196	8 (1—10)	100%	100%	100%
190	17 (1—21)	100%	98%	99%
184	35 (1—40)	99%	88%	98%
178	71 (1—95)	97%	59%	92%
172	156 (110—410)	91%	30%	76%
166	431 (280—1,275)	78%	20%	48%
160	948 (490—3,525)	58%	18%	27%
154	1,937 (750—10,025)	40%	17%	18%
148	3,725 (1,025—20,525)	29%	16%	16%
142	7,084 (1,525—38,525)	25%	13%	15%
136	11,325 (1,775—56,275)	23%	9%	15%
130	16,884 (1,775—74,275)	20%	5%	15%
124	24,033 (2,275—80,775)	17%	2%	14%
118	31,950 (2,275—100,000*)	12%	1%	13%
112	37,663 (2,525—100,000*)	6%	0%	9%
106	41,436 (2,775—100,000*)	3%	0%	5%
100	44,352 (2,775—100,000*)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 km from the sound source.*
Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 µPa^2 - s: decibels referenced to 1 micropascal squared second; m: meters.

Table 73. Ranges to a potentially significant behavioral response for an example mid-frequency sonar bin (i.e., MF5) over a representative range of environments within the action area (Navy 2018d).

Received Level (dB re 1 µPa)	Mean Range (m) with minimum to maximum values in parentheses	Probability of Behavioral Response		
		Odontocetes	Mysticetes	Pinnipeds
196	0 (0—0)	100%	100%	100%
190	2 (1—3)	100%	98%	99%
184	4 (1—9)	99%	88%	98%
178	14 (1—18)	97%	59%	92%
172	29 (1—35)	91%	30%	76%
166	61 (1—80)	78%	20%	48%
160	141 (1—400)	58%	18%	27%
154	346 (1—1,000)	40%	17%	18%
148	762 (420—2,525)	29%	16%	16%
142	1,561 (675—5,525)	25%	13%	15%
136	2,947 (1,025—10,775)	23%	9%	15%
130	5,035 (1,025—17,275)	20%	5%	15%
124	7,409 (1,275—22,525)	17%	2%	14%
118	10,340 (1,525—29,525)	12%	1%	13%
112	13,229 (1,525—38,025)	6%	0%	9%
106	16,487 (1,525—46,025)	3%	0%	5%
100	20,510 (1,775—60,525)	1%	0%	2%

** Indicates maximum range of acoustic model, a distance of approximately 100 km from the sound source.*

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (See Table 4 for behavioral cut-off distances). dB re 1 µPa^2 - s: decibels referenced to 1 micropascal squared second; m: meters.

Table 74. Ranges to a potentially significant behavioral response for an example high frequency sonar bin (i.e., HF4) over a representative range of environments within the action area (Navy 2018d).

Received Level (dB re 1 µPa)	Mean Range (m) with minimum to maximum values in parentheses	Probability of Behavioral Response		
		Odontocetes	Mysticetes	Pinnipeds
196	3 (1—6)	100%	100%	100%
190	8 (1—14)	100%	98%	99%
184	18 (1—35)	99%	88%	98%
178	37 (1—100)	97%	59%	92%
172	78 (1—300)	91%	30%	76%
166	167 (1—725)	78%	20%	48%
160	322 (25—1,525)	58%	18%	27%
154	555 (45—3,775)	40%	17%	18%
148	867 (70—6,775)	29%	16%	16%
142	1,233 (150—12,775)	25%	13%	15%
136	1,695 (260—20,025)	23%	9%	15%
130	2,210 (470—29,275)	20%	5%	15%
124	2,792 (650—40,775)	17%	2%	14%
118	3,421 (950—49,775)	12%	1%	13%
112	4,109 (1,025—49,775)	6%	0%	9%
106	4,798 (1,275—49,775)	3%	0%	5%
100	5,540 (1,275—49,775)	1%	0%	2%

Notes: dB re 1 µPa² - s: decibels referenced to 1 micropascal squared second; m: meters

Exposure Estimates

As described above, for acoustic stressors, we considered exposure estimates from the Phase III NAEMO model at two output points for marine mammals (i.e., unprocessed and final take estimates). The Navy provided NMFS with the total estimated number of unprocessed exposures from acoustic and explosive stressors (i.e., estimates were not broken out between the different acoustic stressors and explosives). This information is presented in Table 75 below. The NAEMO output estimates that ESA-listed marine mammals will be exposed to these stressors throughout the year. Table 75 provides the maximum annual number of unprocessed exposures for each marine mammal species considered in this opinion. The estimates include exposures from both annual and non-annual training and testing activities. In most years, the number of exposures would be less than listed below as some activities are not conducted every year but all potential acoustic exposures from sonar and explosives were included to generate conservative estimates of impacts to marine mammals.

Table 75. Unprocessed exposure estimates of ESA-listed marine mammals to acoustic and explosive stressors.

Species	Unprocessed exposures			
	> 121 dB	> 163 dB	>181 dB	> 205 dB
Blue whales	34,876	4,283	735	8
Fin whales	41,782	4,850	898	11
Gray whales – Western North Pacific DPS	125	20	6	<1
Humpback whales* – Mexico and Central America DPSs	213,978	17,953	2,876	46
Sei whales	5,039	423	67	1
Sperm whales	71,643	6,119	841	22
False killer whales – Main Hawaiian Islands Insular DPS	6,554	639	85	5
Guadalupe fur seals	391,473	48,091	8,434	103
Hawaiian monk seals	5,533	417	126	15

**Note: The unprocessed exposure estimates for humpback whales also includes unprocessed exposures for Hawaii DPS humpback whales which are not listed under the ESA.*

As described previously in the introduction to Section 9.2, only a subset of the unprocessed exposures presented in Table 75 are expected to result in PTS, TTS, or a significant behavioral response (i.e., take as defined under the ESA), based on the criteria and thresholds described in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). Table 76 lists the marine mammal take estimates for Navy training and testing activities using sonar and other transducers conducted annually in the action area. Only the most severe impact expected (i.e., PTS>TTS>behavioral) is quantified in this table. Instances of PTS or TTS are expected to have associated behavioral responses.

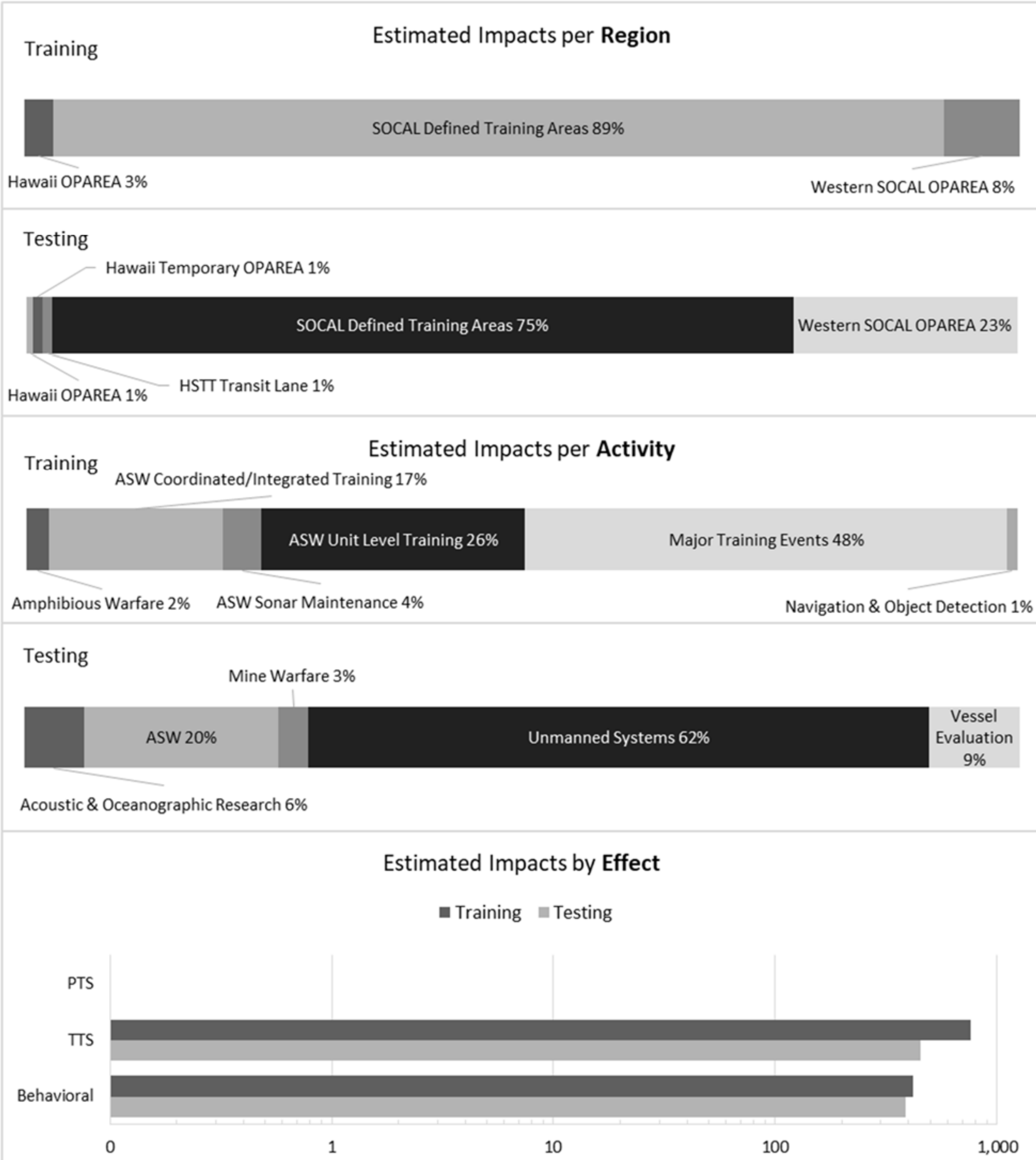
Table 76. Estimated ESA-listed marine mammal impacts (i.e., PTS, TTS, or significant behavioral disruption) per year from sonar and other transducers during training and testing activities.

Species	Location/DPS	Estimated Annual Training Impacts			Estimated Annual Testing Impacts			Total Estimated Annual Impacts		
		Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS
Suborder Mysticeti (baleen whales)										
Family Balaenopteridae (rorquals)										
Blue whale	Hawaii/NA*	9	25	0	6	8	0	15	33	0
	SOCAL/NA	408	739	0	383	444	0	791	1183	0
Fin whale	SOCAL/NA	457	781	0	378	595	0	835	1376	0
	Hawaii/NA	14	19	0	7	8	0	21	27	0
Humpback whale*	SOCAL/Central America DPS	156	428	0	126	160	0	282	588	0
	SOCAL/Mexico DPS	65	591	0	133	312	0	198	903	0
Sei whale	SOCAL/NA	15	37	0	12	14	0	27	51	0
	Hawaii/NA	28	90	0	18	31	0	46	121	0
Family Eschrichtiidae										
Gray whale	SOCAL/Western North Pacific DPS	1	3	0	1	1	0	2	4	0
Suborder Odontoceti (toothed whales)										
Family Physeteridae (sperm whale)										
Sperm whale	SOCAL/NA	1,351	43	0	1,084	10	0	2,435	53	0
	Hawaii/NA	1,691	23	0	775	7	0	2,466	30	0
Family Delphinidae (dolphins)										

Species	Location/DPS	Estimated Annual Training Impacts			Estimated Annual Testing Impacts			Total Estimated Annual Impacts		
		Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS
False killer whale	Hawaii/Main Hawaiian Islands Insular DPS	394	10	0	178	6	0	572	16	0
Suborder Pinnipedia										
Family Otariidae (eared seals)										
Guadalupe fur seal	SOCAL/NA	506	12	0	936	3	0	1442	15	0
Family Phocidae (true seals)										
Hawaiian monk seal	Hawaii/NA	92	44	0	48	12	0	140	56	0

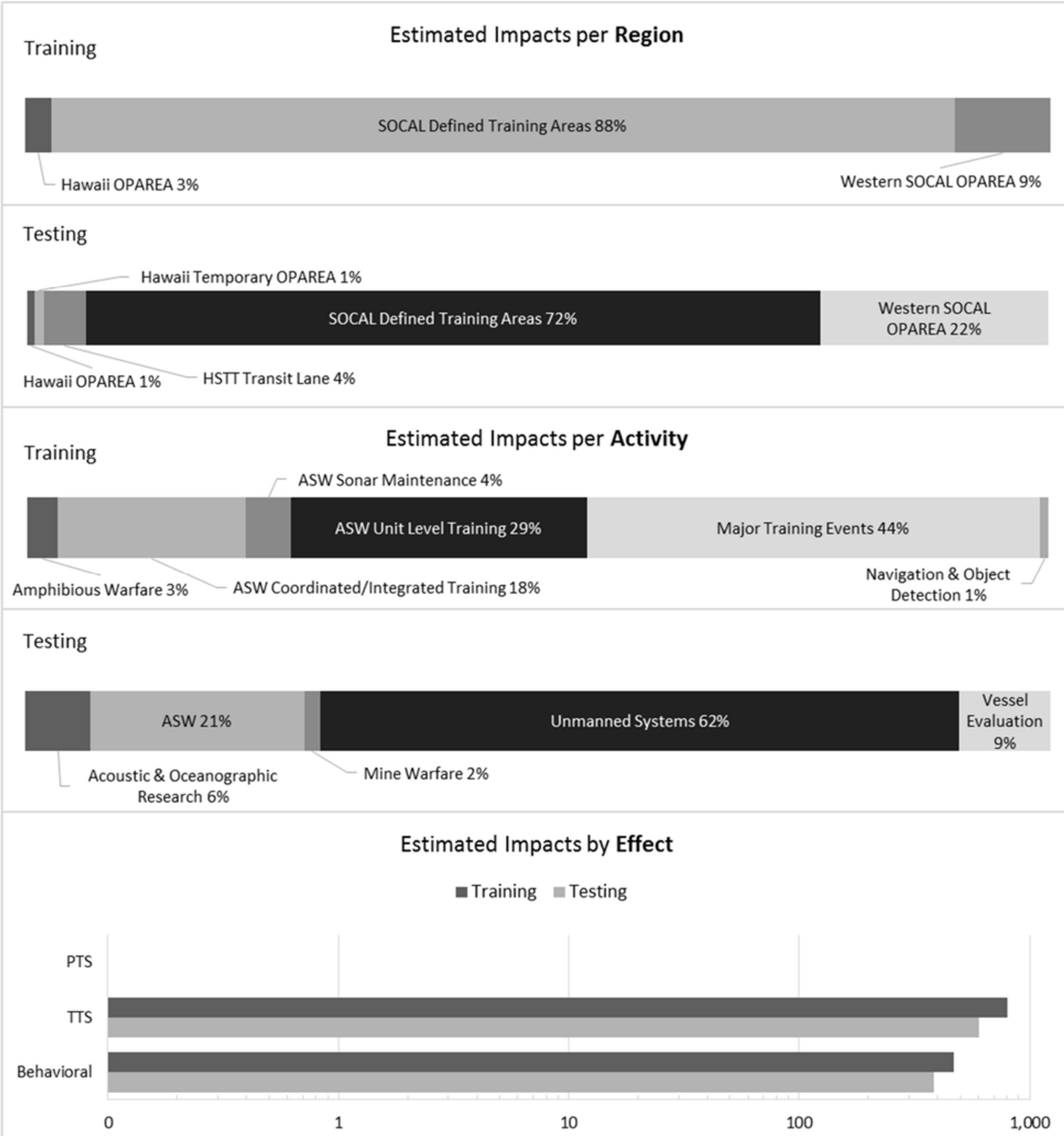
PTS: permanent threshold shift; TTS: temporary threshold shift.
**NA indicates impacts are anticipated to a rangewide population, as listed under the ESA.*

Figure 65 through Figure 73 break these estimates of TTS, and significant behavioral disruption down by region within the action area and activity category. No marine mammal PTS is anticipated from the use of sonar or other transducers during training and testing. There is a potential for impacts to occur anywhere within the action area where sound from sonar and ESA-listed marine mammal species overlap. Only activity categories where 0.5 percent or greater of the impacts are estimated to occur are presented in the tables.



Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. ASW: Anti-Submarine Warfare

Figure 65. Blue whale impacts estimated per year from sonar and other transducers in the action area.

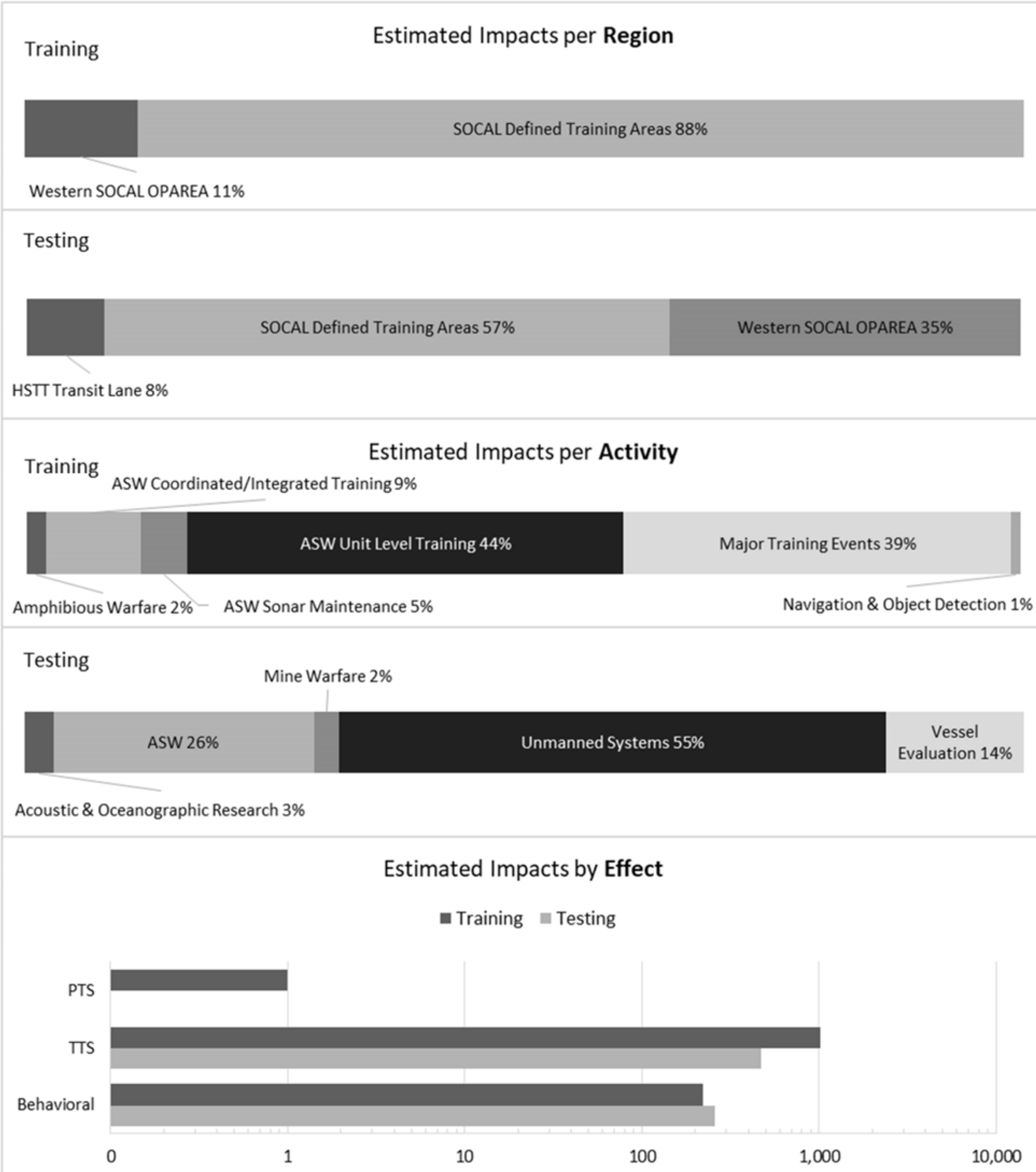


Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. ASW: Anti-Submarine Warfare

Figure 66. Fin whale impacts estimated per year from sonar and other transducers in the action area.

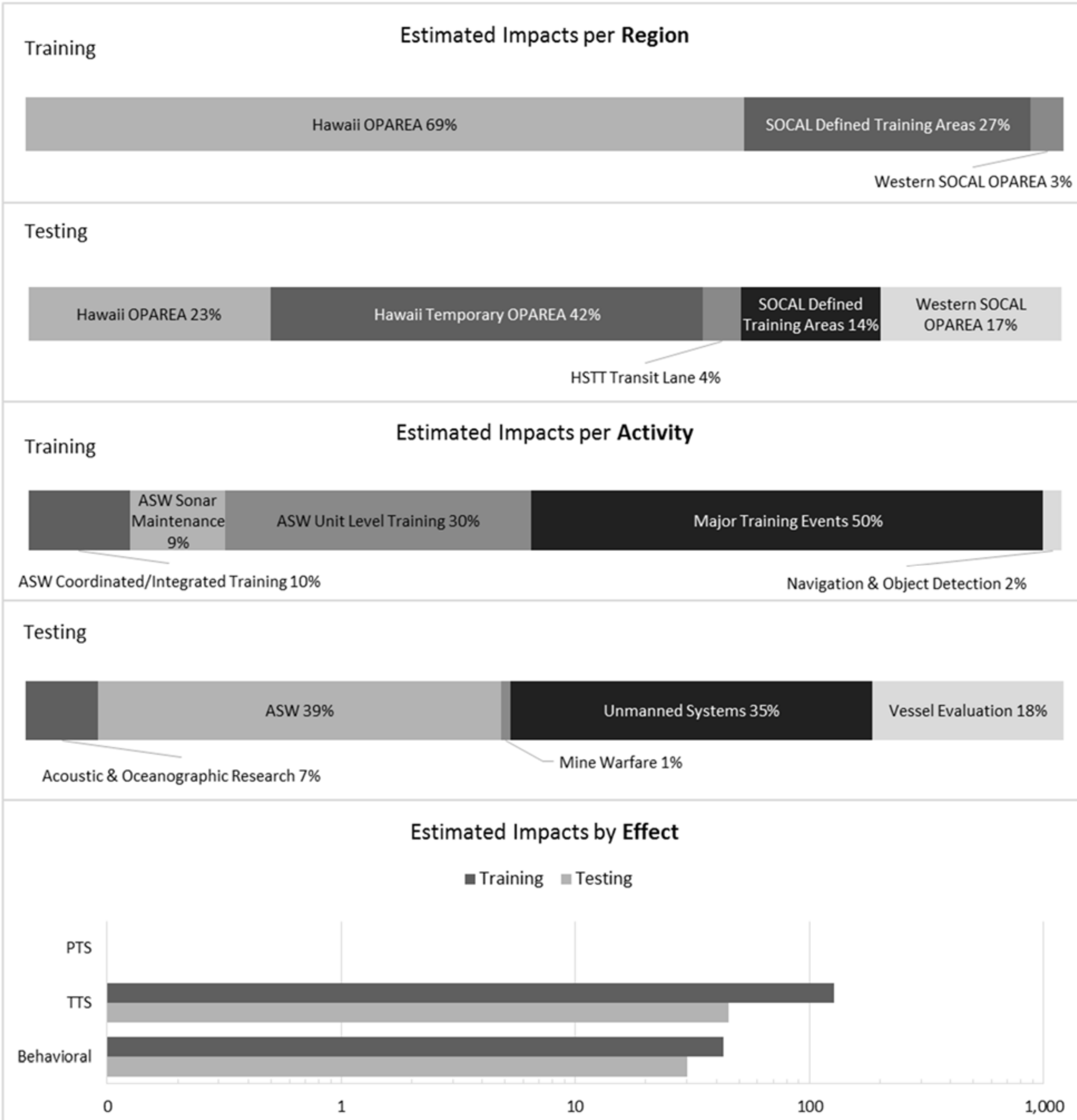
Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this stock. 100% Western North Pacific Stock. ASW: Anti-Submarine Warfare.

Figure 67. Western North Pacific DPS gray whale impacts estimated per year from sonar and other transducers in the action area.



Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. ASW: Anti-Submarine Warfare

Figure 68. Humpback whale impacts estimated per year from sonar and other transducers in the action area.



Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. ASW: Anti-Submarine Warfare

Figure 69. Sei whale impacts estimated per year from sonar and other transducers in the action area.

Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species.
ASW: Anti-Submarine Warfare

Figure 70. Sperm whale impacts estimated per year from sonar and other transducers in the action area.

Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. ASW: Anti-Submarine Warfare

Figure 71. Main Hawaiian Islands Insular DPS False killer whale impacts estimated from sonar and other transducers in the action area.

Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species.

Figure 72. Guadalupe fur seal estimated impacts from sonar and other transducers in the action area.

Region and Activity bar charts show categories +/- 0.5 percent of the estimated impacts. No PTS is estimated for this species. 100% Hawaiian Stock. ASW: Anti-Submarine Warfare.

Figure 73. Hawaiian monk seal impacts estimated per year from sonar and other transducers in the action area.

As stated previously, the take estimates presented above and analyzed in this opinion are based on Navy modeling, as described in Section 2.2. The modeling conclusions from the Navy's analysis represent the best available data on exposure of marine mammals to acoustic stressors from the proposed action, but there is uncertainty. When the Navy's modeling is conducted, proposed activities are modeled as occurring in certain locations based on the Navy's assessment of where these activities are most likely to occur in the future. The Navy will submit annual reports to NMFS that provide information on whether or not training and testing activities were implemented as was assumed during the modeling exercise.

9.2.1.1.3 Response Analysis

Section 9.2.1.1.1 described the range of potential responses of ESA-listed marine mammals to sonar and other transducers associated with the proposed action. Given the above estimated exposure of ESA-listed marine mammals to sonar and other transducers associated with the proposed action, in this section we describe the likely responses of these species to this exposure. This includes behavioral responses and sound-induced hearing loss (i.e., TTS and PTS), as well as other possible responses (e.g., stress) that cetaceans may exhibit to exposure to sound fields from sonar and other transducers. Our aim with this response analysis is to assess the potential responses 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. In cases where data on the responses of the ESA-listed species considered in this opinion to sonar and other transducers are not available, we rely on data from other closely-related species. In addition, we rely on information on the responses of ESA-listed species, as well as other related species, to anthropogenic sound sources other than military sonars (e.g., seismic air guns). We recognize that there can be species and sound-specific responses, and even within species, not all individual animals are likely to respond to all sounds in the same way. Nonetheless, by examining the range of responses that ESA-listed and other related species exhibit to anthropogenic sounds, we incorporate uncertainty in our analysis that stems from intra- and inter-species response heterogeneity and make use of the best available science.

Hearing Threshold Shifts

Whether or not a hearing threshold shift will impact an individual animal's fitness depends on the duration, frequency, and magnitude of the shift. The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. As described previously, the Navy uses sonars operating at a wide range of frequencies (i.e., from low frequency sources to extremely high frequency sources). Cetaceans that experience TTS from sonar sounds are likely to have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Some instances of hearing threshold shift are likely to occur at frequencies utilized by animals for acoustic cues. For example, during the period that a marine mammal has hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. Killer whales are a primary predator of mysticetes and pinnipeds. Some hearing loss could make killer whale calls more difficult to detect until hearing recovers. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete's ability to locate prey or rate of feeding. Odontocetes do use sound to find and capture prey underwater and it is thought that pinnipeds do the same. Therefore, it could be more difficult for odontocetes or pinnipeds with TTS to locate food for a short period before their hearing recovers. Because TTS would likely be minor to moderate (less than 20 dB of TTS) and last for a short period of time, costs would likely be not be consequential to the animal long term.

The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to several days to fully recover, depending on the magnitude of the initial threshold shift. Instances of TTS resulting from Navy training and testing activities are expected to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Though there is uncertainty, this relatively short recovery time is supported by available information from the literature (e.g., Finneran 2015). Exposures resulting in TTS are expected to be short term and of relatively low received level because of animal avoidance and the transient nature of most Navy sonar sources. Behavioral research (See Section 9.2.1.1.1.5) indicates that marine mammals most often will avoid sound sources at levels that would cause hearing loss, particularly more severe instances of TTS or PTS. Additionally, most Navy sonar sources are not stationary, minimizing the likelihood that an animal would remain in close proximity to the source for periods of time that could result in more severe instances of TTS (i.e., because marine mammals generally avoid loud sources of anthropogenic sound). Despite these factors that are expected to minimize the severity of TTS, we assume that some (See Table 76 for estimates) blue, fin, gray, humpback, sei, sperm, and MHI IFKWs, as well as Guadalupe fur and Hawaiian monk seals will experience TTS as the result of being exposed to sonar and other transducers from Navy training and testing activities. As is the nature of TTS, such effects would be temporary and exposed individuals' hearing is expected to return to normal within minutes to days.

Also important to consider is the potential for repeat instances of TTS due to exposure to Navy sonar. In some exposure scenarios, it is possible that a particular animal will be exposed to sonar resulting in TTS and then, prior to being fully recovered, will be exposed again at a level resulting in TTS. Experimental studies have not explored such scenarios, so there is uncertainty as to how long recovery would take in these particular cases. It is possible that repeat instances of TTS could result in PTS. This has been shown in terrestrial animals (e.g., Kujawa and Liberman 2009; Lin et al. 2011a), and in one case, marine mammals as well (Kastak et al. 2008).

Behavioral responses

The Navy uses a behavioral response function to quantify the number of behavioral responses that could qualify as a significant behavioral disruption. Under the behavioral response function, a wide range of behavioral reactions may qualify as significant, including but not limited to avoidance of the sound source, temporary changes in vocalizations or dive patterns, temporary avoidance of an area, or temporary disruption of feeding, migrating, or reproductive behaviors. The estimates calculated using the behavioral response functions (See Section 2.2.1.2.2) do not differentiate between the different types of potential reactions nor the significance of those potential reactions. These estimates also do not provide information regarding the potential fitness or other biological consequences of the reactions on the affected individuals. Therefore, our analysis considers the available scientific evidence to determine the likely nature of modeled behavioral responses and potential fitness consequences for affected individuals.

The range of potential behavioral responses due to sonar exposure is presented in Section 9.2.1.1.1.5. There are two general categories of information available regarding the likely responses of marine mammals to sonar exposure: 1) information from controlled exposure experiments, and 2) information from opportunistic observations during the operation of real world sonar. This research shows that cetacean response to acoustic disturbance varies, depending on the characteristics of the sound source, the animal's experience with the sound source, and their behavioral state (e.g., migrating, breeding, feeding) at the time of the exposure.

As presented in a review by Southall et al. (2016), common responses to sonar during controlled exposure experiments include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, and cessation of foraging. More minor reactions have also been observed including alerting to the sound source and startle responses. Southall et al. (2016) found that many, but not all responses of cetaceans to sonar observed so far have been relatively mild and/or brief. For example, both Goldbogen et al. (2013a) and Melcon et al. (2012) indicated that behavioral responses to simulated or operational sonar were temporary, with whales resuming normal behavior quickly after the cessation of sound exposure. Further, responses were discernible for whales in certain behavioral states (i.e., deep feeding), but not in others (i.e., surface feeding). In summarizing the response of blue whales to mid-frequency sonar, Goldbogen et al. (2013a) states, "We emphasize that elicitation of the response is complex, dependent on a suite of contextual (e.g., behavioral state) and sound exposure factors (e.g., maximum received level), and typically involves temporary avoidance responses that appear to abate quickly after sound exposure." If individual ESA-listed marine mammals briefly respond to underwater sound from Navy training and testing (e.g., by slightly changing their behavior or temporarily relocating a short distance), the effects can be considered a behavioral response, but are unlikely to be significant to the animal unless that interruption is repeated many times. However, Southall et al. (2016) noted the short-term experiments designed to elicit behavioral responses from marine mammals due to sonar exposure were deliberately designed not to harm the affected animals.

Melcon et al. (2012) reported that baleen whales (i.e., blue whales) exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls (D calls) usually associated with feeding behavior. However, they were unable to determine if suppression of D calls reflected a change in their feeding performance or abandonment of foraging behavior and indicated that implications of the documented responses are unknown. Goldbogen et al.

(2013a) speculated that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment in most cases following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a).

While the Navy implements a series of mitigation measures to minimize high level sonar exposures during training and testing events, the responses of animals to real world Navy sonar could vary from the small scale, short-term controlled exposure experiments reviewed by Southall et al. (2016). Most of the studies reviewed by Southall et al. (2016) involved a single platform transmitting sonar or another sound source for a short period of time. This is in contrast to what would be expected during some Navy activities (e.g., MTEs) involving sonar where multiple vessels are operating concurrently in close proximity, during an exercise that lasts for an extended period of time (i.e., multiple days to weeks). The response of an animal to an initial exposure during such an event may be different than what could be expected if an animal is exposed multiple times or for a long period of time during an event. Additionally, while these studies can implement controls for some variables (e.g., the distance and movement of the source), they also introduce additional variables that do not normally occur in a real Navy training or testing activity, including the tagging of whales, intentionally following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation.

Because of the limitations associated with controlled exposure experiments, it is also important to consider studies that opportunistically observed the response of cetaceans to real world Navy sonar. Passive acoustic monitoring and visual observational behavioral response studies have been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real testing and training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2016; Manzano-Roth et al. 2016; Martin et al. 2015; Mccarthy et al. 2011; Mobley and Deakos 2015; Moretti et al. 2014; Tyack et al. 2011b). Collectively, these studies have indicated that responses vary, and include avoidance of the area of sonar exposure, cessation or modification of vocal behavior, changes in dive behavior, and cessation of foraging. In addition, some aerial, visual, and acoustic monitoring is conducted before, during and after training events to ascertain whether behavioral responses occurred or could be observed during training and look for injured or stranded animals after training (Campbell et al. 2010; Farak et al.

2011; HDR 2011; Navy 2011b; Navy 2013a; Navy 2014b; Navy 2015; Norris et al. 2012; Smultea and Mobley 2009; Smultea et al. 2009; Trickey et al. 2015). During all of these monitoring efforts, only a few behavioral responses have been observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed, but typically before the event, or appeared to have been deceased prior to the event; Smultea et al. 2011). However, it should be noted that passive acoustic studies are limited to observations of vocally-active marine mammals and visual studies are limited to what can be observed at the surface. These study types do have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies.

The limitations of opportunistic observations (e.g., limited to observations of vocally-active marine mammals or animals at the surface, limited ability to monitor animal activity long-term, limited ability to control other variable which could impact animal behavior [e.g., prey distribution]) result in some uncertainty as to the likely responses of ESA-listed cetaceans due to sonar exposure. Forney et al. (2017) noted that species that respond to noise (e.g., from military sonars) by avoiding an area are unlikely to be observed using traditional methods (e.g., lookouts or passive acoustic monitoring) because animals react at distances far greater than the detection range of these methods. They suggest that individuals that are observed must be considered relatively tolerant of anthropogenic noise.

In summary, the available information indicates a range of behavioral responses to sonar may occur, but most responses are expected to be brief, with the animal returning to baseline behavior shortly after the exposure is over. However, as noted by Forney et al. (2017), there is uncertainty due to the limitations of observing marine mammal response to sonar in the wild.

Masking (auditory interference)

The potential effects of masking were described in Section 9.2.1.1.1.4. Some limited masking could occur due to the Navy's use of sonar and other transducers 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. As stated previously, masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking from noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically-mediated cooperative behaviors such as foraging or reproductive activities.

Because traditional military sonars typically have low duty cycles, the effects of such masking are expected to be limited. The typical duty cycle with most tactical anti-submarine warfare is about once per minute with most active sonar pulses lasting no more than a few seconds (Navy 2013b). This indicates biologically-relevant sounds for individuals in close proximity would only be masked intermittently for a short time.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for sperm whales, but as explained below, these effects would only happen close to the source. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition, also operate at lower source levels. While the lower source levels of these systems limit the range of impact compared to more traditional systems, animals close to the sonar source could experience masking on a much longer time scale than those exposed to traditional sonars. However, this effect would only occur if the animals were to remain in close proximity to the source.

Non-auditory physical or physiological responses

The available research on the potential for sonar or other sources of anthropogenic noise to result in physiological responses (e.g., stress) is described in Section 9.2.1.1.1.3. 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.

9.2.1.1.4 Risk Analysis

In the exposure and response analysis, we established that a range of impacts including TTS, behavioral response, and stress are likely occur due to exposure to Navy sonar during training and testing events. In this, section we assess the likely consequences of the responses to the individuals that have been exposed. We determined that the potential effects of masking from sonar are limited because of the duty cycles of most military sonars and the transient nature of sonar use, so we have concluded that there is little to no risk associated with exposure and response to masking. As such, the potential effects of masking will not be discussed further in this section. In order to consider the potential consequences of temporary hearing impacts, behavioral response, and stress to affected animals, we must 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.

Since 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, occur at a frequency utilized by the animal for acoustic cues, and are of a profound magnitude. A hearing threshold shift of limited duration, 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. Based on the literature cited in Section 9.2.1.1.1 and the response analysis, we expect instances of TTS from Navy sonar to be short-term and of relatively low severity because of animal avoidance and the transient nature of most Navy sonar sources.

The literature described in the response analysis and in Section 9.2.1.1.16.1.5 indicate that most behavioral responses that have been observed to sonar exposure are of mild to moderate severity, often lasting for the duration of the exposure. Some more severe reactions have been observed, but these have mostly been in cetacean species known to be particularly sensitive to acoustic disturbance (e.g., beaked whales; Southall et al. 2016), which are not listed under the ESA. Based on information available to date, the marine mammal species considered in this opinion are not thought to be particularly sensitive to acoustic disturbance. However, it is worth noting that the controlled exposure experiments reviewed by Southall et al. (2016) were deliberately designed to demonstrate the onset of response and not to produce adverse or permanent effects. Additionally, the limitations of opportunistic observations (e.g., limited to observations of vocally-active marine mammals or animals at the surface, limited ability to monitor animal activity long-term, limited ability to control other variables which could impact animal behavior [e.g., prey distribution]) result in some uncertainty as to the severity and duration of likely responses of ESA-listed marine mammals due to sonar exposure. Forney et al. (2017) noted that species that respond to noise (e.g., from military sonars) by avoiding an area are unlikely to be observed using traditional methods (e.g., lookouts or passive acoustic monitoring) because animals react at distances far greater than the detection range of these methods. They suggest that individuals that are observed must be considered relatively tolerant of anthropogenic noise.

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 sonar. 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. As described further in Section 3.3 (e.g., Table 11), several categories of training exercises (e.g., MTEs such as Composite Training Unit Exercises) are expected to result in hundreds of hours of sonar activity involving multiple platforms (i.e., surface vessels, submarines, and aircraft) utilizing sonar. These exercises range in duration from two days to over ten, and therefore have the potential to result in sustained and/or repeat exposure. However, while MTEs may have a longer duration, they are not concentrated in small geographic areas over that time period. MTEs use thousands to tens of thousands of square miles of ocean space during the course of the event. 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 (e.g., within a few square miles), so there is a low likelihood that animals and Navy activities will 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. Calambokidis et al. (2015) merged existing published and unpublished information, along with expert judgment, on marine mammals along the United States west coast to identify Biologically Important Areas (BIAs) for some of the marine mammal species considered in this opinion. Many of these BIAs are identified by the activity that a particular species is likely to be engaged in within these areas (e.g., foraging), and may represent the best available information about the activities in which marine mammals are likely to be engaged at a certain time and place. If a behavioral response were to occur in these BIAs, we can make reasonable predictions as to the particular activity of an animal at the time of exposure. For example, for blue whales, Calambokidis et al. (2015) identified BIAs within the Southern California portion of the action area for foraging. If a behavioral response occurred in the foraging BIA, the expectation is that feeding would be interrupted. While some blue whale exposures could occur in these areas, it is worth noting that for Phase III training and testing activities, the Navy will implement restrictions on sonar and explosive use in some of these areas (See Section 3.4.2.2.3) in order to minimize potential impacts in known feeding areas.

It's important to note that the BIAs identified by Calambokidis et al. (2015) only consist of a portion of the range of habitats utilized by the species considered in this opinion in the action area.[23] For example, activities such as foraging are expected to occur in areas outside of the identified BIAs as well. Just because an exposure and associated response may not occur in an identified BIA, does not mean important activities will not be disrupted because of those exposures. Additionally, Calambokidis et al. (2015) were not able to identify BIA's for some activities (e.g., calving) for some species due to lack of available information. Therefore, the BIAs identified by Calambokidis et al. (2015) can help predict the activities of some animals in certain situations, but not all activities or species throughout the action area.

For some species, NMFS designated critical habitat can serve a similar purpose. For example, NMFS designated foraging critical habitat around the main Hawaiian Islands out to the 200 m depth contour for Hawaiian monk seals. Within these habitats, it is anticipated Hawaiian monk seals may be foraging so disruptions in these areas could be expected to constitute a disruption in foraging activity.

Also important to consider is an animal's prior experience with a sound source. The majority of animals exposed to sound from Navy training and testing 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, Baird et al. (2017b) found no large-scale avoidance by false killer whales of areas with

[23] Baird et al. (2015) identified BIAs for MHI IFKWs, but did not identify the BIAs by a specific activity (e.g., foraging or calving). The false killer whale BIAs were identified as areas of highest use of the species around the main Hawaiian Islands so this information is not useful in predicting what specific activity the animals may be engaged in when occupying these habitats.

relatively high mid-frequency active sonar use in the Pacific Missile Range Facility in Hawaii. The authors suggested that since sonar had been used at Pacific Missile Range Facility for over 30 years, it was likely that animals in this area had been exposed to sonar multiple times on previous occasions. The authors suggested that more naïve populations may be more likely to exhibit avoidance responses if exposed to sonar.

When considering the potential consequences of exposure and response to Navy sonar, we must also take into account the health of the individual animal affected. Individuals that are in good health, with sufficient energy reserves, are likely to be much more resilient when faced with long-term or repeated disturbance than an animal in poor condition. As described in Harris et al. (2017a), one approach to understanding the potential importance of a behavioral response is to consider an animal's energy budget. Marine mammal behavioral research has indicated that many species including humpback whales (Silve et al. 2016), blue whales (Goldbogen et al. 2013a), and sperm whales (Isojunno et al. 2016) may disrupt foraging when exposed to anthropogenic noise. If the animals are not able to make up for lost foraging opportunities due to such exposure, this could have consequences on the affected animal's available energy supply. For individuals in good health, with sufficient energy reserves, such a reduction could likely be compensated for at a later time, provided the animal is not subject to sustained disruption. However, for individuals in a compromised state, a reduction in available energy has a higher likelihood of being consequential, depending on the duration of the disruption (i.e., long duration disruptions would have a higher likelihood of being consequential).

Quantifying the fitness consequences of sub-lethal impacts 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 factor 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 (Costa et al. 2016c; Farmer et al. 2018; King et al. 2015a; 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 (Miller et al. 2009b) or involve the complete cessation of foraging, may result in an energetic loss to animals. Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (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. 2015a; NAS 2017; New et al. 2014; Southall et al. 2007f; 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 sonar 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 extremely unlikely and not reasonably certain to occur, and so focus our risk analysis on the energetic costs associated with a behavioral response.

To summarize, we would expect many exposures and potential responses of ESA-listed marine mammals to sonar and other transducers 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 behavior 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 marine mammals 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, or resting. If marine mammals exhibited a behavioral response to Navy sonar, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, responses to Navy sonar are anticipated to be short term and instances of hearing impairment 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. 2013a; 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. (2013a) suggested that if the documented temporary behavioral responses interrupted feeding behavior (e.g., as would be expected if a disturbance occurred in the blue whale BIAs in SOCAL), this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual animal could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would still be available in the environment following the cessation of acoustic exposure (i.e., sonar could cause scattering of prey, but would not be expected to injure or kill it). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long-term (Southall et al. 2007a).

Based on the estimated abundance of the ESA-listed marine mammals that are expected to occur in the action area, and the number of instances of behavioral disruption expected (i.e., estimates based on Navy modeling), some individuals of these species could be exposed, and respond, to Navy sonar more than once per year (Table 77). The highest number of behavioral disruptions per animal is anticipated to be of MHI IFKWs (i.e., 3.94 disruptions per animal). No other species is anticipated to experience more than two disruptions per animal annually. For some species, less than one disruption is anticipated per year. This indicates that some or many individuals within the population may not experience a single behavioral disruption due to Navy sonar.

Table 77. Estimated number of significant behavioral disruptions from Navy sonar and other transducers per species/DPS in the action area.

Species	Location/DPS	Estimated Abundance in the Action Area	Annual Behavioral Disruptions from Active Sonar	Annual Disruptions per Animal
Blue whale	Hawaii/NA*	81	48	0.59
	SOCAL/NA	1,647	1,974	1.20
Fin whale	SOCAL/NA	9,029	2,211	0.24
	Hawaii/NA	58	48	0.83
Humpback whale	SOCAL/Central America DPS	1,918	1,971	0.45
	SOCAL/Mexico DPS			
Sei whale	SOCAL/NA	519	78	0.15
	Hawaii/NA	178	167	0.94
Gray whale	SOCAL/Western North Pacific DPS	140	6	0.04
Sperm whale	SOCAL/NA	2,106	2,488	1.18
	Hawaii/NA	3,354	2,496	0.74
False killer whale	Hawaii/Main Hawaiian Islands Insular DPS	149	588	3.94
Guadalupe fur seal	SOCAL/NA	15,830	1,457	0.09

Species	Location/DPS	Estimated Abundance in the Action Area	Annual Behavioral Disruptions from Active Sonar	Annual Disruptions per Animal
Hawaiian monk seal	Hawaii/NA	1,324	196	0.15

Note that NMFS recognizes 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. Some individuals from each species could experience a few more or less disruptions annually than what is presented in Table 77. 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 sonar annually. The estimates presented in Table 77 should not be viewed as exact. Instead, these estimates were presented to indicate the relative magnitude of likely exposures on an annual basis.

Areas of high use by main MHI IFKWs are in the action area (Figure 74). Baird et al. (2012b), found that compared with low use areas, these areas had higher productivity. The authors suggested the areas were high use likely because of increased foraging success compared with some other areas within the species range. Much of the high use areas are from 45m to 3200m depth contour where the Navy conducts fewer of the more sonar-intense activities such as major training exercises. However some portions of areas of higher use by insular false killer whales, primarily the Alenuihaha and Kaiwi Channels, areas to the north of Molokai and Oahu, and south of Oahu do overlap with anti-submarine warfare training using sonar or other active transducers, so animals within the high-use areas could be exposed during those events. As discussed above, false killer whale reactions to sonar are most likely short-term and mild to moderate, especially when sound sources are located more than a few kilometers away or when the animals are engaged in important biological behaviors. Baird et al. (2014b; 2017a; 2013b) tagged four shallow-diving odontocete species (including MHI IFKWs) in Hawaii off the Pacific Missile Range Facility before Navy training events. Consistent with most other studies looking at the response of marine mammals to sonar, none of the tagged animals demonstrated a large-scale or long-term avoidance response to the sonar as they moved on or near the range. Due to the short term nature of the responses anticipated, and that disruptions to individual animals are anticipated to be infrequent (i.e., less than 4 per individual per year), we do not anticipate fitness consequences to individual MHI IFKWs. It is also noteworthy that the Navy's modeling to estimate exposure of marine mammals to sonar does not account for geographic mitigation proposed by the Navy (See Table 39) that will result in some of the highest use areas for MHI IFKWs being avoided during certain times of the year.

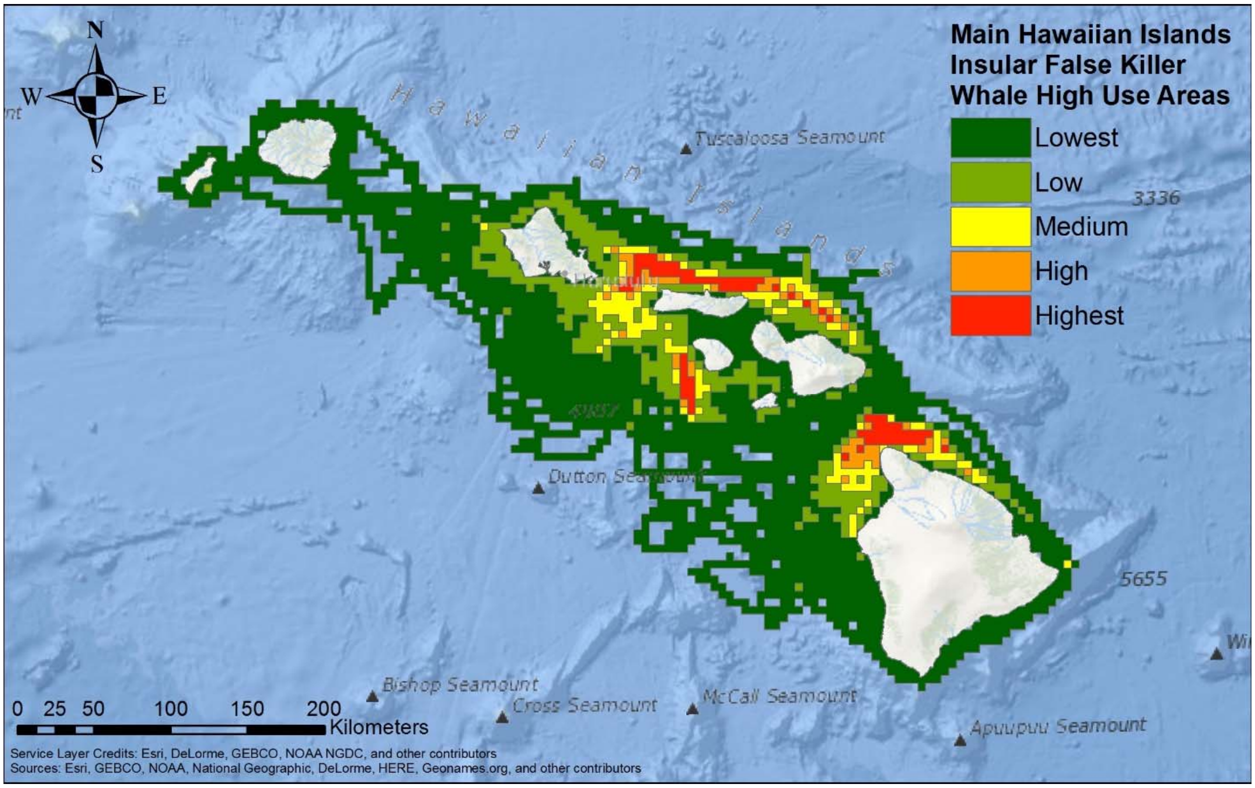


Figure 74. High use areas for Main Hawaiian Islands Insular false killer whales in the action area, as determined by satellite tag data collected by Robin Baird et al.

In summary, we do anticipate some animals in the action area will 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. 2015a; NAS 2017; New et al. 2014; Southall et al. 2007f; Villegas-Amtmann et al. 2015), we do not expect this level of exposure to impact the fitness of exposed animals. Further, 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 TTS, recovery occurs quickly (Finneran 2015). 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 long duration (i.e., more than one day) 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. For these reasons, we do not anticipate that instances of behavioral response or TTS from Navy activities will result in fitness consequences to individual ESA-listed marine mammals in the action area.

9.2.1.2 Explosives – Marine Mammals

As described previously in Section 6.1.6, explosives include, but are not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than than 3 NM from shore, and often in areas designated for explosive use.

In Section 9.2.1.1.2, we presented the total estimated number of unprocessed exposures from all acoustic and explosive stressors annually. As described previously in the introduction to Section 9.2.1, only a subset of the unprocessed exposures presented in Table 75 are expected to result in injury, hearing impairment, or significant behavioral disruptions based on the criteria and thresholds described in the technical report *Criteria and Thresholds for U.S Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (Navy 2017a). This section presents information on the estimated number of exposures of ESA-listed marine mammals to explosives that are expected to injury, hearing impairment, or significant behavioral disruptions, the expected magnitude of effect from those exposures, and the likely responses of the animals to those effects. The exposure estimates were produced by the Navy's NAEMO modeling. We consider these estimates to be the best available data on exposure of marine mammals to acoustic stressors from the proposed action and the estimates of take resulting from this analysis are reasonably certain to occur.

9.2.1.2.1 Potential Effects of Explosives

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 effects of explosions range from death, physical injury or trauma, to an observable behavioral response, to a stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Hearing loss is a noise-induced decrease in hearing sensitivity, which can either be temporary or permanent. 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 the exposure, response, and risk analyses below (i.e., Sections 9.2.1.2.2, 9.2.1.2.3, and 9.2.1.2.4, respectively), we use this information to discuss the likely effects of Navy explosive use on ESA-listed marine mammals.

9.2.1.2.1.1 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. 1973b). 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.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix D (Acoustic and Explosive Concepts) in the HSTT Draft EIS/OEIS (Navy 2017b) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving explosives occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area had been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, however, a group of approximately 100-150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a net explosive weight of 8.76 lbs (3.97 kilograms [kg]) placed at a depth of 48 ft (14.6 m). Approximately 1 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 3 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). Since that incident, the Navy has implemented additional mitigation measures to minimize the risk of such an event occurring again.

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. 1973b; 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. 1973b; Yelverton et al. 1973). Specific physiological observations for each test animal are documented in Richmond et al. (1973b). 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.

Impulse as a Predictor of Explosive Injury

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

For these shallow exposures of small terrestrial mammals (masses ranging from 3.4 to 50 kg) to underwater detonations, Richmond et al. (1973b) reported that no blast injuries were observed when exposures were less than 6 lbs 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 (1982a) examined how lung cavity size would affect susceptibility to blast injury by considering both marine mammal size and depth in a bubble oscillation model of the lung. Animal depth relates to injury susceptibility in two ways: injury is related to the relative increase in explosive pressure over hydrostatic pressure, and lung collapse with depth reduces the potential for air cavity oscillatory damage. The period over which an impulse must be delivered to cause damage is assumed to be related to the natural oscillation period of an animal's lung, which depends on lung size.

Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth. Adaptations for diving include a flexible thoracic cavity, distensible veins that can fill space as air compresses, elastic lung tissue, and resilient tracheas with interlocking cartilaginous rings that provide strength and flexibility (Ridgway 1972). Older literature suggested complete lung collapse depths at approximately 70 m for dolphins (Ridgway 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 m and about 180 m, respectively. More recently, evidence in sea lions suggests that complete collapse might not occur until depths as great as 225 m; although the depth of collapse and depth of the dive are related, sea lions can affect the depth of lung collapse by varying the amount of air inhaled on a dive (Mcdonald 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 marine mammals exhibiting pre-dive exhalation to reduce the lung volume [e.g., phocid seals (Kooyman et al. 1973)].

Peak Pressure as a Predictor of Explosive Injury

High instantaneous peak pressures can cause damaging tissue distortion. Goertner (1982a) 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.

9.2.1.2.1.2 Hearing Loss and Auditory Injury

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss may vary depending on the exposure frequency, with frequencies at and above the exposure frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies.

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. General research findings regarding TTS and PTS in marine mammals are discussed in Section 9.2.1.1.1.2 above.

9.2.1.2.1.3 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).

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. General research findings regarding physiological stress in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 9.2.1.1.1.3 above. 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.

9.2.1.2.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al., 2015). Masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking may lead to a change in vocalizations or a change in behavior (e.g., cessation of foraging, leaving an area).

There are no direct observations of masking in marine mammals due to exposure to explosive sources. General research findings regarding masking in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 9.2.1.1.1.4 above. Due to the short duration of sound from explosives, the potential for explosives to result in masking that would be biologically significant is limited.

9.2.1.2.1.5 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. However, at long distances the rise time increases as the signal duration lengthens (similar to a "ringing" sound), making the impulsive signal more similar to a non-impulsive signal. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes, odontocetes, and pinnipeds. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-air gun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that 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).

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. 2003b; McCauley et al. 2000d; Richardson et al. 1985c; Southall et al. 2007c). 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 if 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, 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. 1986a; 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). However, 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 et al., 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials. In either case there was no dose-response relationship with the received level of the air gun noise, and similar responses were observed in control trials with vessel movement but no 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 km or above 140 dB re 1 μPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al. 2017). McDonald et al. (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 km 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 (Koski and Johnson 1987, as cited in Gordon et al. 2003b) 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. 2012a). 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 $\mu Pa^2 s$ cumulative SEL, and ceased altogether at received levels over 170 dB re 1 $\mu Pa^2 s$ cumulative SEL (Blackwell et al. 2015).

Mysticetes seem to be the most sensitive taxonomic group of marine mammals to impulsive sound sources, with possible avoidance responses occurring out to 30 km and vocal changes occurring in response to sounds over 100 km away. However, responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior. These response patterns are likely to hold true for Navy impulsive sources. However, Navy impulsive sources would largely be stationary (e.g., pile driving), short term (instantaneous for explosives or for air guns, on the order of hours rather than days or weeks), and lower source level (e.g., swimmer defense air guns) than were found in these studies and so responses would likely occur in closer proximity or not at all.

Odontocetes

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

Madsen et al. (2006a) and Miller et al. (2009a) 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. 2009a). 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. 2009a). 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. 2002a). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran et al. 2015a). 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.

Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995c) and Southall et al. (2007c). Blackwell et al. (2004b) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 μPa and in air levels of 112 dB re 20 μPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an underwater impulsive source at levels of 165–170 dB re 1 μPa (Finneran et al. 2003). Harbor and grey seals were also observed to avoid a seismic air gun by rapidly swimming away, and ceased foraging during exposure, but returned to normal behavior afterwards (Thompson et al. 1998, cited in Gordon et al. 2003b). 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, and are likely to only respond to loud impulsive sound sources at close ranges by startling, jumping into the water when hauled out, or even cease foraging, but only for brief periods before returning to their previous behavior (e.g., Southall et al. 2007). Pinnipeds may even experience TTS before exhibiting a behavioral response (Southall et al. 2007c).

9.2.1.2.1.6 Stranding

When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a “stranding” (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). Under U.S. law, a stranding is an event in the wild where: (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 U.S.C. section 1421h).

Explosions also have the potential to contribute to strandings (via injury or behavioral responses), but such occurrences are less common than those that have been related to certain sonar activities. During a Navy training event on March 4, 2011, at the Silver Strand Training Complex in San Diego, California, three long-beaked common dolphins were killed by an underwater detonation. Further details are provided in Section 9.2.1.1.1.6 above.

9.2.1.2.1.7 Potential for Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. 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. However, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

9.2.1.2.2 Exposure Analysis

Section 2.2.1 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 first present information on calculated range to effects for various explosive sources used by the Navy. We then present estimates of injury, hearing impairment, and significant behavioral disruption calculated based on these range to effects, the number and type of explosives used, and marine mammal density estimates in the action area (See Section 2.2.1 for additional detail).

Range to Effects

The following tables provide range to effects for explosives sources to the criteria and thresholds described in Section 2.2.1, as they were used in NAEMO. The range to effects are shown for a range of explosive bins from E1 (up to 0.25 lb net explosive weight) to E12 (up to 1,000 lb net explosive weight). 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 significant behavioral disruption, TTS, PTS, and non-auditory injury.

Table 78 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury as a function of animal mass and explosive bin (i.e., net explosive weight). Ranges to peak pressure-based injury typically exceed ranges to impulse-based injury. Therefore, the maximum range to effect is not mass-dependent. Animals within these ranges 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. Ranges to mortality, based on animal mass, are shown in Table 79.

Table 78. Ranges to non-auditory injury for all marine mammal hearing groups (Navy 2018d).

Bin	Range (m)
E1	12 (11—13)
E2	15 (15—20)
E3	25 (25—30)
E4	32 (0—75)
E5	40 (35—130)
E6	52 (40—110)
E7	145 (100—500)
E8	115 (75—390)
E9	120 (90—280)
E10	170 (100—460)
E11	439 (350—1,775)
E12	225 (110—750)

[1] Distances in meters (m). Average distance to mortality is depicted above the minimum and maximum distances which are in parentheses. Average distance is shown with the minimum and maximum distances due to varying propagation environments. Modeled ranges based on peak pressure for a single explosion generally exceed the modeled ranges based on impulse (related to animal mass and depth); therefore, ranges shown are not animal mass-dependent.

Table 79. Ranges to mortality for all marine mammal hearing groups as a function of animal mass (Navy 2018d).

Bin	Animal Mass Intervals (kg)					
	10	250	1,000	5,000	25,000	72,000
E1	3 (2—3)	0 (0—3)	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
E2	4 (3—4)	1 (0—4)	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)
E3	8 (6—10)	4 (2—8)	1 (0—2)	0 (0—0)	0 (0—0)	0 (0—0)
E4	15 (0—35)	9 (0—30)	4 (0—8)	2 (0—6)	0 (0—3)	0 (0—2)
E5	13 (11—40)	7 (4—35)	3 (3—12)	2 (0—8)	0 (0—2)	0 (0—2)
E6	18 (14—55)	10 (5—45)	5 (3—15)	3 (2—10)	0 (0—3)	0 (0—2)
E7	67 (55—160)	35 (18—140)	16 (12—30)	10 (8—20)	5 (4—9)	4 (3—7)
E8	50 (24—90)	27 (9—55)	13 (0—20)	9 (4—13)	4 (0—6)	3 (0—5)
E9	33 (30—35)	19 (13—30)	10 (8—12)	7 (6—9)	4 (3—4)	3 (2—3)
E10	54 (40—170)	24 (16—130)	13 (11—16)	9 (7—11)	5 (4—5)	4 (3—4)
E11	211 (180—500)	108 (60—330)	47 (40—100)	30 (25—65)	15 (0—25)	13 (11—22)
E12	93 (50—290)	35 (20—230)	16 (13—19)	11 (9—13)	6 (5—8)	5 (4—8)

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

Table 80 through Table 83 show the minimum, average, and maximum ranges to onset of auditory and behavioral effects from explosives based on the thresholds described in Section 2.2. Ranges are provided for a representative source depth and cluster size for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure-based ranges are estimated using the best available data. However, data on peak pressure at far distances from explosions are very limited.

Table 80. Sound exposure level (SEL) -based ranges to PTS, TTS, and behavioral response for low-frequency ceteceans (Navy 2018d).

Range to Effects for Explosives Bin: Low-Frequency Cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	0.1	1	51 (40—70)	227 (100—320)	124 (70—160)
		25	205 (95—270)	772 (270—1,275)	476 (190—725)
E2	0.1	1	65 (45—95)	287 (120—400)	159 (80—210)
		10	176 (85—240)	696 (240—1,275)	419 (160—625)
E3	0.1	1	109 (65—150)	503 (190—1,000)	284 (120—430)
		12	338 (130—525)	1,122 (320—7,775)	761 (240—6,025)
	18.25	1	205 (170—340)	996 (410—2,275)	539 (330—1,275)
		12	651 (340—1,275)	3,503 (600—8,275)	1,529 (470—3,275)
E4	3	2	493 (440—1,000)	2,611 (1,025—4,025)	1,865 (950—2,775)
	15.25	2	583 (350—850)	3,115 (1,275—5,775)	1,554 (1,000—2,775)
	19.8	2	378 (370—380)	1,568 (1,275—1,775)	926 (825—950)
	198	2	299 (290—300)	2,661 (1,275—3,775)	934 (900—950)
E5	0.1	25	740 (220—6,025)	2,731 (460—22,275)	1,414 (350—14,275)
	15.25	25	1,978 (1,025—5,275)	8,188 (3,025—19,775)	4,727 (1,775—11,525)
E6	0.1	1	250 (100—420)	963 (260—7,275)	617 (200—1,275)
	3	1	711 (525—825)	3,698 (1,525—4,275)	2,049 (1,025—2,525)
	15.25	1	718 (390—2,025)	3,248 (1,275—8,525)	1,806 (950—4,525)
E7	3	1	1,121 (850—1,275)	5,293 (2,025—6,025)	3,305 (1,275—4,025)

Range to Effects for Explosives Bin: Low-Frequency Cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
	18.25	1	1,889 (1,025—2,775)	6,157 (2,775—11,275)	4,103 (2,275—7,275)
E8	0.1	1	460 (170—950)	1,146 (380—7,025)	873 (280—3,025)
	45.75	1	1,049 (550—2,775)	4,100 (1,025—14,275)	2,333 (800—7,025)
E9	0.1	1	616 (200—1,275)	1,560 (450—12,025)	1,014 (330—5,025)
E10	0.1	1	787 (210—2,525)	2,608 (440—18,275)	1,330 (330—9,025)
E11	18.5	1	4,315 (2,025—8,025)	10,667 (4,775—26,775)	7,926 (3,275—21,025)
	45.75	1	1,969 (775—5,025)	9,221 (2,525—29,025)	4,594 (1,275—16,025)
E12	0.1	1	815 (250—3,025)	2,676 (775—18,025)	1,383 (410—8,525)
		3	1,040 (330—6,025)	4,657 (1,275—31,275)	2,377 (700—16,275)

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

Table 81. Peak pressure based ranges to PTS and TTS for low frequency cetaceans (Navy 2018d).

Range to Effects for Explosives Bin: Low-Frequency Cetaceans[1]			
Bin	**Source Depth (m)**	**PTS**	**TTS**
E1	0.1	126 (55—140)	226 (90—270)
E2	0.1	161 (65—180)	280 (100—340)
E3	0.1	264 (100—320)	453 (140—600)
	18.25	330 (240—875)	614 (330—1,775)
E4	3	531 (420—625)	916 (650—2,025)
	15.25	525 (350—725)	864 (550—1,275)

Range to Effects for Explosives Bin: Low-Frequency Cetaceans[1]			
Bin	**Source Depth (m)**	**PTS**	**TTS**
	19.8	390 (370—400)	730 (650—800)
	198	379 (340—400)	746 (675—1,525)
E5	0.1	404 (130—525)	679 (180—1,025)
	15.25	547 (360—1,275)	991 (675—1,525)
E6	0.1	496 (150—700)	797 (210—6,025)
	3	817 (650—975)	1,317 (1,025—1,775)
	15.25	735 (420—1,275)	1,266 (875—2,525)
E7	3	1,017 (925—1,025)	1,977 (1,775—2,275)
	18.25	1,246 (875—1,775)	2,368 (1,525—3,775)
E8	0.1	830 (260—1,275)	1,045 (360—1,775)
	45.75	1,306 (550—3,775)	2,008 (675—6,025)
E9	0.1	966 (310—1,525)	1,240 (420—2,525)
E10	0.1	1,057 (330—1,775)	1,447 (450—6,025)
E11	18.5	2,945 (1,025—7,525)	5,497 (2,025—12,525)
	45.75	2,023 (700—6,775)	2,779 (775—11,275)
E12	0.1	1,155 (390—2,025)	1,512 (550—3,775)

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

Table 82. SEL-based ranges to PTS, TTS, and behavioral disturbance for mid-frequency cetaceans (Navy 2018d).

Range to Effects for Explosives Bin: Mid-Frequency Cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	0.1	1	25 (25—25)	118 (80—210)	178 (100—320)
		25	107 (75—170)	476 (150—1,275)	676 (240—1,525)
E2	0.1	1	30 (30—35)	145 (95—240)	218 (110—400)
		10	88 (65—130)	392 (140—825)	567 (190—1,275)
E3	0.1	1	50 (45—65)	233 (110—430)	345 (130—600)
		12	153 (90—250)	642 (220—1,525)	897 (270—2,025)
	18.25	1	38 (35—40)	217 (190—900)	331 (290—850)
		12	131 (120—250)	754 (550—1,525)	1,055 (600—2,525)
E4	3	2	139 (110—160)	1,069 (525—1,525)	1,450 (875—1,775)
	15.25	2	71 (70—75)	461 (400—725)	613 (470—750)
	19.8	2	69 (65—70)	353 (350—360)	621 (600—650)
	198	2	49 (0—55)	275 (270—280)	434 (430—440)
E5	0.1	25	318 (130—625)	1,138 (280—3,025)	1,556 (310—3,775)
	15.25	25	312 (290—725)	1,321 (675—2,525)	1,980 (850—4,275)
E6	0.1	1	98 (70—170)	428 (150—800)	615 (210—1,525)
	3	1	159 (150—160)	754 (650—850)	1,025 (1,025—1,025)
	15.25	1	88 (75—180)	526 (450—875)	719 (500—1,025)
E7	3	1	240 (230—260)	1,025 (1,025—1,025)	1,900 (1,775—2,275)

Range to Effects for Explosives Bin: Mid-Frequency Cetaceans[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
	18.25	1	166 (120—310)	853 (500—1,525)	1,154 (550—1,775)
E8	0.1	1	160 (150—170)	676 (500—725)	942 (600—1,025)
	45.75	1	128 (120—170)	704 (575—2,025)	1,040 (750—2,525)
E9	0.1	1	215 (200—220)	861 (575—950)	1,147 (650—1,525)
E10	0.1	1	275 (250—480)	1,015 (525—2,275)	1,424 (675—3,275)
E11	18.5	1	335 (260—500)	1,153 (650—1,775)	1,692 (775—3,275)
	45.75	1	272 (230—825)	1,179 (825—3,025)	1,784 (1,000—4,275)
E12	0.1	1	334 (310—350)	1,151 (700—1,275)	1,541 (800—3,525)
		3	520 (450—550)	1,664 (800—3,525)	2,195 (925—4,775)

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

Table 83. Peak pressure based ranges to PTS and TTS for mid-frequency cetaceans (Navy 2018d).

Range to Effects for Explosives Bin: Mid-Frequency Cetaceans[1]			
Bin	**Source Depth (m)**	**PTS**	**TTS**
E1	0.1	43 (35—45)	81 (45—95)
E2	0.1	57 (40—65)	102 (50—110)
E3	0.1	96 (50—110)	174 (65—210)
	18.25	101 (100—130)	196 (180—725)
E4	3	261 (180—300)	421 (250—460)
	15.25	162 (120—290)	328 (240—725)

Range to Effects for Explosives Bin: Mid-Frequency Cetaceans[1]			
Bin	Source Depth (m)	PTS	TTS
	19.8	120 (120—120)	240 (240—240)
	198	117 (80—120)	229 (210—230)
E5	0.1	149 (65—160)	272 (95—300)
	15.25	178 (160—430)	358 (290—825)
E6	0.1	188 (70—230)	338 (110—400)
	3	268 (230—360)	527 (410—625)
	15.25	240 (200—460)	479 (400—725)
E7	3	459 (320—625)	730 (575—900)
	18.25	429 (310—550)	676 (550—800)
E8	0.1	337 (300—370)	580 (400—750)
	45.75	431 (340—1,025)	806 (600—2,275)
E9	0.1	450 (350—525)	757 (450—1,025)
E10	0.1	534 (240—700)	902 (410—1,275)
E11	18.5	896 (725—1,025)	1,577 (1,025—2,275)
	45.75	824 (600—2,775)	1,484 (900—4,775)
E12	0.1	669 (430—925)	1,074 (525—1,525)

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

Table 84. SEL based ranges to onset PTS, TTS, and behavioral disruption for otariids.

Range to Effects for Explosives: Otariids[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	0.1	1	7 (7—7)	34 (30—40)	56 (45—70)
		25	30 (25—35)	136 (80—180)	225 (100—320)
E2	0.1	1	9 (9—9)	41 (35—55)	70 (50—95)
		10	25 (25—30)	115 (70—150)	189 (95—250)
E3	0.1	1	16 (15—19)	70 (50—95)	115 (70—150)
		12	45 (35—65)	206 (100—290)	333 (130—450)
	18.25	1	15 (15—15)	95 (90—100)	168 (150—310)
		12	55 (50—60)	333 (280—750)	544 (440—1,025)
E4	3	2	64 (40—85)	325 (240—340)	466 (370—490)
	15.25	2	30 (30—35)	205 (170—300)	376 (310—575)
	19.8	2	25 (25—25)	170 (170—170)	290 (290—290)
	198	2	17 (0—25)	117 (110—120)	210 (210—210)
E5	0.1	25	98 (60—120)	418 (160—575)	626 (240—1,000)
	15.25	25	151 (140—260)	750 (650—1,025)	1,156 (975—2,025)
E6	0.1	1	30 (25—35)	134 (75—180)	220 (100—320)
	3	1	53 (50—55)	314 (280—390)	459 (420—525)
	15.25	1	36 (35—40)	219 (200—380)	387 (340—625)
E7	3	1	93 (90—100)	433 (380—500)	642 (550—800)
	18.25	1	73 (70—75)	437 (360—525)	697 (600—850)
E8	0.1	1	50 (50—50)	235 (220—250)	385 (330—450)
	45.75	1	55 (55—60)	412 (310—775)	701 (500—1,525)
E9	0.1	1	68 (65—70)	316 (280—360)	494 (390—625)
E10	0.1	1	86 (80—95)	385 (240—460)	582 (390—800)

Range to Effects for Explosives: Otariids[1]					
Bin	Source Depth (m)	Cluster Size	PTS	TTS	Behavioral
E11	18.5	1	158 (150—200)	862 (750—975)	1,431 (1,025—2,025)
	45.75	1	117 (110—130)	756 (575—1,525)	1,287 (950—2,775)
E12	0.1	1	104 (100—110)	473 (370—575)	709 (480—1,025)
	0.1	3	172 (170—180)	694 (480—1,025)	924 (575—1,275)

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

Table 85. Peak pressure based ranges to PTS and TTS for otariids.

Range to Effects for Explosives: Otariids[1]			
Bin	Source Depth (m)	PTS	TTS
E1	0.1	35 (30—40)	64 (40—95)
E2	0.1	45 (35—50)	82 (45—95)
E3	0.1	77 (45—95)	133 (60—150)
	18.25	81 (80—100)	163 (150—480)
E4	3	175 (130—210)	375 (220—410)
	15.25	114 (100—190)	252 (190—420)
	19.8	100 (100—100)	190 (190—190)
	198	98 (95—100)	187 (180—190)
E5	0.1	117 (55—130)	212 (80—250)
	15.25	144 (130—310)	278 (240—725)
E6	0.1	148 (65—170)	263 (95—310)
	3	215 (190—260)	463 (330—625)
	15.25	191 (170—410)	386 (310—825)
E7	3	355 (260—500)	614 (490—750)
	18.25	439 (330—550)	628 (575—675)
E8	0.1	272 (260—280)	482 (370—525)

Range to Effects for Explosives: Otariids[1]			
Bin	**Source Depth (m)**	**PTS**	**TTS**
	45.75	401 (280—950)	770 (500—1,775)
E9	0.1	368 (320—400)	610 (420—800)
E10	0.1	442 (230—525)	715 (330—1,025)
E11	18.5	765 (625—1,000)	1,342 (950—2,025)
	45.75	811 (525—2,025)	1,498 (850—3,525)
E12	0.1	550 (400—700)	881 (500—1,275)

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

Table 86. SEL based ranges to PTS, TTS, and behavioral disruption for phocids.

Range to Effects for Explosives: Phocids[1]					
Bin	**Source Depth (m)**	**Cluster Size**	**PTS**	**TTS**	**Behavioral**
E1	0.1	1	45 (40—65)	210 (100—290)	312 (130—430)
		25	190 (95—260)	798 (280—1,275)	1,050 (360—2,275)
E2	0.1	1	58 (45—75)	258 (110—360)	383 (150—550)
		10	157 (85—240)	672 (240—1,275)	934 (310—1,525)
E3	0.1	1	96 (60—120)	419 (160—625)	607 (220—900)
		12	277 (120—390)	1,040 (370—2,025)	1,509 (525—6,275)
	18.25	1	118 (110—130)	621 (500—1,275)	948 (700—2,025)
		12	406 (330—875)	1,756 (1,025—4,775)	3,302 (1,025—6,275)
E4	3	2	405 (300—430)	1,761 (1,025—2,775)	2,179 (1,025—3,275)
	15.25	2	265 (220—430)	1,225 (975—1,775)	1,870 (1,025—3,275)
	19.8	2	220 (220—220)	991 (950—1,025)	1,417 (1,275—1,525)
	198	2	150 (150—150)	973 (925—1,025)	2,636 (2,025—3,525)
E5	0.1	25	569 (200—850)	2,104 (725—9,275)	2,895 (825—11,025)
	15.25	25	920 (825—1,525)	5,250 (2,025—10,275)	7,336 (2,275—16,025)

Range to Effects for Explosives: Phocids[1]					
Bin	Source Depth (m)	Cluster Size	PTS	TTS	Behavioral
E6	0.1	1	182 (90—250)	767 (270—1,275)	1,011 (370—1,775)
	3	1	392 (340—440)	1,567 (1,275—1,775)	2,192 (2,025—2,275)
	15.25	1	288 (250—600)	1,302 (1,025—3,275)	2,169 (1,275—5,775)
E7	3	1	538 (450—625)	2,109 (1,775—2,275)	2,859 (2,775—3,275)
	18.25	1	530 (460—750)	2,617 (1,025—4,525)	3,692 (1,525—5,275)
E8	0.1	1	311 (290—330)	1,154 (625—1,275)	1,548 (725—2,275)
	45.75	1	488 (380—975)	2,273 (1,275—5,275)	3,181 (1,525—8,025)
E9	0.1	1	416 (350—470)	1,443 (675—2,025)	1,911 (800—3,525)
E10	0.1	1	507 (340—675)	1,734 (725—3,525)	2,412 (800—5,025)
E11	18.5	1	1,029 (775—1,275)	5,044 (2,025—8,775)	6,603 (2,525—14,525)
	45.75	1	881 (700—2,275)	3,726 (2,025—8,775)	5,082 (2,025—13,775)
E12	0.1	1	631 (450—750)	1,927 (800—4,025)	2,514 (925—5,525)
	0.1	3	971 (550—1,025)	2,668 (1,025—6,275)	3,541 (1,775—9,775)

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

Table 87. Peak pressure based ranges to PTS and TTS for phocids.

Range to Effects for Explosives: Phocids[1]			
Bin	Source Depth (m)	PTS	TTS
E1	0.1	144 (60—160)	258 (95—300)
E2	0.1	180 (70—220)	323 (110—370)
E3	0.1	303 (100—350)	533 (150—675)
	18.25	373 (270—950)	697 (470—1,775)
E4	3	548 (470—700)	1,230 (675—2,525)
	15.25	567 (460—750)	927 (675—1,525)
	19.8	459 (440—480)	823 (800—900)
	198	431 (420—440)	864 (800—1,000)

Range to Effects for Explosives: Phocids[1]			
Bin	Source Depth (m)	PTS	TTS
E5	0.1	469 (140—600)	815 (190—6,025)
	15.25	604 (550—900)	1,061 (725—1,775)
E6	0.1	582 (160—775)	910 (230—6,025)
	3	888 (750—1,025)	1,484 (1,025—1,775)
	15.25	822 (650—1,525)	1,426 (875—2,775)
E7	3	1,109 (1,025—1,525)	2,109 (1,775—2,525)
	18.25	1,482 (1,025—2,025)	2,766 (1,775—4,775)
E8	0.1	987 (500—1,275)	1,472 (625—2,025)
	45.75	1,695 (800—4,525)	2,896 (1,275—8,025)
E9	0.1	1,207 (550—1,525)	1,790 (700—3,025)
E10	0.1	1,407 (450—3,275)	2,043 (775—5,275)
E11	18.5	3,311 (1,775—7,025)	5,848 (2,275—12,525)
	45.75	3,053 (1,525—8,275)	4,178 (1,775—11,275)
E12	0.1	1,580 (675—2,525)	2,228 (825—3,775)

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

Exposure Estimates

Table 88 lists the marine mammal estimates of PTS, TTS, and behavioral impacts for the marine mammal species considered in this opinion for Navy training and testing activities using explosives conducted annually in the action area. Note that only the most severe impact expected (i.e., PTS>TTS>behavioral) is quantified in this table. All impacts anticipated are PTS, TTS, or behavioral impacts. No ESA-listed marine mammal mortality or non-auditory injury is anticipated.

Table 88. Estimated ESA-listed marine mammal impacts per year from explosives during training and testing activities.

Species	Location/DPS	Annual Impacts from Training				Annual Impacts from Testing				Total Annual Impacts			
		Behavioral Response	TTS	PTS	Injury	Behavioral Response	TTS	PTS	Injury	Behavioral Response	TTS	PTS	Injury
Suborder Mysticeti (baleen whales)													
Family Balaenopteridae (rorquals)													
Blue whale	Hawaii/NA*	0	0	0	0	0	0	0	0	0	0	0	0
	SOCAL/NA	0	8	1	0	0	5	0	0	0	13	1	0
Fin whale	SOCAL/NA	0	7	0	0	0	7	1	0	0	14	1	0
	Hawaii/NA	0	0	0	0	0	0	0	0	0	0	0	0
Humpback whale*	SOCAL/Central America DPS	0	1	0	0	0	5	0	0	0	6	0	0
	SOCAL/Mexico DPS	0	13	1	0	0	4	0	0	0	17	1	0
Sei whale	SOCAL/NA	0	1	0	0	0	0	0	0	0	1	0	0
	Hawaii/NA	0	0	0	0	0	0	0	0	0	0	0	0
Family Eschrichtiidae													
Gray whale	SOCAL/Western North Pacific DPS	0	0	0	0	0	0	0	0	0	0	0	0
Suborder Odontoceti (toothed whales)													
Family Physeteridae (sperm whale)													
Sperm whale	SOCAL/NA	2	1	0	0		2	0	0		3	0	0
	Hawaii/NA	0	0	0	0	0	0	0	0	0	0	0	0
Family Delphinidae (dolphins)				0				2					
False killer whale	Hawaii/Main Hawaiian	0	1	0	0	0	0	0	0	0	1	0	0

Species	Location/DPS	Annual Impacts from Training				Annual Impacts from Testing				Total Annual Impacts			
		Behavioral Response	TTS	PTS	Injury	Behavioral Response	TTS	PTS	Injury	Behavioral Response	TTS	PTS	Injury
	Islands Insular DPS												
Suborder Pinnipedia													
Family Otariidae (eared seals)													
Guadalupe fur seal	SOCAL/NA	0	0	0	0		0	0	0		0	0	0
Family Phocidae (true seals)													
Hawaiian monk seal	Hawaii/NA	0	3	1	0 0		3	0	0 0		6	1	0

PTS: permanent threshold shift; TTS: temporary threshold shift

3 3

9.2.1.2.3 Response Analysis

Hearing Loss

The response of ESA-listed marine mammals from exposure to explosives resulting in PTS or TTS is expected to be similar to the response of ESA-listed marine mammals experiencing hearing loss due to sonar or other transducers. The exception is that because active sonar is transmitted at a specified frequency, animal's experiencing TTS or PTS from sonar will only experience threshold shifts around that particular frequency. In contrast, explosives are a broadband source, so if an animal experiences TTS or PTS from explosives, a greater frequency band will be affected. Because a greater frequency band will be affected due to explosives, there is increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. Table 88 provides information on the number of instances of PTS and TTS anticipated for each species.

Behavioral response

The exposure analysis indicates that two exposures to explosives are expected to result in significant behavioral disruptions of sperm whales and three exposures to explosives are expected to result in significant behavioral disruptions of Hawaiian monk seals. No other ESA-listed marine mammals are expected to experience a significant behavioral disruption from Navy explosives in the action area (See Table 88).

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 in Section 9.2.1.2.1 above. 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. Due to the sustained nature of seismic air gun use, behavioral responses due to seismic activity are anticipated to be more significant than could be expected from Navy explosives. The available information on the response of sperm whales and Hawaiian monk seals to impulsive sound sources indicates animals may alert to the sound source, may alter foraging behavior, or exhibit avoidance behavior. However, these responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends.

9.2.1.2.4 Risk Analysis

In this section, we assess the likely consequences of the responses to the individuals that have been exposed to explosive stressors. In the exposure and response analysis, we established that a range of impacts including non-auditory injury, hearing loss, and behavioral response are likely to occur due to exposure to Navy explosives during training and testing events (See Table 88). The majority of impacts are expected to be in the form of TTS, though a single instance of PTS is expected for some species. All ESA-listed marine mammal species except Western North Pacific DPS gray whales and Guadalupe fur seals considered in this opinion are anticipated to experience TTS from explosive exercises. Sperm whales and Hawaiian monk seals are expected to experience behavioral disruptions. One blue, fin, and humpback (Mexico DPS) whale, as well as a Hawaiian monk seal, are anticipated to experience PTS. As described in the exposure analysis, no non-auditory injuries or instances of mortality of ESA-listed marine mammals are reasonably certain to occur due to the use of explosives.

As described previously, 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 period of time (e.g., PTS), occur at a frequency utilized by the animal for acoustic cues, and/or are of a profound magnitude. It is important to note that 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, the temporary duration of TTS is expected to be on the shorter end of the range and last briefly. Even longer duration TTS is only expected to last hours or at most a few days (Finneran 2015). 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 fitness consequences for the individuals affected. 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. Because explosives are a broadband source, a larger range of frequencies could be affected than with sonar. 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 marine mammals ability 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 important for mating and mother-calf communication as discussed above with TTS. For Hawaiian monk seals, PTS also has the potential to affect an animal's ability to find food. Given this, permanent hearing impairment has the potential to affect individual Hawaiian monk seal survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness.

Our exposure and response analyses indicate that some whales and Hawaiian monk seals 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 blue, fin, and humpback (Mexico DPS) whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. Affected Hawaiian monk seals could also be less efficient at foraging, but because we anticipate only minor degrees of PTS, we expect affected Hawaiian monk seals will still be able to forage successfully.

In our response analysis, we determined that any instances of behavioral response due to explosives would be temporary. Sperm whales and Hawaiian monk seals may alert to the sound source, alter foraging behavior, or exhibit avoidance behavior. However, these responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends. Due to the short duration of any expected behavioral responses to explosives and the limited number of behavioral responses rising to the level of take that are reasonably certain to occur, we do not anticipate behavioral responses due to explosive use will result in fitness consequences to affected animals. This is supported by several studies that indicate infrequent exposures resulting in behavioral disruptions lasting a short time are unlikely to result in long-term consequences to the exposed animals (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015a; NAS 2017; New et al. 2014; Southall et al. 2007f; Villegas-Amtmann et al. 2015).

In summary, we determined that instances of behavioral response and TTS due to explosives are not anticipated to result in fitness consequences to affected ESA-listed marine mammals. However, we anticipate that instances of blue whale, fin whale, humpback whale, and Hawaiian monk seal PTS could result in fitness consequences to the individual.

9.2.1.3 Air Guns – Marine Mammals

Additional discussion of air guns as a potential stressor is included in Section 6.1.5. Air guns would only be using during testing activities and would be fired at offshore locations in both the SOCAL and Hawaii Range Complexes.

Research and observations show that if marine mammals are exposed to sounds from air guns they could potentially react with short-term behavioral reactions and physiological stress. It is important to point out that many observations of marine mammal reactions to air guns are from oil and gas exploration activities that use large air gun arrays and operate continuously for multiple weeks to cover large areas of the ocean. In contrast, Navy activities only use single air guns over a much shorter period and within a limited area. Cetaceans (both mysticetes and odontocetes) may react in a variety of ways to impulsive sounds, which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, changing vocalization, or showing no response at all. Research shows that pinnipeds may be the least sensitive taxonomic group to most noise sources, and are likely to respond to loud impulsive sound sources only at close ranges by startling or ceasing foraging, but only for brief periods before returning to their previous behavior. Pinnipeds may even experience mild TTS before exhibiting a behavioral response (Southall et al. 2007c). Marine mammals disturbed while engaged in activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. The sound from air gun shots is broadband, but they have a very short duration, lasting for less than a second each, and are used intermittently. This limits the potential for any significant masking in marine mammals.

The approach, as well as the criteria and thresholds, used to determine the potential extent of exposure of marine mammals to air guns is described in Section 2.2. Table 89 below presents the range to effects from air guns for 1 pulse and Table 90 presents the range to effects from air guns for 10 pulses.

Table 89. Range to effects from air guns for 1 pulse (Navy 2018d).

Range to Effects for Airguns[1] for 1 pulses (m)					
Hearing Group	**PTS (SEL)**	**PTS (Peak SPL)**	**TTS (SEL)**	**TTS (Peak SPL)**	**Behavioral[2]**
Low-Frequency Cetaceans	3 (3—4)	2 (2—3)	27 (23—35)	5 (4—7)	651 (200—1,525)
Mid-Frequency Cetaceans	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)	689 (290—1,525)
Otariids	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)	590 (290—1,525)
Phocids	0 (0—0)	2 (2—3)	0 (0—0)	5 (4—8)	668 (290—1,525)

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

Table 90. Range to effects from air guns for 10 pulses (Navy 2018d).

Range to Effects for Airguns[1] for 10 pulses (m)					
Hearing Group	PTS (SEL)	PTS (Peak SPL)	TTS (SEL)	TTS (Peak SPL)	Behavioral[2]
Low-Frequency Cetaceans	15 (12—20)	2 (2—3)	86 (70—140)	5 (4—7)	651 (200—1,525)
Mid-Frequency Cetaceans	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)	689 (290—1,525)
Otariids	0 (0—0)	0 (0—0)	0 (0—0)	0 (0—0)	590 (290—1,525)
Phocids	0 (0—0)	2 (2—3)	4 (3—5)	5 (4—8)	668 (290—1,525)

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

Based on the Navy's NAEMO modeling, a single behavioral disruption of a blue whale is anticipated from air gun sounds associated with testing activities. The other ESA-listed marine mammal species in the action area (i.e., fin, gray – Western North Pacific DPS, humpback – Mexico and Central America DPSs, sei, sperm, and MHI IFKWs, in addition to Guadalupe fur and Hawaiian monk seals) could also be exposed, though based on the Navy's modeling, this is extremely unlikely and thus discountable.

General research findings regarding potential behavioral reactions from marine mammals due to exposure to impulsive sounds, such as those associated with air guns, are discussed in detail in Section 9.2.1.2.1 above. The available information on the response of blue whales to impulsive sound sources indicates animals may alert to the sound source, may alter foraging behavior, or exhibit avoidance behavior. However, these responses are expected to be temporary with behavior returning to a baseline state shortly after the activity using air guns ends. Due to the short duration of the expected behavioral response of a blue whale to air guns and that only one behavioral response of a single animal is reasonably certain to occur, we do not anticipate this behavioral response due to air guns use will result in fitness consequences to the affected blue whale. This is supported by several studies that indicate infrequent exposures resulting in behavioral disruptions lasting a short time are unlikely to result in long-term consequences to the exposed animals (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015a; NAS 2017; New et al. 2014; Southall et al. 2007f; Villegas-Amtmann et al. 2015).

9.2.1.4 Vessel Strike – Marine Mammals

Vessel strikes from commercial, recreational, and military vessels are known to affect large whales and have resulted in serious injury and occasional fatalities to cetaceans (Berman-Kowalewski et al. 2010b; Calambokidis 2012; Douglas et al. 2008; Laggner 2009; Lammers et al. 2003). Records of collisions date back to the early 17th century, and the worldwide number of collisions appears to have increased steadily during recent decades (Laist et al. 2001; Ritter 2012).

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals often, but not always (e.g., McKenna et al. 2015), 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 (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986b; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984b; Corkeron 1995; Erbe 2002b; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003c; Scheidat et al. 2004; Simmonds 2005; Watkins 1986a; Williams et al. 2002b; Wursig et al. 1998b). 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). Water disturbance may also be a factor. These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators. Avoidance behavior is expected to be even stronger when the Navy is conducting training or testing activities (e.g., when active sonar or explosives are in use). The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (*e.g.*, the sperm whale). In addition, some baleen whales seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al., 2004). These species are primarily large, slow moving whales.

Some researchers have suggested the relative risk of a vessel strike can be assessed as a function of animal density and the magnitude of vessel traffic (e.g., Fonnesbeck et al. 2008; Vanderlaan et al. 2008). Differences among vessel types also influence the probability of a vessel strike. The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and personnel, as well as the behavior of the animal. Vessel speed, size, and mass are all important factors in determining if injury or death of a marine mammal is likely due to a vessel strike. For large vessels, speed and angle of approach can influence the severity of a strike. For example, Vanderlaan and Taggart (2007) found that between vessel speeds of 8.6 and 15 knots, the probability that a vessel strike is lethal increases from 0.21 to 0.79. Large whales also do not have to be at the water's surface to be struck. Silber et al. (2010a) found when a whale is below the surface (about one to two times the vessel draft), there is likely to be a pronounced propeller suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes.

Comparison of commercial vessel traffic with Navy vessel traffic in the action area over a 1-year period showed that Navy surface ships accounted for 97,000 hours of accumulated at-sea time whereas commercial shipping accounted for 875,000 hours (Mintz 2012). Therefore, Navy vessel traffic represented 10 percent of all vessel hours within the action area. Within the Hawaii portion of the action area, significant commercial traffic is present as vessels bring shipments of goods to Hawaii as well as shipments between the islands. There are also non-military vessels from major ports in Asia (such as Shanghai, China) that pass through the Hawaii portion of the action area and between some of the main Hawaiian Islands en route to the Panama Canal and back.

Within the Southern California portion of the action area, evidence of significant mortality of species of baleen whales (mostly from data on blue, fin, and humpback whales) from commercial ship strikes in the Santa Barbara Channel of Southern California have prompted a detailed analysis of the situation and how it can be resolved. There are approximately 6,500 commercial vessels annually using the Santa Barbara Channel (Channel Islands National Marine Sanctuary 2015). An additional large number of vessels also transit farther offshore along the coast heading to ports beyond those in Southern California. Stranding locations also appeared to be concentrated near major Southern California ports suggesting they are likely indicative of commercial vessel interactions (Berman-Kowalewski et al. 2010a). This area appears to be highly problematic, largely because it represents an overlap of important feeding grounds for these species of whale with a major shipping lane to/from Southern California ports (See Abramson et al. (2011)). Rockwood et al. (2017) found that the highest risk of vessel strike for fin and blue whales off the West Coast was in the shipping lanes off San Francisco and Long Beach, but that only a fraction of the total estimated mortality occurs in these proportionally small areas. Between 1988 and 2007, 21 blue whale deaths were reported along the California coast, and many of these showed evidence of ship strike (Berman-Kowalewski et al. 2010a).

Large Navy vessels (greater than 18 m in length) within the offshore areas of the action area operate differently from commercial vessels in ways important to the prevention of whale collisions. For example, the average speed of large Navy ships ranges between 10 and 15 knots. By comparison, this is slower than most commercial vessels where full speed for a container ship is typically 24 knots (Bonney and Leach 2010). Even given the advent of "slow steaming" by commercial vessels in recent years due to fuel prices (Barnard 2016; Maloni et al. 2013), this is generally a reduction of only a few knots given 21 knots would be considered slow; 18 knots is defined as extra slow; and 15 knots is considered super slow (Bonney and Leach 2010), which all exceed the typical Navy large vessel average speed. In the Rockwood et al. (2017) modeling exercise to estimate blue, fin, and humpback whale ship strike mortality on the U.S. West Coast, the majority of vessels in their model represented large tanker and cargo vessels with limited visibility and poor reaction capability. For that reason, they considered avoidance behavior by vessels to be close to zero in their modeling exercise. This is in contrast to what would be expected for Navy vessels for the reasons described below.

There are some other key differences between the operation of military and non-military vessels, which make the likelihood of a military vessel striking a whale lower than some other vessels (e.g., commercial merchant vessels). Key differences include:

- Many military ships have their bridges positioned closer to the bow, offering better visibility ahead of the ship (compared to a commercial merchant vessel).
- There are often aircraft associated with the training or testing activity (which can serve as lookouts), which can more readily detect cetaceans in the vicinity of a vessel or ahead of a vessel's present course before crew on the vessel would be able to detect them.
- Military ships are generally more maneuverable than commercial merchant vessels, and if cetaceans are spotted in the path of the ship, could be capable of changing course more quickly.
- The crew size on military vessels is generally larger than merchant ships, allowing for stationing more trained lookouts on the bridge. At all times when vessels are underway, trained lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including cetaceans. Additional lookouts, beyond those already stationed on the bridge and on navigation teams, are positioned as lookouts during some training events.
- When submerged, submarines are generally slow moving (to avoid detection) and therefore marine mammals at depth with a submarine are likely able to avoid collision with the submarine. When a submarine is transiting on the surface, there are Lookouts serving the same function as they do on surface ships.

Additionally, the Navy implements procedural mitigation (described in Section 3.4.2.1), including the use of Lookouts and minimum approach distances to reduce the likelihood of a marine mammal vessel strike.

9.2.1.4.1 Exposure Analysis

We consider vessel strike of marine mammals comprehensively, as a result of all Navy vessel movement within the action area, as opposed to in the context of specific training or testing exercises. Training and testing activities that include vessel movements would occur throughout the Hawaii and Southern California portions of the action area, as well as the transit corridor.

In the SOCAL portion of the action area, the Navy struck a total of 16 marine mammals in the 20-year period from 1991 through 2010 (i.e., an average of one per year). Of the 16 Navy vessel strikes over the 20-year period in SOCAL, there were seven mortalities and nine injuries reported. The vessel species struck include: two mortalities and eight injuries of unknown species, three mortalities of gray whales (one in 1993 and two in 1998), one mortality of a blue whale in 2004, and one morality and one injury of fin whales in 2009. In the Hawaii portion of the action area, the Navy struck a total of five marine mammals in the 20-year period from 1991 through 2010. Of the five Navy vessel strikes over the 20-year period in Hawaii, all were reported as injuries. The vessel struck species include: one humpback whale in 1998, one unknown species and one humpback whale in 2003, one sperm whale in 2007, and an unknown species in 2008. No more than two whales were struck by Navy vessels in any given year in the Hawaii portion of the action area within the last 20 years. There was only one 12-month period in 20 years in the Hawaii portion of the action area when two whales were struck in a single year

(2003). There have not been any documented vessel strikes associated with training and testing in the action area since 2010 and 2008, respectively.

Since the implementation of the Navy's Marine Species Awareness Training in 2007, refined policy guidance has been issued by the Navy regarding marine mammal incidents (e.g., ship strikes) in order to collect the most accurate and detailed data possible in response to a possible incident. Mitigation, reporting, and monitoring requirements have been in place with routine implementation since 2009 and these same requirements are expected to continue into the future. The level of vessel use and the manner in which the Navy trains and tests in the future (2018-2023) is expected to be consistent with the 2009 to 2016 time period, so data from this past nine-year period have been used to calculate the probability of a Navy vessel striking a whale during proposed training activities in the action area. From January 2009 through December 2016, a total of two (2) whale strikes occurred during Navy training and testing activities in the HSTT action area; both strikes were to fin whales and both occurred in 2009 in the SOCAL Range Complex.

The Navy has had similar mitigation, reporting, and monitoring requirements in place since 2009 and these are proposed to continue for Phase III training and testing activities. Therefore, the conditions affecting the potential for ship strikes are the most consistent across this time frame. As a result, data from the past eight years (i.e., 2009 to 2016) were used to calculate the probability of a Navy vessel striking a whale during proposed training and testing activities in the action area. The year 2009 was selected because this coincided with when the Navy's mitigation, monitoring, and reporting requirements became standardized across the Navy with the issuance of MMPA authorizations for sonar and explosive usage in at-sea Navy ranges; acknowledges advances in Navy marine species awareness training and overall enhanced sensitivity to marine resource issues in general; and is the first year of the codification of multiple marine species mitigation measures including specific measures to avoid large whales by 500 yd as long as it is safe for navigation. The level of vessel use and the manner in which the Navy trains and tests in the future is expected to be consistent with this time period. Additionally, there have been no large-scale changes in animal abundance, distribution, or behavior since 2009 that would be expected to affect the relative susceptibility of ESA-listed large whales to vessel strike.

There have not been any documented cases of a Navy vessel striking a pinniped or small odontocete (e,g., MHI IFKW). Due to these species' maneuverability, relative lack of known susceptibility to ship strike, the lack of documented incidences where these species have been struck, and the Navy's mitigation to avoid striking marine mammals, the likelihood of Hawaiian monk seals, Guadalupe fur seals, or MHI IFKWs is extremely low, and therefore discountable. The discussion below focuses on the potential for Navy vessels to strike large whales in the action area. Because the probability of a Navy vessel strike to large whales is influenced by the amount of time at sea for Navy vessels within the action area during future training and testing activities, historical vessel use (i.e., steaming days) and reported ship strike data from 2009-2016 were used to calculate the probability of a direct strike during proposed training and testing activities in the action area over the five-year period of the proposed MMPA rule.

Data over a period from 2009 to 2016 are used to calculate the most current probability of a Navy vessel striking a whale in the action area. From January 2009 through December 2016, a total of two reported whale strikes have occurred from Navy training and testing activities in the action area, both fin whales in 2009 in the SOCAL Range Complex.

Since the probability of a Navy vessel strike to large whales is influenced by the amount of time at sea for Navy vessels within the action area, the Navy compiled information on historic at-sea days in the action area from 2009-2016 and estimated potential at-sea days for the period from 2019-2023. The at-sea days then are used to calculate a strike rate based on the 2009-2016 reporting period. Total ship at-sea days for this period were 33,860 days. Dividing the two reported strikes by ship at-sea day (2/33,860) results in a strike rate of 0.00006 strikes per day. Estimated ship at-sea days within the action area for the period from 2019-2023 is 21,163 days. Note that this value includes manned surface ships and unmanned surface vessels. The historic strike rate (0.00006 strikes per day) can be multiplied by the estimated at-sea days from 2019-2023 to estimate the number of whale strikes that could be anticipated (0.00006 strikes per day x 21,163 days). This calculation predicts up to 1.2 strikes over the period from 2019-2023.

The probabilities of a specific number of strikes (n=0, 1, 2, etc.) over the period from 2019-2023 can be derived from a Poisson distribution. A Poisson distribution is often used to describe random occurrences when the probability of an occurrence is small, e.g., count data such as cetacean sighting data, or in this case strike data, often described as a Poisson or over-dispersed Poisson distribution. The formula for a Poisson distribution is:

$$P \langle n | \mu \rangle = \frac{e^{-\mu} \bullet \mu^{n}}{n!}$$

P($n|\mu$) is the probability of observing n events in some time interval, when the expected number of events in that time interval is μ. For this analysis, $\underline{\mu}$ is the estimated 2019-2023 strike rate of 1.2.

From the strike rate (1.2), the Poisson distribution can estimate the probability of *n* where n=0 (no strikes), 1 strike, 2 strikes, and 3 strikes:

- P(0)= 0.286 or a 29% chance of zero strikes over the period from 2019-2023
- P(1)= 0.358 or a 36% chance of one strike over the period from 2019-2023
- P(2)= 0.224 or a 22% chance of two strikes over the period from 2019-2023
- P(3)= 0.0.093 or a 9% chance of three strikes over the period from 2019-2023

Based on the resulting probabilities presented in the analysis above, we anticipate that the Navy will strike up to three large whales (inclusive of ESA-listed and non ESA-listed large whales) incidental to training and testing activities within the action area over the course of the 5 years of the proposed MMPA rule. The chances of striking more than three whales is low (i.e., less than 4 percent) and not reasonably certain to occur.

Most Navy-reported whale strikes are not identified to the species level, making it difficult to predict which species of large whales are most likely to be struck during future training and testing activities. In order to predict the likelihood of striking any particular species, we compiled information from the latest NMFS Stock Assessment Reports (SARs) for each species or stock on detected annual rates of large whale serious injury and mortality from vessel collisions (Table 91). We used information from the 2016 (Carretta et al. 2017c), 2017 (Carretta et al. 2018c) SARs, and 2018 draft SARs (Carretta et al. 2018a), as this represented the best available information at the time of consultation. We recognize that not all ship strikes are documented or reported (e.g., See Rockwood et al. 2017), so not all instances of serious injury and mortality are represented in the annual rates reported in the SARs. However, the annual rates of large whale serious injury and mortality from vessel collisions in the SARs do provide a good representation of the relative susceptibility of large whale species to vessel strike in the action area. To calculate the relative likelihood of striking each species, we summed the annual rates of mortality and serious injury, then divided each species' annual rate by this number. We include non-ESA-listed large whales in this calculation as some of the unidentified whales struck by the Navy in previous years could have been these species as well.

Table 91. Annual rates of mortality and serious injury for large whales from vessel collisions compiled from National Marine Fisheries Service stock assessment reports and estimated percent chance of striking each large whale species in the action area over a five-year period.

Species	Location/DPS or stock	Annual rate of M/SI* from vessel collision	Percent chance of ONE strike	Percent chance of TWO strikes
Blue whale	*Hawaii/NA**	0	0	0
	SOCAL/NA	0.2	1.96	0.04
Fin whale	*SOCAL/NA*	1.6	15.65	2.45
	Hawaii/NA	0	0	0
Humpback whale	*SOCAL/Central America DPS*	2.1	20.54	4.22
	SOCAL/Mexico DPS			
Sei whale	*SOCAL/NA*	0.2	1.96	0.04
	Hawaii/NA	0	0	0
Gray whale	*SOCAL/Western North Pacific DPS*	0	0	0
Sperm whale	*SOCAL/NA*	0.2	1.96	0.04
	Hawaii/NA	0	0	0
Gray whale	SOCAL/Eastern North Pacific stock	0.8	7.82	0.61
Bryde's whale	SOCAL/Eastern Tropical Pacific stock	0.2	1.96	0.04
	Hawaii/Hawaiian stock	0	0	0
Minke whale	SOCAL/ California Oregon Washington stock	0	0	0
	Hawaii/Hawaii stock	0	0	0
Humpback whale	Hawaii/Central North Pacific stock	2	19.56	3.83

**M/SI = Mortality/Serious Injury; Species that are listed under the ESA are in italics.*
***This represents the average annual M/SI figure from 2009 to 2015, based on information presented in the previous two stock assessment reports (Carretta et al. 2018c; Carretta et al. 2017c).*

The probability analysis described above concluded that there was a 29 percent chance that zero whales would be struck by Navy vessels over the next five years, indicating a 71 percent chance that at least one whale would be struck over the next five years. To estimate the percent likelihood of striking a particular species of large whale, we multiplied the relative likelihood of striking each species by the total probability of striking a whale (i.e., 71 percent) and also considered other factors such as whether or not the Navy has a record of striking that particular species in the past during training and testing activities. To calculate the percent likelihood of striking a particular species of large whale twice, we squared the value estimated for the probability of striking a particular species of whale (i.e., to calculate the probability of an event occurring twice, multiply the probability of the first event by the second).

The information presented in Table 91 indicates there is at least a ten percent chance of striking a fin and humpback (Central America or Mexico DPSs) whale during the five year period of the MMPA authorization. Based on the relatively high likelihood of strike for these species, it is reasonable to assume that the Navy will strike one humpback and one fin whale over the five year period of the proposed rule and each subsequent five-year period. Table 91 indicates there is a 20.54 percent chance the Navy will strike a single humpback whale from either the Mexico or Central America DPSs. To determine which of these DPSs is most likely to be struck, and therefore a strike that is reasonably certain to occur, we evaluated the relative abundance of each of these DPS in California waters. Based on data summarized by Wade et al. (2016), up to 20 percent of the humpback whales off the coast of California may be from the Central America DPS. The remaining are expected to be from the Mexico DPS. Based on this information, the likelihood of striking a Central America DPS humpback whale is 4.1 percent and the likelihood of striking a Mexico DPS humpback whale is 16.44 percent. For this reason, we anticipate that a vessel strike of a humpback whale would most likely be from the Mexico DPS. Additionally, the NMFS Permits Division is not authorizing vessel strike of a Central America DPS humpback whale in the final MMPA regulations. Based on the available information, it is extremely unlikely that the Navy will strike a Central America DPS humpback whale. For this reason, striking this species is not reasonably certain to occur.

The information presented in Table 91 indicates there is just under a two percent chance of striking a blue, sperm, and sei whale. While the probability analysis described above indicates a relatively low likelihood of a blue or sperm whale being struck, other information supports the conclusion that it is reasonably likely that one blue and one sperm whale will be struck by a Navy vessel over the five year period of the proposed rule and each subsequent five-year period. Blue whales are known to be struck in southern California waters by vessels (e.g., Rockwood et al. 2017) and the Navy struck a blue whale in this portion of the action area in 2004. The Navy also struck a sperm whale in the action area in 2007 while conducting training and testing activities. For these reasons, it is reasonably certain that the Navy will strike a blue whale and a sperm whale in the action area during the five year period of the proposed rule and each subsequent five year period. Regarding sei whales, vessel strike of this species is not know to be common in the action area. The draft 2018 SAR reported that a single sei whale strike occurred off the coast of California in 2015. However, the previous SARs did not report vessel strikes of sei whales in the action area. Additionally, the Navy has not struck a sei whale in the action area. Finally, the NMFS Permits Division is not authorizing vessel strike of a sei whale in the final

MMPA regulations. Based on the available information, it is extremely unlikely that the Navy will strike a sei whale. For this reason, striking this species is not reasonably certain to occur.

The information presented in Table 91 indicates there is a zero percent chance of striking a Western North Pacific DPS gray whale in the action area. For this reason, the chances of striking these species is extremely unlikely and thus discountable. Striking this species then is not reasonably certain to occur. Based on this analysis, there is also a very low percent chance of striking any particular species more than once (i.e., less than 4 percent chance for all species). However, the Navy did have two documented instances of fin whale strikes in 2009. For that reason, it is reasonable to assume that the Navy is likely to strike two individuals of this particular species during the five year period of the proposed rule. We consider these strikes reasonably certain to occur. For the other species, the chances of striking two individuals is extremely unlikely and thus discountable.

In summary, based on the analysis presented above, we are reasonably certain that the Navy will strike one blue, two fin, one Mexico DPS humpback, and one sperm whale over the five-year period of the proposed MMPA rule (but no more than three large whales in total).

9.2.1.4.2 Response Analysis

Vessel collisions with large whales can result in death or serious injury of the animal. Wounds resulting from ship strike may include massive trauma, hemorrhaging, broken bones, or propeller lacerations (Knowlton and Kraus 2001). Superficial strikes may not kill or result in the death of the animal. The severity of injuries typically depends on the size and speed of the vessel (Conn and Silber 2013a; Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007). Impact forces increase with speed, as does the probability of a strike at a given distance (Gende et al. 2011; Silber et al. 2010b).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death or serious injury (Knowlton and Kraus 2001; Laist et al. 2001; Pace and Silber 2005; Vanderlaan and Taggart 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 13 knots.

Jensen and Silber (2003) detailed 292 records of known or probable ship strikes (inclusive of military and non-military vessels) of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67 percent) resulted in serious injury or death (19 of those resulted in serious injury as determined by blood in the water, propeller gashes or severed tailstock, and fractured skull, jaw, vertebrae, hemorrhaging, massive bruising or other injuries noted during necropsy and 20 resulted in death). Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79 percent) of these strikes occurred at speeds of 13 knots or greater.

The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 to 75 percent as vessel speed increased from 10 to 14 knots, and exceeded 90 percent at 17 knots. Higher speeds during collisions result in greater force of impact and also appear to increase the chance of severe injuries or death. While modeling studies have suggested that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed ((Clyne et al. 1999; Knowlton et al. 1995), this is inconsistent with Silber et al. (2010b), which demonstrated that there is no such relationship (*i.e.*, hydrodynamic forces are independent of speed).

In a separate study, Vanderlaan and Taggart (2007) analyzed the probability of lethal mortality of large whales at a given speed, showing that the greatest rate of change in the probability of a lethal injury to a large whale as a function of vessel speed occurs between 8.6 and 15 knots. The chances of a lethal injury decline from approximately 80 percent at 15 knots to approximately 20 percent at 8.6 knots. At speeds below 11.8 knots, the chances of lethal injury drop below 50 percent, while the probability asymptotically increases toward 100 percent above 15 knots. The Jensen and Silber (2003) report notes that the database represents a minimum number of collisions, because the vast majority probably goes undetected or unreported. In contrast, Navy vessels are likely to detect any strike that does occur due to the number of lookouts and other personnel onboard, and they are required to report all ship strikes involving marine mammals (Navy Memorandum for the Record; May 14, 2018).

Our exposure analysis considered vessel strike of marine mammals comprehensively, as a result of all Navy vessel movement within the action area, as opposed to in the context of specific training or testing exercises. For this reason, we are not able to predict the speed or size of Navy vessels that are expected to result in ship strikes of large whales. Because of these unknowns, we assume that all incidences of ESA-listed large whale vessel strike associated with Navy training and testing activities in the action area will result in mortality to the affected animal.

9.2.1.4.3 Risk Analysis

In our exposure analysis, we concluded that the Navy is likely to strike one blue, two fin, one Mexico DPS humpback whale, and one sperm whale over the five-year period of the proposed MMPA rule. In our response analysis, we determined that all incidences of ESA-listed large whale vessel strike associated with Navy training and testing activities in the action area will result in mortality to the affected animal. Instances of mortality will remove that animal from the population.

9.2.2 Sea Turtles

This section discusses the effects of explosive and vessel strike stressors on ESA-listed sea turtles.

9.2.2.1 Explosives Stressors – Sea Turtles

Explosives that may be used as part of the proposed action include bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys (Navy 2018d). Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; and mines and demolition charges could be detonated in the water column or on the ocean bottom (Navy 2018d). Most detonations would occur in waters greater than 200 ft in depth and greater than three NM from shore, although mine warfare, demolition, and some testing detonations would occur in shallow water close to shore. Most activities involving the use of explosives would occur in the Hawaii and SOCAL Range Complexes (Navy 2018d). A small number of training activities involving explosives, including air to surface bombing exercises and surface to surface gunnery exercises, are proposed within the HSTT transit corridor However, given the anticipated small number of explosive events and the very low sea turtle densities, it is highly unlikely that sea turtles would be exposed to explosive stressors in the transit corridor. As such, this area will not be considered further in our explosives exposure analysis.

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. Unlike other acoustic stressors, explosions release energy at a high rate producing a shock wave that can result in both sublethal and lethal effects on marine animals. Potential impacts considered include mortality, injury, hearing loss due to threshold shift (permanent or temporary), masking of other biologically relevant sounds, physiological stress, and changes in behavior. Based on what is known about potential sea turtle impacts from explosives studies and other activities that use explosives (e.g. oil and gas exploration), NMFS assumes underwater explosives can kill, injure, and impair sea turtles exposed to detonations. Lethal injuries result from massive trauma or combined trauma to internal organs as a result of close proximity to the point of detonation. Types of lethal injuries include massive lung hemorrhage, gastrointestinal tract injuries (contusions, ulcerations, and ruptures), and concussive brain damage, cranial and skeletal (shell) fractures, hemorrhage, or massive inner ear trauma (Ketten 1995). Examples of nonlethal injuries include eardrum rupture, bruising, and immobilization of severely stunned animals. Stunned animals beneath the water may drown or become vulnerable to other impacts while they are immobilized. Minor organ injuries and contusions can also occur as a result of underwater explosions; however, some sea turtles would be expected to recover over time through normal healing processes. Still, delayed complications arising from nonlethal injuries may ultimately result in the death of the animal because of increased risks from secondary infection, predation, or disease; and a reduced foraging capacity.

9.2.2.1.1 Exposure and Response Analysis

This subsection starts with a discussion of the sea turtle density information used to estimate the number of exposures to explosives. Next, we summarize the results from the Navy's NAEMO

Phase III exposure model and discuss the anticipated responses (i.e., numbers of individuals taken, types of take anticipated) based on the sea turtle exposure levels predicted by the model.

Sea Turtle Densities Used for Explosives Exposure Analysis

The Navy compiled density data from several sources, and developed a protocol to select the best available data sources based on species, area, time (season, and type of density model). The resulting GIS database, called the Navy *Marine Species Density Database*, includes seasonal density values for sea turtle species present within the action area (Navy 2017d). When aerial surveys are used to collect data on sea turtle occurrence it is often difficult to distinguish between the different sea turtle species. To account for the known occurrence of multiple sea turtle species in the action area and the general lack of species specific occurrence data for most species, a sea turtle guild, composed of green and hawksbill turtle sightings, was created to estimate sea turtle densities in the HRC. The sea turtle guild was not used to estimate sea turtle densities in the transit corridor (eastern or western portions) or for the SOCAL Range Complex due to the scarcity of sea turtle sightings data in these areas.

While the analysis of sea turtle guild survey data applies to all species, it is more reflective of green turtles, which account for nearly all sightings in the HRC. The number of observations of hawksbill turtles would be so low as to render the data unusable for estimating density of this species. By considering the hawksbill and green turtle sightings together, a more powerful result can be provided for sea turtles as a guild. In theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles, but these species have not been identified during the collection of Navy monitoring data. The model results for the sea turtle guild as a whole were proportioned by species (on the back end) based on the relative proportion of each species in fisheries bycatch for different areas (i.e., nearshore and offshore).

Central North Pacific DPS of green sea turtles are often seen in the water in Hawaii and basking on some beaches (Whittow and Balazs 1982). Transoceanic migrations between Japan and Baja California, Mexico suggest that loggerheads may be present in the HRC. The leatherback turtle occurs in offshore areas surrounding the Hawaiian Islands beyond the 100 m isobath; shoreward of the 100 m isobath is an area of rare leatherback occurrence. Bailey et al. (2012) used tracking data for 135 individual leatherbacks and data on longline fishing effort to predict areas, or "hot spots," where leatherback turtles in the Pacific Ocean are most likely to be at risk of bycatch. The study identified areas of relative high use by leatherback turtles that varied seasonally and correlated with likely migration routes. Higher use areas in the vicinity of the Hawaiian Islands were mainly south of the Islands from January through March, distinctly to the south from July through September, and to the southeast from October through December. From April through June, areas of higher use were centered on the Hawaiian Islands with a slightly greater intensity of use northeast of the Islands. Strandings and observations of hawksbill turtles in Hawaii are uncommon. There is a very small hawksbills nesting population on the Hawaiian Islands. Rare instances of olive ridley nesting on the Hawaiian Islands have also been reported.

Density estimates around Hawaii are derived from the Pacific Navy Marine Species Density Database. The Navy conducted aerial surveys for strandings of marine mammals in Hawaii under the monitoring program from 2009–2013, and incidentally observed sea turtles were also documented. Based on the number of turtles observed and the area of the strip transect, the Navy calculated the density of sea turtles for the nearshore waters of each island that was surveyed. A correction factor was applied to account for the number of turtles that are present but not observed, because the turtles are either camouflaged or too deep below the surface to be seen (Buckland et al. 2001). The Navy model estimates that only ten percent of the turtles actually present were at the surface of the water or shallow enough to be seen from an aerial platform. Coastline surveys that recorded turtle sightings are available for the Islands of Kauai, Lanai, Molokai, and Oahu. For islands that were not surveyed by plane, the mean density of the four islands with data was used. Density values are applied out to the 100 m (330 ft) isobath around all of the islands. To address the area of the HRC beyond the 100 m isobath, the Navy reduced the mean density value by two orders of magnitude.

As a requirement under the Sikes Act (16 U.S.C. §670a–670o), the Navy maintains an Integrated Natural Resources Management Plan for Pearl Harbor. Natural resource monitoring occurs under the Integrated Natural Resources Management Plan. As a result, the Navy used data from in-water surveys conducted in Pearl Harbor from 2000 to 2011 to estimate sea turtle densities in this portion of the HRC. Navy scientists divided Pearl Harbor into numbered sections and calculated in-water turtle densities for strip transects performed in each section. In areas where there was a gap between surveyed areas, the Navy extrapolated values in a step-wise gradient, as was done between the 100 m isobaths around the islands of Lanai and Molokai (Table 92). Sea turtle guild densities estimated for each island were proportioned by species to estimate the exposures to explosives for each species.

Sea turtles were not evenly distributed in Pearl Harbor. The turtles tend to concentrate along the margins of the channel leading into Pearl Harbor compared to other locations, and more turtles occurred in the channel south of Pearl Harbor in the cool season (November to April) than during the warm season (Hanser et al., In Prep. As cited in Navy 2018d). Within Pearl Harbor, the turtles were encountered more frequently in the western loch than in either the eastern or middle lochs.

Table 92. Summary of Density Values for the Sea Turtle Guild in the Hawaii Range Complex.

Location	Density (Animals/km^2)
	Year-Round
Kauai	0.2786
Lanai	0.4491
Molokai	0.1624
Oahu	1.1252
Other Islands	0.4288
Beyond 100 m isobath	0.0043
Pearl Harbor	S

S = spatial model with various density values throughout the range. See Figure 75 and Figure 76 for estimated densities in Pearl Harbor.

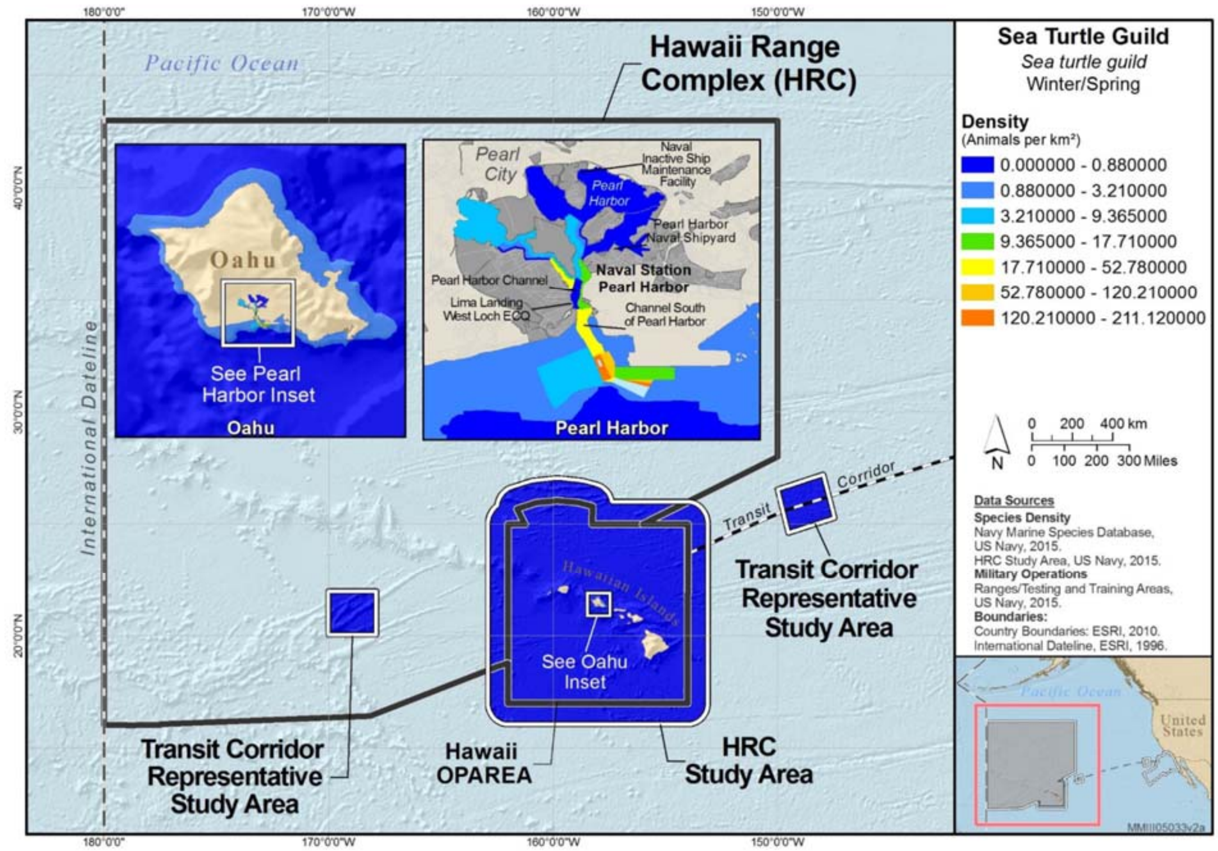


Figure 75. Winter/Spring Distribution of Sea Turtles in the Sea Turtle Guild in Hawaii Range Complex (Navy 2018d).

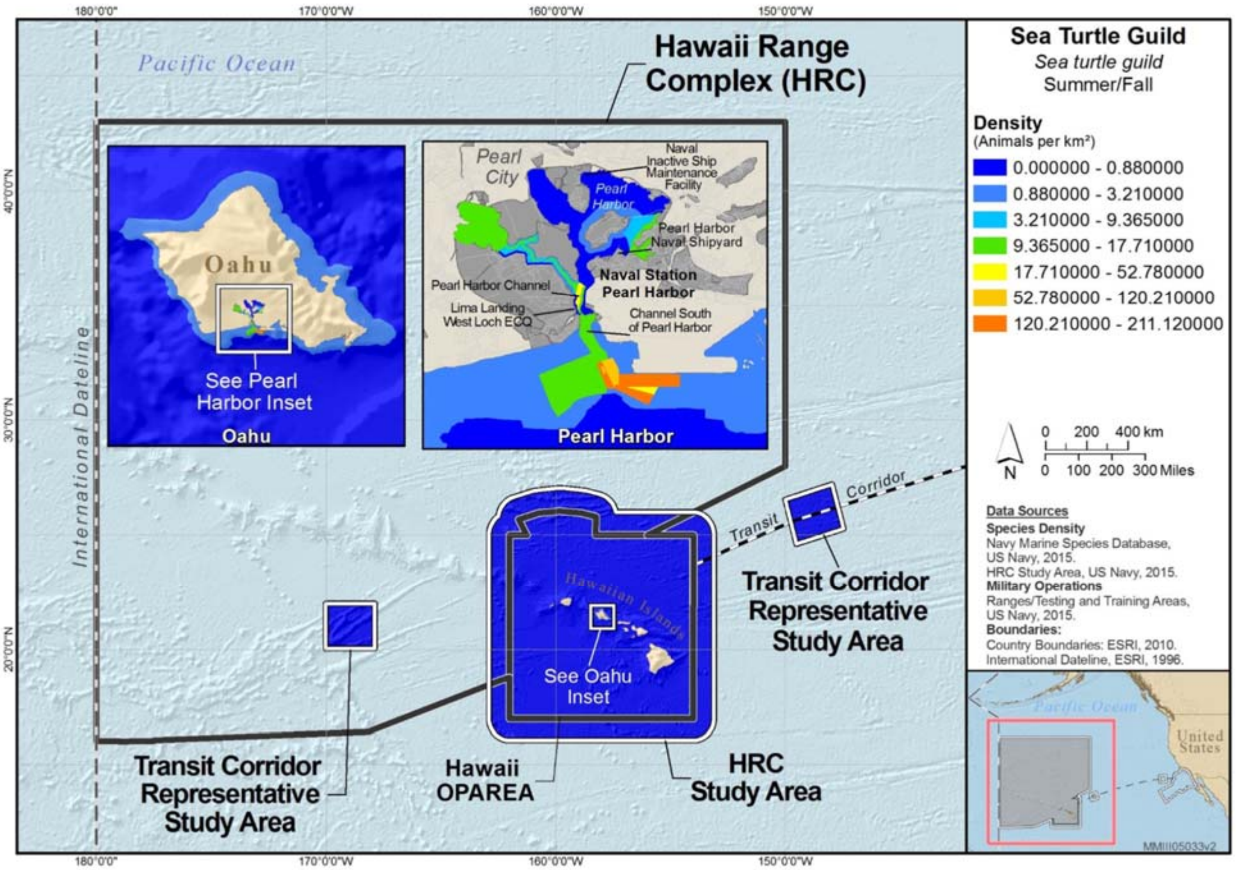


Figure 76. Summer/Fall Distribution of Sea Turtles in the Sea Turtle Guild in Hawaii Range Complex (Navy 2018d).

The Navy funded visual surveys from the coast of Southern California out to approximately 100 nm from 2008 through 2012. These surveys are able to sight small surfaced and submerged animals such as sharks, ocean sunfish, and fish schools, and have been demonstrated to sight sea turtles in other areas where turtles are more common (Eguchi and Seminoff 2011). Over 870 hours and 43,500 nm of visual survey effort was made over this five-year period during which not a single sea turtle visual sighting was reported. Despite these survey results, based on anecdotal information, species life history, and limited stranding data, we assume ESA-listed sea turtles do occur off the Southern California coast. However, survey results suggest sea turtles occur in very low abundance in this area. One reported at-sea sighting of sea turtles about 200 to 250 miles off the Southern California coast occurred in January, 2015 during a NMFS marine mammal survey. Researchers observed more than 70 confirmed or likely young loggerhead turtles over several days (NMFS 2015d). This sighting could be indicative of regular presence of loggerheads at this life stage in this area during certain times of the year. Aside from the Navy and NOAA surveys discussed above, there are no other data available for estimating sea turtle densities in the SOCAL Range Complex. The Navy used data from the scientific literature (Eguchi et al. 2010) to estimate green sea turtle densities in San Diego Bay. However, since the proposed action would not include activities involving detonations in San Diego Bay, these density estimates were not used in our explosives exposure analysis.

Loggerhead, leatherback and green sea turtles are known to occur in the Southern California portion of the action area. However, available data are sparse and so little is known about the distribution or abundance of these species in this area that reasonable in-water density estimates cannot be made at this time. With the exception of green sea turtles in San Diego Bay (where explosives would not be used), based on previous survey efforts the distribution and abundance of sea turtles within the SOCAL Range Complex is thought to be fairly limited. Given the number of explosive detonations proposed, the large spatial area over which explosives would be used, and the anticipated low densities of these species, we find the likelihood of a North Pacific DPS loggerhead, leatherback or Eastern Pacific green sea turtle exposure to the effects of explosives extremely unlikely and thus discountable.

Density data does not exist for hawksbill or olive ridley turtles in southern California; therefore exposures were not modeled for these species for the SOCAL Range Complex. Hawksbill sea turtles are not expected to occur in the SOCAL Range Complex where explosives may be detonated based on previous survey efforts and stranding data. There are few documented occurrences of olive ridley sea turtles in waters off the U.S. Pacific coast (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1998c). Based on sea surface temperature preferences, this species is also not expected to occur in the SOCAL Range Complex.

Exposure Estimates from the Phase III NAEMO Model

The Navy's quantitative analysis to determine impacts to sea turtles and marine mammals uses NAEMO to produce initial estimates of the number of animals that may experience effects from particular stressors. The model takes into account (1) criteria and thresholds used to predict impacts from explosives, (2) the density and spatial distribution of 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. These estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. The NAEMO modeling and classification of modeled effects from acoustic stressors, such as TTS and PTS, are considered a conservative overestimate of 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. A more detailed explanation of this analysis is provided in the Navy's technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g).

NAEMO outputs only represent estimates for larger sea turtles (i.e., those greater than 30 cm in diameter). The data used by the Navy to quantitatively assess impacts to sea turtles is primarily from NMFS' aerial surveys with supplemental data from shipboard surveys from NMFS and others. The data are largely derived from aerial surveys, corrected for sighting availability, which can only detect these larger sea turtles (Epperly et al. 1995). For these reasons, neither age class nor size are explicitly accounted for in the sea turtle density data, although the size makes sightability and identification of age and species easier. While the density data used may not explicitly account for size of sea turtles smaller than 30 cm, the Navy's explosives analysis takes into consideration smaller sea turtle effects correlated with sea turtle mass. For example, the criteria for estimating the potential for slight lung injury and mortality are directly correlated to the mass of an animal. Therefore, juvenile weights are incorporated, and effects are considered for the population affected. At this time the Navy and NMFS are unaware are of any additional datasets that would provide size class estimates for smaller sea turtles.

During the early life histories of sea turtles, hatchlings and juveniles spend a majority of time passively floating in prevailing ocean currents and inhabiting floating vegetation mats. Because of this, the major ocean currents entrain most small sea turtles in offshore gyres of the Sargasso Sea, which are far away from the locations where most of the Navy's acoustic or explosive activities would occur. The Navy has also proposed mitigation measures aimed at minimizing impacts on floating vegetation used by hatchling and juvenile sea turtles. Although the density data does not quantitatively allow the separation of sea turtle size classes, the effects to small sea turtles (less than 30 cm diameter) is somewhat accounted for in the Navy analysis and minimized through mitigation.

The quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtles would be killed. The mortality threshold is based on the exposure level 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 quantitative model also predicts up to one green sea turtle from the Central North Pacific DPS would be exposed annually to levels of explosive sound and energy that could cause injury during training activities only (Table 93). No Eastern Pacific green, hawksbill, olive ridley, leatherback, or loggerhead sea turtles are likely to be exposed to levels of explosive sound and energy that could cause injury during training and testing activities under the proposed action. 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 (1982b). There is some uncertainty regarding whether slight lung injuries or contusions to the gastrointestinal tract may have long-term effects on survival rates due to the lack of studies. It reasonable to assume that animals with slight lung injuries or gastrointestinal tract contusions could survive, whereas those with extensive lung injuries or gastrointestinal tract contusions would not (U.S. Department of the Navy 2017b). In addition to minor lung injuries or gastrointestinal tract contusions from the blast wave, it is possible that sea turtles may be physically injured due to fragmentation of exploding munitions. However, given that fragments would quickly decelerate in water, and that injury due to the blast wave would extend much further than any risk from fragmentation, sea turtles that may experience injury from fragmentation are also assumed to experience injury due to the blast wave. As such, the estimates produced by NAEMO modeling for non-auditory injuries are assumed to encompass any sea turtles that may also be injured due to fragmentation.

Green sea turtles are also expected to experience hearing loss (both TTS and PTS) as a result of training activities involving explosives. Annually, up to 20 Central North Pacific DPS green sea turtles could experience TTS and up to seven could experience PTS during training activities only. The model predicts that 60 percent of green sea turtle exposures would be from mine warfare, 11 percent from surface warfare, and 29 percent from other training activities. No East Pacific green, hawksbill, olive ridley, leatherback, or loggerhead sea turtles are likely to be exposed to the levels of explosive sound and energy that could cause PTS or TTS during testing or training activities under the proposed action.

The response of ESA-listed sea turtles from exposure to explosives resulting in hearing loss is expected to be similar to the response of ESA-listed sea turtles experiencing hearing loss due to sonar or other transducers, with those associated with TTS expected to be only temporary, and recoverable, but those associated with PTS to be permanent. The exception is that because active sonar is transmitted at a specified frequency, sea turtles experiencing hearing loss from sonar would only experience threshold shifts around that particular frequency. In contrast, explosives are a broadband source (Hildebrand 2009a), so if an animal experiences TTS or PTS from explosives, a greater frequency band will be affected. Because a greater frequency band will be affected due to explosives, there is increased chance that the hearing impairment will affect frequencies utilized by sea turtles for acoustic cues such as the sound of waves, coastline noise, the presence of a vessel or predator. However, sea turtles are not known to rely heavily on sound for life functions (Nelms et al. 2016; Popper et al. 2014d), and instead, 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).

Table 93. Estimated Sea Turtle Impacts per Year from Explosive Training Activities.

Species	Annual			
	TTS	PTS	Injury	Behavioral Response[2]
Explosive Training Activities				
Family Cheloniidae (hardshell turtles)				
Green turtle[1]	20	7	1	1,814
Hawksbill turtle	0	0	0	17
Loggerhead turtle	0	0	0	21
Olive ridley turtle	0	0	0	13
Family Dermochelyidae (scuteless turtles)				
Leatherback turtle	0	0	0	23

[1] *Exposures only applicable to the Central North Pacific DPS.*
[2] *These numbers represent the predicted exposures at or exceeding 175 dB re 1 μPa SPL (rms). We conservatively assume that all such exposures could result in a behavioral response.*

Any acoustic stimuli within sea turtle hearing ranges in the marine environment could elicit behavioral responses in sea turtles, including noise from explosions. The quantitative model predicts that all five species would be exposed to received levels from explosions that may result in behavioral responses (i.e. at or exceeding 175 dB re 1 μPa SPL (rms)). Behavioral responses are anticipated as a result of explosions during both training and testing activities for all species (Table 93 and Table 94). Up to 1,831 green sea turtles from the Central North Pacific DPS could be exposed annually to explosions that result in a behavioral response. Most of these would occur as a result of training activities. Up to 193 leatherback and 182 loggerhead sea turtles are predicted to be exposed annually to explosions that result in a behavioral response. For these species, the large majority of exposures to explosives are associated with testing activities. The model also predicts up to 17 hawksbill and 96 olive ridley sea turtle exposures annually to explosions that result in a behavioral response. These represent conservative estimates of the number of behavioral responses anticipated since they are based on a maximum year of testing and training activities and not all exposures to the threshold received levels modeled (i.e. 175 dB) would necessarily produce a behavioral response.

Table 94. Estimated Sea Turtle Impacts per Year from Explosive Testing Activities.

Species	Annual			
	TTS	PTS	Injury	Behavioral Response[1]
Family Cheloniidae (hardshell turtles)				
Green turtle	0	0	0	17
Hawksbill turtle	0	0	0	4
Loggerhead turtle	0	0	0	161
Olive ridley turtle	0	0	0	83
Family Dermochelyidae (scuteless turtles)				
Leatherback turtle	0	0	0	170

[1] These numbers represent the predicted exposures at or exceeding 175 dB re 1 μPa SPL (rms). We conservatively assume that all such exposures could result in a behavioral response.

9.2.2.1.2 Risk Analysis

In the exposure and response analysis, we established that a range of impacts including non-auditory injury, hearing loss (PTS and TTS), and behavioral response are likely to occur due to exposure of ESA-listed sea turtles to Navy explosives during HSTT activities. In this section, we assess the likely consequences of the responses of individuals exposed to explosive stressors.

As described above, the injury threshold we used is based on the exposure level expected to result in a slight lung injury (i.e., slight lung hemorrhage) or gastrointestinal tract contusion, whereas the mortality threshold is based on the exposure level expected to result in severe lung hemorrhage, from which are not recoverable injuries. For the purposes of this analysis, we assume that the ESA-listed sea turtles experiencing non-auditory injuries would be temporarily injured/impaired, but would recover from the injury after some duration. During recovery, we assume that an injured ESA-listed sea turtle's ability to conduct important life functions (e.g., breeding, feeding) would be diminished, but that the animal would survive overtime. We recognize there is uncertainty in this assumption as we do not have information available to determine how long an injured sea turtle would take to recover. However, based on the quantitative analysis, non-auditory injuries of sea turtles due to exposure to explosives would be exceedingly rare. Only one Central North Pacific DPS green sea turtle is predicted to be injured per year from explosives; zero injuries are predicted per year for all other sea turtle species.

Sea turtles are not known to depend heavily on acoustic cues for vital biological functions (Nelms et al. 2016; Popper et al. 2014d). As such, the likelihood that the loss of hearing in a sea turtle would impact its fitness (i.e., survival or reproduction) is low when compared to marine mammals, which rely heavily on sound for basic life functions. Sea turtles may use acoustic cues such as waves crashing, wind, vessel and/or predator noise to perceive the environment around them. If such cues increase survivorship (e.g., aid in avoiding predators, navigation), hearing loss may have effects on individual sea turtle fitness. TTS of sea turtles is expected to only last for several days following the initial exposure (Moein et al. 1994). Given this short period of time, and that sea turtles are not known to rely heavily on acoustic cues, we do not anticipate that single TTSs would have any long-term fitness impacts on individual turtles. PTS would permanently impair a sea turtle's ability to hear environmental cues, depending on the frequency of the cue and the frequencies affected by the hearing impairment. Given this longer time frame, we anticipate that at least some sea turtles that experience PTS may have a reduction in fitness either through some slight decrease in survivorship (e.g., decreased ability to hear predators or hazards such as vessels) or reproduction (e.g., minor effects to navigation that may reduce mating opportunities). The quantitative model predicts that only Central North Pacific DPS green sea turtles would likely experience TTS and PTS as a result of exposure to explosives. No other sea turtle species would likely be exposed to levels resulting in either TTS or PTS. Although green sea turtles could experience both short-term and long-term fitness consequences due to hearing loss, the number of individuals affected (i.e., up to 20 TTS and seven PTS in a maximum year of training activities) is relatively small compared to the Central North Pacific DPS population size.

There is very 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). As described previously, NMFS conservatively uses the limited information on sea turtle behavioral responses to air guns as a surrogate for the sound sources produced during Navy activities, including explosive exposure analysis. Because sea turtles exhibited 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, assuming the exposure did not result in injury. Additionally, significant behavioral responses that result in disruption of important life functions are more likely to occur from multiple exposures within 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, while a large number of sea turtles may experience a behavioral response from exposure to explosives (See Table 93 and Table 94), the anticipated impacts on fitness and survival are minor and short-term.

ESA-listed sea turtles that experience either TTS, PTS, non-auditory injury or 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. Long-term injuries such as non-auditory injuries and PTS may result in some prolonged stress that in combination with the injuries themselves, may function to reduce an individual sea turtle's fitness. However, as discussed above, a very small number of sea turtles are expected to experience such injuries as a result of HSTT activities involving explosives.

The Navy will implement mitigation measures (described in 3.4.2) which include several Lookout scenarios with large exclusion zones (Navy 2018d). The mitigation for Phase III includes the following changes from Phase II designed to further minimize impacts from explosives: (1) a 250 yd increase in the mitigation zone size for sonobuoys using up to 2.5 lb net explosive weight so that all explosive sonobuoys will implement a 600 yd mitigation zone, regardless of net explosive weight, (2) a 400 yd increase in the mitigation zone size for surface-to-surface activities using explosive medium-caliber projectiles (now a 600 yd mitigation zone) and large-caliber projectiles (now a 1,000 yd mitigation zone), and (3) a 1,100 yd increase in mitigation zone size (now 2,000 yd) for missiles and rockets using 21–250 lb net explosive weight, (4) an increase in the mitigation zone size during explosive mine neutralization activities involving Navy divers for positive control charges in bin E4 or below and bin E7. These measures would reduce the number of sea turtles that could be exposed to explosives by ensuring (as much as possible) that sea turtles are not present during exposure to this stressor.

In summary, while sea turtles are expected to experience TTS, behavioral and physiological stress responses from exposure to explosives, these responses alone are not expected to have any long-term impacts nor affect the fitness of individual sea turtles. The explosives associated with the proposed action are also expected to result in PTS and non-auditory injury, which could have fitness impacts on individual sea turtles. However, these effects are only predicted to occur in Central North Pacific DPS green sea turtles. Based on the overall low number of green sea turtle individuals that could experience PTS or a non-auditory injury, we do not anticipate that the use of explosives as proposed by the Navy would have measurable impacts at the population level for Central North Pacific DPS green sea turtles. For all other sea turtle species in the action area the predicted effects from explosives would be limited to behavioral responses with no anticipated long-term impacts nor fitness consequences for individual sea turtles. As such, we do not anticipate that the use of explosives as proposed by the Navy would have measurable impacts at the population level for Eastern Pacific DPS green, leatherback, hawksbill, North Pacific Ocean DPS loggerhead, or olive ridley Mexican and all other breeding populations.

9.2.2.2 Vessel Strike – Sea Turtles

The majority of the Navy's training and testing activities considered in this biological opinion involve vessel activity. The activities and locations that involve vessels (and in-water devices) are discussed in 6.4 of this opinion and described in more detail in the HSTT DEIS/OEIS and in the HSTT BA (Navy 2018d). Within the action area, Navy boat or vessel traffic is heaviest in the nearshore waters, near major ports, and in shipping lanes (See Figure 26 above). While commercial traffic is relatively steady throughout the year, Navy vessel usage within the range complexes is episodic, based on specific exercises being conducted at different times of the year (Mintz 2016). Unlike when a vessel strikes a large whale, it is difficult to detect when a vessel strikes a turtle. This is largely due to the relatively small size of a sea turtle compared to the vessels used by the Navy in military readiness training and testing activities.

Any of the sea turtle species found in the action area can occur at or near the surface in open-ocean and coastal areas, whether resting, feeding or periodically surfacing to breathe. Therefore, all ESA-listed sea turtles considered in the opinion are potentially at risk of vessel strike by Navy vessels. Sea turtle vulnerability to vessel strike increases with vessel speed. Hazel et al. (2007) found that vessel operators could not rely on turtles at the surface to actively avoid being struck for vessel speeds greater than four km/hr. In inshore waters (where vessel encounters with sea turtles may be higher), Navy vessel use occurs more regularly and is mainly from small, high-speed vessels. High-speed vessel movements in nearshore and inshore waters present a relatively greater risk of vessel strike because of the higher concentrations of sea turtles in these areas and the difficulty for vessel operators to see them and avoid collisions during high speed activities. The Navy also conducts propulsion testing as part of their activities involving vessels. Although such testing is infrequent, this activity, which can involve ships operating at speeds in excess of 30 knots, may pose a higher strike risk due to the high vessel speeds.

Our ship strike exposure analysis below estimates the number of non-lethal and lethal vessel strikes of each sea turtle species (or DPS) that are anticipated annually as a result of the proposed action. In their HSTT Phase III BA the Navy provided a quantitative analysis of ship strikes on sea turtles. We adopt the Navy's basic approach for this opinion, with several modifications and additions (as discussed below) to account for new or updated information and different assumptions to address inherent uncertainties associated with this analysis.

Areas Considered in Ship Strike Analysis

Vessel use for Navy training and testing activities resulting in physical disturbance and strikes of sea turtles would most likely occur in areas that overlap high density sea turtle habitats, particularly nearshore foraging areas or off nesting beaches. Sea turtles are expected to be more highly dispersed in deeper offshore waters and, given the large area over which Navy vessels could potentially conduct training activities, the likelihood of co-occurrence is lower in offshore waters. Leatherback turtles, in particular, could be impacted by offshore vessel movement given this species' preference for open-ocean habitats and its surface foraging behavior. Hatchlings and pre-recruitment juveniles of all sea turtle species may also occur in open-ocean habitats, where they typically reside among mats of floating vegetation. As part of the proposed action, the Navy proposes to use lookouts to observe floating vegetation, which would includekelp paddies. If floating vegetation is observed, the Navy would avoid initiating activities until it passes, or move to another area . While there is no explicit measure proposed to avoid vessels traveling through floating vegetation, we anticipate that in most cases the Navy would avoid traveling through large patches of floating vegetation to prevent fouling the propeller or other underwater vessels components.

The Navy's approach to estimating ship strikes was based on available strandings information (including cause of strandings) and the relative proportion of all vessel activity (e.g., commercial fishing vessels, non-fishing commercial vessels, recreational boats, cargo ships, ferries, cruise ships, and military vessels) within portions of the action area attributed to Navy vessel activity. The Navy's sea turtle ship strike analysis focuses on the areas of greatest overlap between Navy vessel activity and ESA-listed sea turtles. The areas identified as having the highest ship strike potential were nearshore waters in close proximity to Navy ports. For the Hawaiian Range Complex, our analysis focuses on nearshore waters off the main Hawaiian Islands, since Navy vessels are based out of Pearl Harbor and are concentrated in this part of the Hawaiian Archipelago (Mintz 2016). The density of sea turtles is also substantially lower in offshore waters compared to nearshore of the HRC. Sea turtles struck far offshore within the HRC are less likely to strand than those struck in more nearshore waters. Based on data from 1982-2003, Chaloupka et al. (2008) reported that 99 percent of green turtle strandings recorded in the Archipelago occurred around the four main islands of Kauai, Oahu, Maui (including Molokai and Lanai) and Hawaii, with most of these (75 percent) occurring around Oahu. We have no empirical data to indicate Navy vessels strike turtles in offshore waters of the HRC and also no data to indicate what percent of those that may be struck in offshore waters strand. Therefore, as was done for the reinitiated HSTT Phase II biological opinion, turtle vessel strike in the HRC is calculated solely based on stranding data for the Main Hawaiian Islands.

For Southern California, Navy traffic is heaviest in the easternmost part of the Range Complex. Our ship strike analysis focuses on San Diego Bay since Navy vessels are based out of this port and vessel activity is concentrated in this part of the action area (Figure 26). Available survey data and stranding data indicate that sea turtles are rarely observed (alive or stranded) off the

Southern California coast (Eguchi and Seminoff 2011), indicating very sparse density and low population abundance. We have no empirical data to indicate Navy vessels strike turtles in the SOCAL Range Complex outside of San Diego Bay, and also no data to indicate what percent of those that may be struck in offshore waters strand. Because the available scientific and commercial data indicate such low sea turtle densities in SOCAL (outside of San Diego Bay), we do not anticipate ship strike of sea turtles to occur in this area.

In addition to the two range complexes within the HSTT action area, Navy vessels would also traverse the transit corridor between Hawaii and Southern California. While a Navy vessel moving between range complexes could strike a sea turtles, the likelihood of this occurring is very small given the low sea turtle densities anticipated within the transit corridor and the small number of transits that would occur. We have no empirical data to indicate Navy vessels strike turtles within the transit corridor. As such, we do not discuss this area further in our sea turtle vessel strike analysis.

Strandings Probabilities

Strandings data can provide valuable information on minimum mortality at sea and likely causes of death attributed to both anthropogenic and natural factors (e.g., fishery bycatch, disease, or vessel strike). Autopsies of stranded turtles can often indicate the likely cause of stranding, including whether or not the turtle was struck by a vessel. Since it is possible that a vessel strike can occur post-mortem, vessel strike may not be the proximal cause of death in all stranded turtles exhibiting vessel strike wounds. For stranded sea turtles with injuries consistent with vessel strike in the action area, we have no information indicating what proportion of those injuries were sustained ante-mortem versus post mortem. In a study from Virginia, Barco et al. (2016) found that all 15 dead loggerhead turtles encountered with signs of acute vessel interaction were apparently normal and healthy prior to being struck. While this suggests vessel strike did not occur post-mortem, this is just one study based on a small sample size of stranded turtles. For our analysis, we conservatively assume that vessel strike was the cause of mortality for any stranded turtle with signs of vessel strike.

Estimating total at sea mortality based on reported strandings can prove challenging since stranding probabilities are usually very low and highly variable in space and time (Koch et al. 2013). Juvenile and adult sea turtles have a specific gravity greater than seawater and both adjust their buoyancy by inflating their lungs (Milsom 1975). Consequently, moribund turtles sink to the bottom. As a result of decomposition, the animal will eventually bloat and float to the surface, only to sink again later. Thus, the probability of a moribund turtle beaching in an area is largely dependent upon the near-bottom current field (Epperly et al. 1996).

Previous studies suggest that the stranding probability of a sea turtle that dies at sea usually does not exceed 10 to 20 percent of total at sea mortality, even in nearshore waters (Epperly et al. 1996; Hart et al. 2006; Mancini et al. 2012). Although sea turtle stranding rates are variable, strandings typically represent only a small portion of the total mortality, as predators, scavengers, wind, and currents prevent carcasses from reaching the shore (Koch et al. 2013). Hart et al.

(2006) used results from oceanic drift-bottle experiments to validate their predictions and provide an upper limit on sea turtle stranding proportions. Drift bottle return rates in this study suggest an upper limit for the proportion of sea turtle carcasses that strand at around 20 percent. (Epperly et al. 1996) evaluated how well beach strandings functioned as an indicator of fishery-induced mortality. They found that the number of dead turtles that washed up on the beaches represented a maximum of 7-13 percent of the estimated fishery-induced mortalities. They attributed the low stranding probability to offshore bottom currents, which normally transport lifeless turtles away from the beach during the winter. Depending on currents, wind and other factors, strandings may represent as low as five percent of total mortalities in some particular locations (Mancini et al. 2011). At greater distances from shore, stranding probability diminishes even more, and for animals that die far offshore stranding probabilities may approach zero. In addition, many stranding may never be noticed or recorded in a database, particularly in more remote areas or areas without sea turtle stranding monitoring programs. In such areas the observed stranding rate is likely even smaller than the stranding probabilities predicted by experimental studies.

For the Main Hawaiian Islands we use ten percent as a conservative estimate of the observed stranding probability. This estimate considers (1) the large geographic span of the islands, (2) the physical factors (e.g., wind, currents, bathymetry) in this region that may prevent a carcass from stranding, and (3) the remote, less populated areas within the Main Hawaiian Islands, some of which are used for Navy or other vessel activities, where unobserved strandings may occur. Though available information does not allow us to estimate the percentage of vessel struck turtles that are observed stranded in San Diego Bay, we expect this observed stranding rate to be somewhat higher than the Main Hawaiian Islands due to the large human population along the bay and the fact that San Diego Bay is relatively enclosed. For San Diego Bay we use 20 percent as a conservative estimate of the observed stranding probability.

Proportion of Sea Turtle Ship Strikes Attributed to Navy Vessels

Combining available information on the number of reported strandings with evidence of vessel strike and the estimated stranding probability, we can arrive at an estimate of the total number of vessel strike mortalities. For purposes of our effects analysis, we then need to determine what proportion of the sea turtles killed by vessel strike are attributable to Navy vessels as part of the proposed action. To estimate vessel strikes by Navy vessels we need to determine the proportional level of Navy vessel activity relative to all vessel activity that can result in sea turtle vessel strike. Vessel activity can be measured several ways, including number of ships/vessels, number of transits in and out of ports, or number of ship-hours on the water. Based on the information available for our analysis, we determined that ship-hours on the water was the best correlate of sea turtle ship strike risk. All other things being equal (e.g., vessel speed, vessel size, vessel noise, locations, and sea turtle densities), the number of vessel strikes should be roughly proportional to the number of vessel hours on the water.

As shown in Table 95 and Figure 77, Navy ships makes up an estimated eight percent of total ship traffic in the HRC, and four percent of total ship traffic in SOCAL Range Complex (Mintz 2016). These percentages were used in our effects analysis as a proxy for the proportion of all sea turtles killed by vessel strike attributable to Navy vessels. As discussed above, our sea turtle vessel strike analysis is focused on particular locations within the action area where vessel strikes are likely to occur (i.e. Main Hawaiian Islands and San Diego Bay). The percent of ship-hours attributable to Navy ships, as presented in Mintz (2016), are based on ship traffic throughout each entire range complex (i.e., eight percent in the HRC and four percent in the SOCAL Range Complex). Lacking more detailed information on the relative percent of Navy ship traffic in only the Main Hawaiian Islands or San Diego Bay, we assume that the percentages provided for the RCs are a close approximation of the percentages in these smaller areas. We believe this is a reasonable assumption since both Navy and other vessel traffic are concentrated in these smaller areas. It should also be noted that the analysis by Mintz (2016) only includes large vessels, generally those over 65 ft in length. Thus, smaller Navy boats, small commercial vessels and most pleasure craft are not included. We anticipate that, due to their generally larger sizes and faster speeds, a large proportion of sea turtle vessel strikes, particularly lethal strikes, within the action area would be from large commercial and military vessels. However, we recognize that sea turtles are also susceptible to vessel strike by smaller vessels including small Navy and other military vessels, recreational boats, and small fishing vessels. As such, we consider the percentages cited above (from Mintz, 2016) as a conservative estimate of the proportion of sea turtles killed by vessel strike that are attributable to Navy vessels.

Table 95. Interpolated ship-hours from 2011-2015 positional records in the action area.

Ship Category	HRC Vicinity	SOCAL Vicinity
U.S. Navy	358,000	1,076,000
U.S. Coast Guard	42,000	138,000
Foreign Military	68,000	56,000
Nonmilitary	3,903,000	27,223,000

Note: Interpolated SeaLink data from 2011 through 2015 which represents an unknown fraction of actual vessel traffic. This data represents a relative traffic level, not absolute ship presence (Mintz 2016).

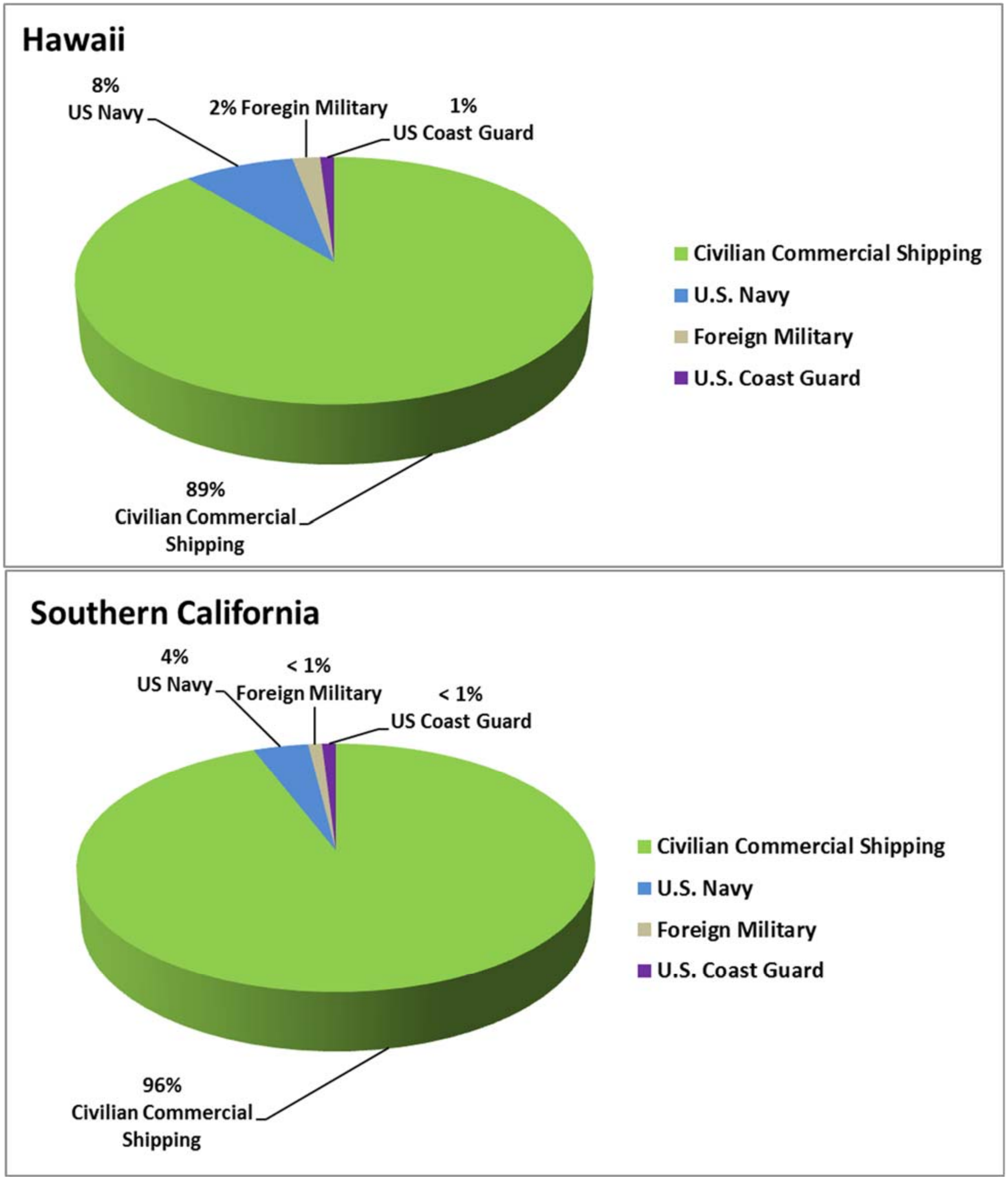


Figure 77. Surface ship traffic by percent ship-hours 2011 to 2015 in the action area (Mintz 2016).

Estimated Sea Turtle Lethal Vessel Strikes in the HRC

We combined the available information from strandings reports with our estimated strandings probabilities and estimated proportion of vessel traffic attributed to Navy vessels to arrive at an estimate of vessel strikes as a result of the proposed action. Figure 78 shows the number of green sea turtle strandings in Hawaii from 1982-2017 by likely cause of stranding. In recent years (i.e., 2015-2017) the average annual number of green sea turtles strandings due to vessel strike is around 20. Boat (or vessel) strike (see purple line) includes traumatic injury judged to be caused by a boat, usually involving propeller strike. If there is evidence of a traumatic injury but it cannot clearly be determined to be caused by a boat, the cause of stranding is listed as miscellaneous (see orange line). Presumably some of the strandings recorded as miscellaneous were the result of boat strike as well. As a conservative approach, we add any stranding reported as "miscellaneous with trauma" to the boat strike category for purposes of our analysis. Based on information from the most recent NMFS Hawaii sea turtle stranding annual report (NMFS 2015b), there were five green sea turtle stranding reported as miscellaneous with trauma in 2014. We add this to the average annual number of strandings in Hawaii due to vessel strike in recent years (i.e., 20 turtles) to get 25 green sea turtles. Based on our strandings probability analysis above, we estimate that these 25 turtles represent about ten percent of the total number of green sea turtles in Hawaiian waters that are struck annually by vessels. Thus, our estimate of the total number of green sea turtle vessel strikes (by all vessels) in Hawaiian waters is 250 green sea turtles. The next step is to determine the proportion of this total vessel strike estimate attributable to Navy vessels as part of the proposed action. For Hawaii, we estimate that eight percent of all vessel traffic (based on ship-hours) is by Navy vessels. Therefore, the estimated number of Central North Pacific green sea turtle vessel strikes annually by Navy vessels operating in the HRC is 20 turtles (i.e., 250 * 0.08).

Sea turtles that strand due to vessel strike are nearly all found dead. Of all the possible causes of stranding, vessel strike was the most likely to result in a dead stranded green sea turtle in Hawaii (shark attack was the second most likely) (Chaloupka et al. 2008). In a long-term study (1982-2003) of green sea turtle strandings in Hawaii, Chaloupka et al. (2008) found that over 95 percent of vessel strike caused strandings resulted in mortality. More recently, in 2014 100 percent of the vessel strike caused strandings of green sea turtle in Hawaii were found dead. The few turtles struck by vessels that strand alive would likely have serious injuries that may result in reduced fitness, increased vulnerability to other threats (e.g., predation and disease) and eventual mortality. Therefore, we conservatively assume that all 20 of the estimated green sea turtles that strand annually due to a Navy vessel strike in the HRC would be killed. Below we estimate the number of non-lethal vessel strikes of sea turtles that do not strand.

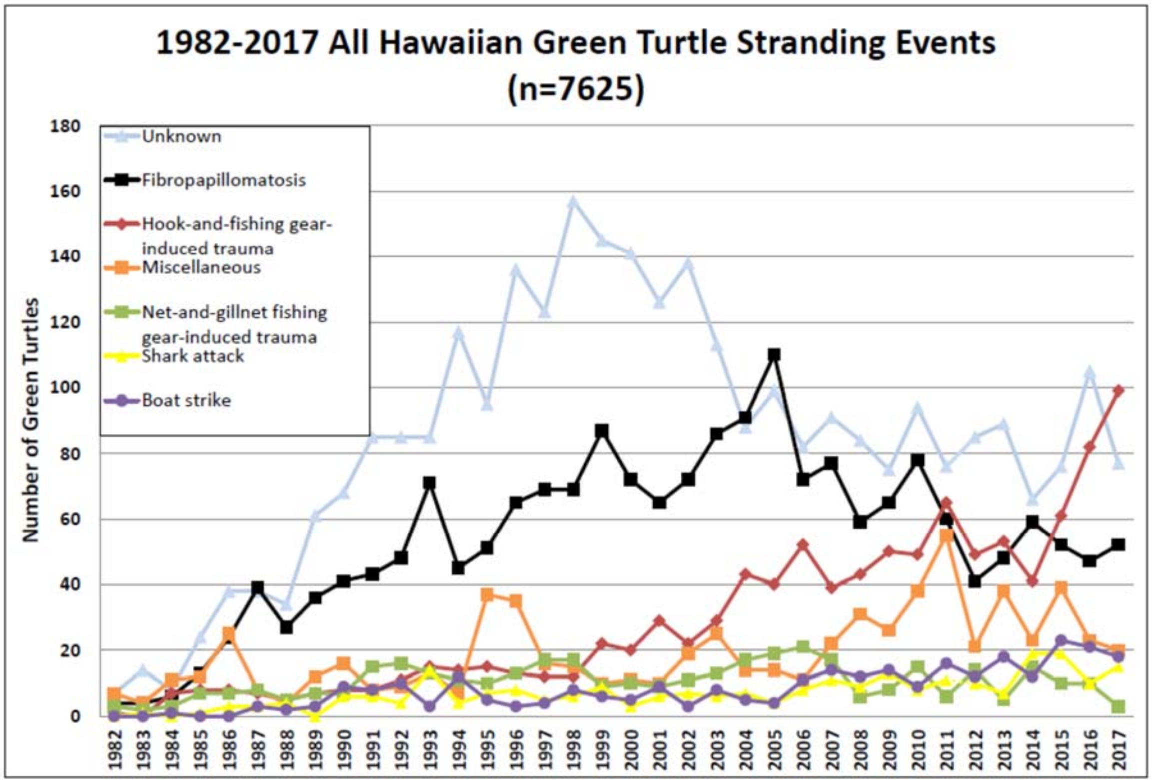


Figure 78. Number of green sea turtle strandings in Hawaii from 1982-2017 by likely cause of stranding (NMFS MTBAP unpublished data).

Green sea turtles account for over 95 percent of all sea turtle strandings in Hawaii (Chaloupka et al. 2008; NMFS 2015b). Based on historical data, hawksbills are the second most likely species to strand, accounting for between one and three percent. For purposes of our analysis, we conservatively assume three percent of strandings could be hawksbill in a given year. To estimate hawksbill vessel strikes we apply the ratio of historical hawksbill strandings to green sea turtle stranding to our estimated number of green sea turtle vessel strikes by Navy vessels (25) from above. Therefore, the estimated number of hawksbill sea turtle lethal vessel strikes annually by Navy vessels operating in the HRC is 0.8 turtles (i.e., 3/97 * 25 = 0.8), which we conservatively round up to one turtle per year.

Based on historical data, olive ridley sea turtles likely account for less than one percent of all turtle strandings in Hawaii. For purposes of our analysis, we conservatively assume one percent of strandings could be olive ridleys in a given year. Therefore, the estimated number of olive ridley sea turtle lethal vessel strikes annually by Navy vessels operating in the HRC is 0.3 turtles (i.e., 1/97 * 25 = 0.3), which we conservatively round up to one turtle per year.

Leatherbacks and loggerhead are very rarely found stranded in Hawaii and historically account an extremely small proportion (less than 0.1 percent) of observed sea turtle strandings (Chaloupka et al. 2008). This is likely a function of the low densities of these species in the

HRC, particularly in areas with heavy vessel traffic. We have no information to indicate Navy vessels strike these species within the HRC, although strandings probabilities for these species would likely be very low given their preference for offshore habitats. Based on the best available information, we find that the likelihood of a Navy vessel strike of a loggerhead or leatherback sea turtle in the HRC as part of the proposed action to be extremely unlikely, and thus discountable.

Estimated Sea Turtle Lethal Vessel Strikes in the SOCAL Range Complex

The vessel strike analysis for the NMFS 2015 HSTT Phase II biological opinion used sea turtle stranding data for San Diego Bay over a period from 1990 to 2014. A total of ten stranded sea turtles (all greens) with signs of vessel strike were reported over this 25-year period. More recent information suggests that sea turtle strandings in San Diego Bay may be occurring more frequently than this historical time series would predict. In 2015 and 2016 there were three green sea turtle strandings reported each year (six total over two years) in San Diego Bay with signs of vessel strike (NMFS, unpublished data). For purposes of our analysis, we conservatively estimate that three green sea turtle vessel strikes occur per year in San Diego Bay. Although this estimate only represents two years of data, these are the most recent two years available and may be indicative of an upward trend in vessel strikes due to an increasing East Pacific DPS green sea turtle abundance (Seminoff et al. 2015).

Based on our strandings probability analysis above, we estimate that stranded turtles in San Diego Bay (estimated at three per year) represent about 20 percent of the total number of green sea turtles that are struck annually by vessels in the Bay. Thus, our estimate of the annual number of green sea turtle vessel strikes (by all vessels) in San Diego Bay is 15 turtles. The next step is to determine the proportion of this vessel strike estimate attributable to Navy vessels as part of the proposed action. For San Diego Bay, we estimate that four percent of all vessel traffic (based on ship-hours) is by Navy vessels (Mintz 2016). Therefore, the estimated number of Eastern Pacific DPS green sea turtle vessel strikes annually by Navy vessels operating in San Diego Bay is 0.6 turtles (i.e., 15 * 0.04), which we conservatively round up to one turtle per year. As discussed above for Hawaii, we assume that stranded turtles due to vessel strikes in San Diego Bay would result in mortality. We do not expect Navy vessel strikes of other sea turtle species in San Diego Bay because of low, to no, abundance of any species besides green turtles (i.e., extremely unlikely to occur and thus discountable for other sea turtle species).

Estimating Non-Lethal Vessel Strikes

Several studies have reported live sea turtles with vessel strike injuries. This indicates that under some circumstances (e.g., very small vessels, slow moving vessels, or a partial vessel strike only grazing a fin or outer shell) vessel strike can result in non-lethal effects on sea turtles that neither strand nor are killed by the interaction. In order to calculate the total number of non-lethal vessel strikes in the action area, we reviewed the literature for reported occurrences of non-lethal vessel strikes. As reported in the literature, the proportion of live sea turtles with non-lethal vessel strike injuries for most populations is around two to four percent (Blumenthal et al. 2009; Deem et al.

2006; Denkinger et al. 2013; Norem 2005), although for one population it was as high as 19 percent (Denkinger et al. 2013). The injuries observed in a population at any given point in time likely occurred over many years, since a turtle can exhibit signs of a non-lethal vessel strike injury for many years after the encounter. Thus, the proportion of a population that experiences a non-lethal vessel strike encounter in any given year (i.e. annual rate) would be much smaller than those reported with such an injury at any single point in time (i.e., a snapshot).

The information needed to directly estimate non-lethal vessel strikes of sea turtles within the action area as a result of the proposed action is lacking. Therefore, we use a ratio of lethal to non-lethal sea turtle vessel strikes based on the ship strike effects analysis conducted by NMFS for the draft biological opinion on the Bureau of Ocean Energy Management's Oil and Gas Program Activities in the Gulf of Mexico (NMFS 2018b). NMFS (2018b) estimates that 25 percent of green sea turtle vessel strikes would be non-lethal and 75 percent would be lethal. Based on the estimated number of green sea turtle lethal vessel strikes annually by Navy vessels from above (20 in Hawaii; one in San Diego Bay), we estimate there would be 6.7 (25/75 * 20) non-lethal green turtle vessel strikes annually in Hawaii and 0.3 (25/75 * 1) non-lethal green turtle vessel strikes annually in San Diego Bay. We conservatively round these up to seven non-lethal strikes in Hawaii (Central North Pacific DPS) and one non-lethal strike in San Diego Bay (Eastern Pacific DPS).

From above, we also anticipate about one hawksbill and one olive ridley lethal vessel strike per year by Navy vessels in Hawaii. Applying the same approach used for green sea turtles, we estimate (after rounding up) about one hawksbill and one olive ridley non-lethal vessel strike per year by Navy vessels in Hawaii.

Sea Turtle Vessel Strike: Summary

We conclude that vessel strike of sea turtles by Navy vessels would likely occur as a result of the proposed action. Collisions with vessels would likely result in blunt trauma and lacerations leading to mortality, although some non-lethal interactions are also anticipated. The large majority of vessel strikes (about 20 lethal and 7 non-lethal per year) would affect the Central North Pacific DPS green sea turtle population in the Main Hawaiian Islands portion of the action area. We expect a much smaller number of Eastern Pacific DPS, hawksbill and olive ridley sea turtles will be struck by Navy vessels as a result of the proposed action (i.e., up to one lethal and one non-lethal strike per year). It is extremely unlikely that a Navy vessel will strike a loggerhead or leatherback sea turtle as part of the proposed action and thus, the effect of vessel strike on these species is considered discountable.

The mortality of any individual sea turtle from a population represents the loss of 100 percent of that individual's reproductive potential. For long-lived species, such as sea turtles, mortality of juveniles or subadults affects future reproductive potential and could have effects on a population for decades. However, based on the relatively low number of turtles we estimate would be affected, we do not anticipate that vessel strike by Navy vessels would have measurable impacts at the population level for any sea turtle species.

9.2.3 Fishes

Explosives used during Navy training and testing activities are likely to result in adverse effects to ESA-listed fishes. Contrary to the information available for marine mammals and sea turtles, we do not have quantitative data to determine the number of ESA-listed fishes that could be impacted by explosives due to the lack of density and abundance information on these species in the action area. The Navy was also able to model density numbers as they did for marine mammals and sea turtles. Instead, we provide the ensonified zones in the water column that correlate with onset of injuries and behavioral disruption, or overlap of Navy activities with life history patterns of fish species.

Within the action area, explosives used in training and testing activities proposed by the Navy would be conducted in both the Hawaii and Southern California portions of the action area. Training activities involving explosions could occur anywhere within the action area with higher concentrations in the SOCAL Range Complex. Training activities that involve underwater detonations and explosive munitions typically occur more than 3 NM from shore. However, most mine warfare and demolition activities would occur in shallow water close to shore. Testing activities using explosions also do not normally occur within 3 NM of shore, with the exception of some mine warfare activities in nearshore areas of San Clemente Island.

9.2.3.1 Exposure Analysis – Fishes

NMFS considers explosive exposure the stressor that poses the highest risk of injury and mortality for ESA-listed fishes in the action area. In the action area, all ESA-listed fishes could be exposed to energy and sound from explosions associated with proposed activities. The general categories of the explosives, such as size and number of detonations, are described in the Section 6.2 of this biological opinion. The Navy also provided detailed descriptions of this stressor in Appendix A (Navy Activity Descriptions) in the HSTT DEIS/OEIS (Navy 2017b).

The effects on species from exposure to this explosives may result in mortality, non-lethal injury, temporary loss of hearing, physiological stress, masking, and behavioral responses. Effects on species is determined by the specific threshold criteria the Navy used based upon a fish's hearing sensitivity (e.g. hearing specializations and sound detections of the specific source) and physical characteristics of the species (e.g. presence and type of swim bladder). Along with these, several other factors influence the potential degree of impact, such as level and duration of sound, where in the sound field the fish is in proximity to the source, as well as the current condition and attentional focus of the fish.

NMFS does not currently have "formal" criteria established for explosives thresholds and effects on fishes, and in most cases bases interim thresholds upon the lowest level of sound where onset of injury may occur. In general, this lowest level (SEL_{cum}) correlates with TTS and therefore typically establishes the starting point where a spectrum of effects may occur for fishes ranging from minor, recoverable injury, TTS, to lethal injury and mortality. The Navy used a similar approach, and based the mortality threshold used for analyses upon the lowest pressure levels supported in the scientific literature (Hubbs and Rechnitzer 1952b). This is consistent with other NMFS explosives analyses for fishes as well as the with the recommendation described more recently with the 2014 ANSI Guidelines (Popper et al. 2014a). Historically, most research regarding fish and explosives only utilized the peak pressure metric to correlate a percentage mortality, therefore there is very limited data currently available for explosives and fishes that have both the peak and SEL pressure metrics established for fishes. The 2014 ANSI Guidelines provide a conservative peak value for mortality, which allows for calculation of a maximum lethal impact range for fishes exposed to underwater detonations.

As previously described for impulsive sound sources, and effects on fishes, the acoustic criteria (Section 2.3) NMFS uses were developed for impact pile driving (FHWG 2008) wherein the onset of physical injury would be expected if either the peak SPL exceeds 206 dB re 1 μPa, or the SELcum, accumulated over all impulses (e.g. pile strikes) generally occurring within a single day, exceeds 187 dB re 1 μPa^2-s for fish two grams or larger, or 183 dB re 1 μPa^2-s for smaller fish. However, at the time the criteria were developed, there was very limited data on impact pile driving. Therefore, the criteria were largely derived from data taken from explosives (Yelverton et al. 1975; converted to SEL by Hastings and Popper 2005) and seismic air guns (Popper et al. 2005a). Although the criteria for pile driving may be conservative for those reasons, they have been applied to a broader range of sound sources (both air guns and explosives) in order to provide reasonable means for assessment of impacts on fishes from these type of sound sources. Similarly, due to the lack of detailed data for onset of injury in fishes exposed to explosives, thresholds from impact pile driving exposures are used as a proxy for this analysis of explosives (Halvorsen et al. 2012a; Halvorsen et al. 2012b; Halvorsen et al. 2011b) which is also consistent with the ANSI Guidelines (Popper et al. 2014a), wherein dual metric sound exposure criteria are utilized to estimate injury from exposure to explosives. (See Table 96 below).

The Navy used the criteria provided in the 2014 ANSI Guidelines, which also divides fish according to presence of a swim bladder and if the swim bladder is involved in hearing. Because we have no way of estimating the abundance and assemblage of fishes with or without these characteristics, NMFS assumes the zone of impact would encompass the distance it would take for the sound wave to reach the criteria for the most sensitive fish species and onset of the lowest level of injury along the injury continuum, in this case would be either greater than 207 dB peak re 1 μPa, or greater than 186 dB SEL_{cum} dB re 1 μPa^2-s. However, for a more accurate assessment of the potential range and severity of effects, we will consider all three distances the Navy modeled which includes criteria for mortality, onset of injury, and TTS. These distances are based upon the injury criteria and the characteristics of the explosives the Navy will use in the action area.

Table 96. Sound exposure criteria for mortality, injury, and TTS from explosives (Navy 2017).

Fish Hearing Group	Onset of Mortality	Onset of Injury		TTS
	SPL_{peak}	SEL_{cum}	SPL_{peak}	(SEL_{cum})
Fishes without a swim bladder	229	> 216	> 213	NC
Fishes with a swim bladder not involved in hearing	229	203	> 207	> 186

Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 μPa]), > indicates that the given effect would occur above the reported threshold. TTS = Temporary Threshold Shift. NC = no criteria, > indicates that the given effect would occur above the reported threshold.

Density data for fish species within the action area are not currently available; therefore, it is not possible to estimate the total number of individual fish that may be affected by activities using explosives. In order to estimate the longest range at which a fish may be killed instantaneously, mortally injured, or sustain recoverable injury and TTS, depends on fish size and location in the water column (i.e. depth), and geometry of exposure.

All ESA-listed fishes that may be present in the action area are capable of detecting sound produced by explosions. The Navy calculated ranges to effects for fish species based upon the criteria discussed above. Fishes within these ranges would be predicted to receive the associated effect. Ranges may vary greatly depending on factors such as the cluster size of the explosives, location, depth, and season of the activity. Range to effects for any fishes without a swim bladder are presented in Table 97. These ranges would include all ESA-listed elasmobranch species that may be present in the action area (i.e., giant manta ray, oceanic whitetip sharks, and scalloped hammerhead sharks).

Table 97. Range to effect for fishes without a swim bladder from explosives (Navy 2017).

Bin	Cluster Size	Range to Effects (meters)		
		Onset of Mortality	Onset of Injury	
		SPL_{peak}	SEL_{cum}	SPL_{peak}
E1 (0.25 lb NEW)	1	49 (35–65)	< 1 (0–2)	< 254 (90–775)
	200	49 (35–65)	< 24 (22–25)	< 254 (90–775)
E2 (0.5 lb NEW)	1	62 (40–75)	< 6 (2–13)	< 302 (100–600)
E3 (2.5 lb NEW)	1	107 (55–310)	< 4 (4–5)	< 559 (140–1,775)
	12	107 (55–310)	< 15 (13–20)	< 559 (140–1,775)
E4 (5 lb NEW)	1	160 (140–430)	< 9 (6–30)	< 821 (490–2,275)
E5 (10 lb NEW)	1	170 (65–500)	< 7 (7–19)	< 801 (180–1,775)
	25	170 (65–500)	< 34 (25–140)	< 801 (180–1,775)
E6 (20 lb NEW)	1	217 (75–525)	< 10 (9–21)	< 974 (210–6,025)
E7 (60 lb NEW)	1	419 (300–825)	< 27 (25–40)	< 1,926 (1,025–6,525)
E8 (100 lb NEW)	1	443 (320–1,025)	< 22 (15–25)	< 2,430 (600–7,525)
E9 (250 lb NEW)	1	497 (370–600)	< 21 (21–21)	< 2,216 (675–2,775)
E10 (500 lb NEW)	1	604 (200–775)	< 25 (25–45)	< 2,579 (650–5,025)
E11 (650 lb NEW)	1	976 (650–3,025)	< 66 (65–120)	< 5,292 (2,275–12,525)
E12 (1,000 lb NEW)	1	775 (450–1,025)	< 43 (30–55)	< 3,277 (800–3,775)

[1] Range to effects represent modeled predictions in different areas and seasons within the action area. Each cell contains the estimated average, minimum, and maximum range to the specified effect.
Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NEW = net explosive weight, "<" indicates that the given effect would occur below the reported range(s).

For Southern California DPS steelhead, an ESA-listed fish that possesses a swim bladder that is not involved in hearing, the range to effects are presented in Table 98.

Table 98. Range to effect for fishes with a swim bladder not involved in hearing from explosives (Navy 2017).

Bin	Cluster Size	Range to Effects (meters)			
		Onset of Mortality	Onset of Injury		TTS
		SPL_{peak}	SEL_{cum}	SPL_{peak}	SEL_{cum}
E1 (0.25 lb NEW)	1	49 (35–65)	8 (8–20)	< 476 (130–1,275)	< 50 (40–65)
	200	49 (35–65)	97 (60–130)	< 476 (130–1,275)	< 573 (160–1,525)
E2 (0.5 lb NEW)	1	62 (40–75)	24 (10–90)	< 534 (150–1,025)	< 145 (45–725)
E3 (2.5 lb NEW)	1	107 (55–310)	20 (17–22)	< 991 (190–3,525)	< 125 (65–300)
	12	107 (55–310)	65 (40–100)	< 991 (190–3,525)	< 399 (120–1,025)
E4 (5 lb NEW)	1	160 (140–430)	46 (25–110)	< 1,504 (775–4,525)	< 300 (160–975)
E5 (10 lb NEW)	1	170 (65–500)	29 (25–120)	< 1,345 (250–6,275)	< 184 (85–900)
	25	170 (65–500)	130 (70–600)	< 1,345 (250–6,275)	< 768 (200–4,275)
E6 (20 lb NEW)	1	217 (75–525)	39 (30–130)	< 1,722 (320–6,775)	< 257 (95–1,525)
E7 (60 lb NEW)	1	419 (300–825)	137 (100–430)	< 3,577 (1,275–10,775)	< 1,000 (525–2,525)
E8 (100 lb NEW)	1	443 (320–1,025)	99 (55–160)	< 4,205 (775–12,275)	< 709 (300–2,025)
E9 (250 lb NEW)	1	497 (370–600)	84 (75–110)	< 3,699 (850–5,775)	< 563 (360–1,275)
E10 (500 lb NEW)	1	604 (200–775)	121 (90–200)	< 4,050 (900–6,275)	< 748 (280–1,775)
E11 (650 lb NEW)	1	976 (650–3,025)	338 (290–800)	< 8,019 (3,275–20,275)	< 2,182 (1,525–7,525)
E12 (1,000 lb NEW)	1	775 (450–1,025)	209 (120–550)	< 4,998 (1,025–6,525)	< 974 (460–5,025)

[1] Range to effects represent modeled predictions in different areas and seasons within the action area. Each cell contains the estimated average, minimum, and maximum range to the specified effect.
Notes: SEL_{cum} = Cumulative sound exposure level, SPL_{peak} = Peak sound pressure level, TTS = Temporary Threshold Shift, NEW = net explosive weight, "<" indicates that the given effect would occur below the reported range(s).

9.2.3.2 Response Analysis – Fishes

Injury and Mortality

As described previously, NMFS considers the potential effects from explosives exposure to pose the highest risk of injury and mortality compared to all other sound sources the Navy proposes to use. Based upon the range to effect calculations for onset of injury to fishes from the sound produced from explosions, fish located within hundreds (most of the charges) to a few thousand meters (largest charges) could be injured or killed. In general, the explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. For the largest charges, there are usually only one or very few of this type of explosives proposed for use during the five-year duration of the activities. Some ranges will also vary depending upon the number of explosions in a single activity, depth and weight of the charge. Fishes without a swim bladder, adult or fully developed fishes, and larger species are assumed to generally be less susceptible to injury and mortality from explosions compared to small, juvenile or larval fishes. Other factors also influence the degree of sensitivity such as state of buoyancy, proximity to the blast (e.g., depth in the water, bodily alignment), and condition of the fish during the exposure event.

Hearing Impairment (TTS)

For elasmobranch species, to date, no hearing loss has been demonstrated when exposed to other impulsive acoustic stressors such as air guns and pile driving. For this reason, the risk of it occurring for these species is much lower than those fish species that do possess swim bladders. Therefore, ranges for these species would likely be lower than what is calculated for steelhead given the fact TTS has not been demonstrated at the thresholds, and the criteria for TTS is already based upon a very conservative value for more sensitive fish species with swim bladders. Steelhead do not have any hearing specializations, and do not have swim bladders involved in hearing. Similar to elasmobranchs, we are unaware of any research demonstrating TTS in this species (or others with a swim bladder not involved in hearing) from explosives. Although TTS has not been demonstrated in these species' groups, this does not mean it does not occur. Because we know it can occur from other acoustic stressors, we assume it is possible from exposure to an explosive sound stressor. If TTS does occur, it would likely co-occur with barotraumas, and therefore would be within the range of other injuries these fishes are likely to experience from blast exposures. Depending on the severity of the TTS and underlying degree of hair cell damage, a fish would be expected to recover from the impairment over a period of weeks (for the worst degree of TTS). Most TTS however, would likely be restored to normal hearing ranges within a few hours or days.

Physiological Stress and Behavioral Responses

Physiological and behavioral responses of fishes to acoustic stressors have been described in greater detail for other acoustics stressors on fishes. Exposure to explosions could cause spikes in stress hormone levels, or alter a fish’s natural behavioral patterns. There are currently no behavioral thresholds for explosives established for fishes. Behavioral responses could be expected to occur within the range to effects for other injurious or physiological responses, and perhaps be extended beyond these ranges if a fish could detect the sound at those greater distances. Given that none of the species considered here have any specialized hearing adaptations, and the threshold for TTS is considered conservative for these hearing groups, most behavioral responses would be expected to occur within the range to effects for injury, mortality and TTS. However, because sound generated from a detonation is brief, long-term effects on fish behavior are unlikely. Similarly, long periods of masking are unlikely from blast exposure for fishes, although some brief masking periods could also occur if multiple detonations occurred (within a few seconds apart). If multiple exposures occurred within a short period of times, such as over the course of a day or consecutive days, fishes may also choose to avoid the area of disturbance. The Navy's training and testing activities involving explosions are generally dispersed in space and time throughout the large action area, and repeated exposure of individual fishes to sound and energy from underwater explosions over the course of a day or multiple days is not likely. Thus, most physiological stress and behavioral effects are expected to be temporary, of a short duration, and would return to normal quickly after cessation of the blast wave.

9.2.3.3 Risk Analysis – Fishes

In this section, we assess the likely consequences of the responses of individual fish exposed to explosive stressors, the populations those individuals represent, and the species those populations comprise. In the exposure and response analysis, we established that a range of impacts including mortality, barotrauma (non-auditory injury), hearing loss (TTS), and behavioral responses are likely to occur due to exposure of ESA-listed fishes to Navy explosives during training and testing events.

For all ESA-listed fish species, behavioral effects resulting from reactions to sound created by the explosions will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-detonation behavior immediately following each explosion.

Southern California DPS Steelhead

The Southern California DPS steelhead posseses a swim bladder and could be exposed to sound energy produced during detonations and sustain injury or hearing impairment, or be killed in the SOCAL Range Complex. Steelhead could also experience masking, physiological stress, and behavioral reactions from explosives in this area. Southern California DPS steelhead could be susceptible to effects from any of the explosive bins listed in Table 98, though as described below, based on the low number of Southern California DPS steelhead and the limited time such individuals spend in the action area, instances where this species would be exposed to explosive stressors are expected to be rare. The majority of the explosives used in SOCAL Range Complex can be categorized in, or below, E5, with occasional detonations of larger charge sizes (e.g., bins E8 and E11). These smaller bins produce smaller ranges to higher order effects such as mortality or injury compared to larger bin sizes (See Table 98) thus further reducing the potential that steelhead would incur impacts that would or could lead to fitness consequences.

Trends in abundance and reproductive success of Pacific salmonids are typically observed through monitoring in the streams and rivers in which they spawn. Boughton et al. (2005) assessed the occurrence of steelhead in southern California coastal watersheds in which the species occurred historically by conducting a combination of field reconnaissance and spot checks (snorkel surveys). Surveys indicated that between 38 percent and 45 percent of the streams surveyed in the range of the Southern California steelhead DPS contained the species, but that there were higher extirpation rates in the southern end of the range. Anthropogenic barriers appeared to be the factor most associated with extirpations. Of the 11 streams surveyed that drain into the action area, only San Mateo Creek contained steelhead. Though the authors expressed some uncertainty, NMFS (2005b) concluded that, with the exception of the small population in San Mateo Creek, the anadromous form of the species appears to be completely extirpated from all systems between the Santa Monica Mountains and the Mexican border. The San Mateo Creek population was formerly considered extirpated (Nehlsen et al. 1991), but California Department of Fish and Game documented presence of the species in 2003 NMFS (2005b). Many of the streams in this region contain resident populations of *O. mykiss* (Boughton et al. 2005; NMFS 2005b). However, fish from these populations in the watersheds that drain into the HSTT action area (e.g., San Diego River, Sweetwater River, Otay River) are not known to exhibit anadromy due to anthropogenic barriers to fish passage. The most recent monitoring data available for the Southern California steelhead DPS is from watersheds north of the HSTT action area (i.e., Santa Ynez River, Ventura River, Santa Clara River, Topanga Creek, Malibu Creek). Surveys indicated that very small (less than 10 fish), but consistent, runs of the species occur on an annual basis (Ford 2011). A recent status review report for the Southern California steelhead DPS questioned how such small annual runs could persist, and suggested that the runs could be maintained either by strays from some another source population or by production of smolts from the resident population of rainbow trout (Ford 2011).

Both outmigrating steelhead and adults returning to spawn are expected to occur in the action area. However, as also discussed in Section 9.1.3.1.5.2, 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. Steelhead are thought to rely heavily on offshore marine waters for feeding, typically in northern latitudes (e.g., Myers et al. 1996), with high seas tagging programs indicating steelhead make more extensive migrations offshore in their first year than any other Pacific salmonids (Quinn and Myers 2004). Steelhead typically spend approximately 1-3 years in freshwater, then migrate rapidly through estuaries, bypassing coastal migration routes of other salmonids, moving into oceanic offshore feeding grounds (Daly et al. 2014; Quinn and Myers 2004). 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 this life history, we would not anticipate outmigrating steelhead to spend extended period of time in the SOCAL Range Complex where explosives are used. Instead, we anticipate outmigrating individuals will quickly move offshore and into northern latitudes out of the action area to forage (Myers et al. 1996). This is where available information suggests steelhead from California spend the majority of their lives while in marine environments.

Adult Southern California DPS steelhead returning to spawn would pass through the action area and could be susceptible to effects from explosives if the animals were to co-occur with Navy explosive use in space and time. However, due to the low number of steelhead that return to spawn in rivers in close proximity to the action area, the likelihood of an adult steelhead co-occuring with Navy explosive use is very low.

The information presented above regarding abundance and life history characteristics suggests that Southern California DPS steelhead are rare in the action area. For this reason, and intermittent nature of Navy explosive use in the action area, instances where steelhead are exposed to explosive stressors would not be common. Based on the range to effects values in Table 98, the most common adverse effect anticipated would be injury. Mortality from any explosive bin would only occur if the fish were within 970 m of the detonation for the largest explosives, but less than 200 m for more commonly used explosives (e.g., bin E5 and below). For all of these reasons, though information is not available to estimate the number of Southern California DPS steelhead that are likely to be injured or killed from Navy explosives, we anticipate a very small percentage of the Southern California DPS to be exposed and adversely affected by Navy explosives stressors. We anticipate that most steelhead migrating through the action area would not co-occur with explosive stressors within the range to adverse effects as described in Table 98. For this reason, the level of mortality and injury anticipated will represent a very small reduction in abundance spread over several years that is not likely to result in population level impacts to Southern California DPS steelhead.

Some individual steelhead may also experience TTS as a result of explosives in the action area. However, steelhead lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual’s fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014c). Additionally, hearing is not thought to play a role in steelhead migration (e.g., Putnam et al. 2013b). TTS is also short term in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because these species are able to rely on alternative mechanisms for these essential life functions and because this effect is temporary, instances of TTS would not likely result in fitness consequences to affected steelhead.

Eastern Pacific DPS Scalloped Hammerhead Shark

Scalloped hammerhead sharks do not posses a swim bladder so like the other elasmobranchs, are less susceptible to injury or mortality from explosives. However, this species still could be exposed to sound energy produced during detonations and sustain injury or be killed in the SOCAL Range Complex. Scalloped hammerhead sharks could also experience masking, physiological stress, and behavioral reactions from explosives in this area. Scalloped hammerhead sharks could be susceptible to effects from any of the explosive bins listed in Table 97, though as described below, based on the low number of scalloped hammerhead sharks anticipated to occur in the action area, instances where this species would be exposed to explosive stressors are expected to be rare. Additionally, the majority of the explosives used in SOCAL Range Complex can be categorized in, or below, E5, with occasional detonations of larger charge sizes (e.g., bins E8 and E11). These smaller bins produce smaller ranges to higher order effects such as mortality or injury compared to larger bin sizes (See Table 97) thus further reducing the potential that scalloped hammerhead sharks would incur impacts that would or could lead to fitness consequences.

The SOCAL Range Complex and Silver Strand Training Complex overlap with the extreme northern-most extent of the Eastern Pacific DPS of the scalloped hammerhead shark's range. For this reason, most Eastern Pacific DPS scalloped hammerhead sharks likely do not occur at any time within the action area. Scalloped hammerhead sharks primarily occur over continental and insular shelves and rarely in waters cooler than 22 °C. The species ranges from surface waters to depths of 512 m, with occasional dives to deeper water up to 1000 m. It is also known to occur in bays and estuaries. Neonate and juvenile aggregations are more common in near shore nursery habitats because these habitats may provide valuable refuge from predation. Scalloped hammerhead sharks appear to prefer areas with stronger currents, greater turbidity, and higher sedimentation and nutrient flow. Based on the observation of 19 juveniles in 1997, it has been suggested the southern San Diego Bay may serve as a pupping ground and warm water refugium during warm water years (Lea and Rosenblatt 2000, Shane 2001).

The waters of the Pacific Ocean off the coast of southern California are relatively cold and rarely approach 22 °C, which is likely why the action area barely overlaps the known range for scalloped hammerhead sharks. Only 23 specimens have been recorded from southern California and 19 of those specimens were juveniles collected during a single extremely warm El Niño event in 1997 when sea water temperatures were 3 to 4 °C above normal. It is expected that water temperatures within the SOCAL Range Complex and Silver Strand Training Complex will not exceed 22 °C except during extreme weather events such as the 1997 El Niño. Although climate change may lead to warmer Pacific temperatures off the coast of southern California, it is not expected to raise the temperature 3 to 4°C within the foreseeable future because the heat buffering capacity of water will likely cause ocean temperatures to rise at a slower pace than global air and land temperatures. Global air temperatures are expected to rise by less than 4.8 °C while global ocean temperatures within 100 m of the ocean's surface are expected to rise by less than 2.0 °C by the year 2100 (IPCC 2014).

The scalloped hammerhead shark is primarily a shallow water, coastal species and a majority of explosive ordnance use be performed in offshore waters. Training also primarily occurs during the day when this species is more likely to be closer to shore. This suggests the co-occurrence of most explosive activities with this species is not expected to be common except in the rare event water temperatures are sufficiently warm within the action area to support the species. In inshore waters, the primary activity proposed is underwater detonations from Mine Neutralization training events. During this activity, as described in Table 30, to avoid impacts on ESA-listed scalloped hammerhead sharks within the SOCAL Range Complex, divers will notify their supporting small boat or Range Safety Officer of hammerhead shark sightings (of any hammerhead species, due to the difficulty of differentiating species) during the activity. Detonations will cease if divers sight a hammerhead shark when setting the charge and will recommence when the shark is no longer observed.

The information presented above regarding the habitat use of scalloped hammerhead sharks suggest that this species is not common within the action area. For this reason, and the intermittent nature of Navy explosive use in the action area, instances where scalloped hammerhead sharks are exposed to explosive stressors would not be common. The Navy's mitigation during Mine Neutralization activities will further reduce risk for this species. Based on the range to effects values in Table 97, the most common adverse effect anticipated would be injury. Mortality from any explosive bin would only occur if the fish were within 970 m of the detonation for the largest explosives, but less than 200 m for more commonly used explosives (e.g., bin E5 and below). For all of these reasons, though information is not available to estimate the number of Eastern Pacific DPS scalloped hammerhead sharks that are likely to be injured or killed from Navy explosives, we anticipate a very small percentage of the DPS to be exposed and adversely affected by Navy explosives stressors. We anticipate that most scalloped hammerhead sharks in the action area would not co-occur with explosive stressors within the range to adverse effects as described in Table 97. For this reason, the level of mortality and injury anticipated will represent a very small reduction in abundance spread over several years that is not likely to result in population level impacts to Eastern Pacific DPS scalloped hammerhead sharks.

Oceanic Whitetip Shark

Oceanic whitetip sharks also do not posses a swim bladder, so are less susceptible to injury or mortality from explosives than fishes with swimbladders. However, this species still could be exposed to sound energy produced during detonations and sustain injury or be killed in the SOCAL and Hawaii Range Complexs. This species could also experience masking, physiological stress, and behavioral reactions from explosives in these areas. Oceanic whitetip sharks could be susceptible to effects from any of the explosive bins listed in Table 97, though as described below, based on the low number of oceanic whitetip sharks anticipated to occur in the action area, instances where this species would be exposed to explosive stressors are expected to be rare. Additionally, the majority of the explosives used in the action area can be categorized in, or below, E5, with occasional detonations of larger charge sizes (e.g., bins E8 and E11). These smaller bins produce smaller ranges to higher order effects such as mortality or injury compared to larger bin sizes (See Table 97) thus further reducing the potential that oceanic whitetip sharks would incur impacts that would or could lead to fitness consequences.

Oceanic whitetip sharks reside in deeper, offshore waters and spend much of their time at the surface, potentially increasing the risk of exposure to surface detonations. However, both the SOCAL and Hawaii Range Complexes are at the northern extent of the range of this species in the Pacific Ocean. For this reason, most oceanic whitetip sharks in the Pacific Ocean likely do not occur at any time within the action area and would not be susceptible to Navy explosive use. Due to the dispersed, infrequent occurrence and short duration of explosives use throughout the SOCAL and Hawaii ranges, and the rarity of oceanic whitetip shark presence in these areas, exposure of this species to explosive stressors is not expected to be common. Additionally, most explosive use in SOCAL is concentrated at Fleet Training Area Hot and the SOCAL Offshore Antisubmarine Warfare Range (Figure 16), located in more coastal environments than where this species is likely to occur. This further reduces the likelihood of exposure, except on rare occurrences. Mortality from any explosive bin would only occur if the fish were within 970 m of the detonation for the largest explosives, but less than 200 m for more commonly used explosives (e.g., bin E5 and below). For all of these reasons, though information is not available to estimate the number of oceanic whitetip sharks that are likely to be injured or killed from Navy explosives, we anticipate a very small percentage of the DPS to be exposed and adversely affected by Navy explosives stressors. We anticipate that most oceanic whitetip sharks in the action area would not co-occur with explosive stressors within the range to adverse effects as described in Table 97. For this reason, the level of mortality and injury anticipated will represent a very small reduction in abundance spread over several years that is not likely to result in population level impacts to oceanic whitetip sharks.

Giant Manta Ray

Giant manta rays also do not posses a swim bladder, so are less susceptible to injury or mortality from explosives than fishes with swimbladders. However, this species still could be exposed to sound energy produced during detonations and sustain injury or be killed in the SOCAL and Hawaii Range Complexes. This species could also experience masking, physiological stress, and behavioral reactions from explosives in these areas. Giant manta rays could be susceptible to effects from any of the explosive bins listed in Table 97, though as described below, based on the low number of giant manta rays anticipated to occur in the action area and the Navy's proposed mitigation in the HRC, instances where this species would be exposed to explosive stressors are expected to be rare. Additionally, the majority of the explosives used in the action area can be categorized in, or below, E5, with occasional detonations of larger charge sizes (e.g., bins E8 and E11). These smaller bins produce smaller ranges to higher order effects such as mortality or injury compared to larger bin sizes (See Table 97) thus further reducing the potential that oceanic whitetip sharks would incur impacts that would or could lead to fitness consequences.

Adult giant manta rays are typically found offshore but occasionally visit coastal areas where upwelling occurs. In particular, large aggregations of giant manta rays are known to occur along the Kona coast off the Big Island of Hawaii. As described in Table 39, the Navy will not use explosives in the Hawaii Island mitigation area during training and testing activities. This area is inclusive of the locations where large aggregations of giant manta rays occur. Though the Navy proposed this mitigation to minimize impacts on marine mammals, this will also have protective benefits to ESA-listed giant manta rays in this area.

Due to the dispersed, infrequent occurrence and short duration of explosives use throughout the SOCAL and Hawaii ranges, the rarity of giant manta rays in the SOCAL range complex, and the Navy's mitigation in the HRC to avoid explosive use in areas around Hawaii Island where this species congregates, exposure of this species to explosive stressors is not expected to be common. Mortality from any explosive bin would only occur if the fish were within 970 m of the detonation for the largest explosives, but less than 200 m for more commonly used explosives (e.g., bin E5 and below). For all of these reasons, though information is not available to estimate the number of giant manta rays that are likely to be injured or killed from Navy explosives, we anticipate a very small percentage of the Pacific Ocean to be exposed and adversely affected by Navy explosives stressors. We anticipate that most giant manta rays in the action area would not co-occur with explosive stressors within the range to adverse effects as described in Table 97. For this reason, the level of mortality and injury anticipated will represent a very small reduction in abundance spread over several years that is not likely to result in population level impacts to giant manta rays.

9.3 Designated Critical Habitat

In this section, we consider the potential impacts of the proposed action on the essential habitat features and conservation value of critical habitat designated for black abalone, Hawaiian monk seals, and MHI IFKWs.

9.3.1 Black Abalone

The primary constituent elements for black abalone designated critical habitat are rocky substrate, food resources, juvenile settlement habitat, suitable water quality, and suitable nearshore circulation patterns. Navy training and testing activities are not anticipated to affect black abalone critical habitat as the planned activities that may affect these primary constituent elements would not be in close proximity to critical habitat. Stimuli from readiness activities including noise emissions and other pollution, shock waves from underwater detonations, amphibious training exercises and ship to shore bombardment might produce effects but they would not likely be of sufficient levels to produce an adverse effect due to distance from the source. For these reasons, it is extremely unlikely that the primary constituent elements of black abalone would be adversely affected and the effects of the action on black abalone designated critical habitat are considered discountable.

9.3.2 Hawaiian Monk Seal

Proposed Navy training and testing activities using explosives overlap marine areas that have been designated critical habitat for juvenile and adult monk seal foraging. Hawaiian monk seals eat a variety of fish species, as well as some invertebrates. If activities using explosives were to occur in marine areas for foraging, Hawaiian monk seal prey could be injured or killed. However, relative to the vast area that has been designated foraging critical habitat for monk seals, the area that could be affected by Navy explosives is very small and we would anticipate a correspondingly small percentage of monk seal prey to be impacted. Most detonations occurring in nearshore waters of the HRC would occur in established ranges which were excluded from monk seal critical habitat designation. Further, most detonations in the HRC not occurring in these nearshore ranges would occur in waters deeper than 200 m (i.e., outside of the area designated as critical habitat). For these reasons, a relatively small number of explosives are anticipated to occur in marine areas around the Hawaiian islands that have been designated critical habitat for monk seals. Additionally, most of the explosives that would be used in these nearshore areas would be of smaller net explosive weight, resulting in relatively low zones of impact for monk seal prey (e.g., see Table 97 and Table 98 for zones of impact for fish species based on explosive bin). As described in Table 38, the Navy will also not use explosives within 350 yds of mapped shallow water coral reefs. These are areas where Hawaiian monk seal prey are more likely to occur at higher densities. Finally, any effects to monk seal prey abundance would be temporary as following the explosion, unaffected animals in close proximity will likely move into the area that was disturbed by the explosive to utilize the unoccupied habitat. We anticipate reductions in abundance of Hawaiian monk seal prey in designated critical habitat from the use of explosives, but these reductions in abundance will be highly localized and temporary and would have an insignificant effect (i.e., so minor that the effect cannot be meaningfully evaluated) on prey abundance and quality in marine waters designated as critical habitat. Most Navy explosive use in the HRC will occur in established nearshore ranges which were excluded from the critical habitat designation or waters offshore of designated monk seal critical habitat for foraging. For these reasons, the effects of Navy explosive use on prey resources in Hawaiian monk seal critical habitat are insignificant.

Anchors associated with seafloor devices used during training and testing activities may, in some cases, be left behind. According to the Navy's supplemental consultation package submitted in October 2018 (Navy 2018f), an anchor remaining on the seafloor could cover a crack in the seafloor where Hawaiian monk seal prey may have been found. However, a very small area of habitat may be exposed to physical disturbance from anchors (i.e., anchors are generally 14 inches in diameter and a limited number are left behind in Hawaiian monk seal critical habitat). Further, most of the kinetic energy from an anchor dissipates within the first few feet of the object entering the water, causing it to slow considerably by the time it reaches the bottom. Because of this, we do not anticipate anchors will strike or smother Hawaiin monk seal prey. For these reasons, the effects of Navy activities involving anchors on prey resources in Hawaiian monk seal critical habitat are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.3.3 Main Hawaiian Islands Insular DPS False Killer Whales

The analysis below describes potential effects of the following stressors on designated critical habitat for MHI IFKWs: vessel noise, physical disturbance and strike, explosives, and sonar and other transducers.

9.3.3.1 Vessel Noise

Additional discussion on vessel noise as a potential stressor is included in Section 6.1.1, as well as Sections 9.1.1.1.1 and 9.1.3.1.1. Naval vessels (including ships and small craft) produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. Navy vessel movements involve transits to and from ports to various locations within the action area, and many proposed activities within the action area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels), as well as unmanned vehicles. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to two weeks. Navy vessel traffic could occur throughout designated critical habitat for MHI IFKWs and would also occur in other portions of the action area (Mintz 2016).

The analysis below describes the potential effects of Navy vessel noise on the following characteristics of the PBF of MHI IFKW designated critical habitat: 1) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and 2) sound levels that would not significantly impair false killer whales' use or occupancy.

As documented further in Section 9.1.3.1.1, all fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Similarly, available information indicates that aquatic invertebrates, such as squid, are primarily sensitive to low frequency sounds. Most cephalopods (e.g., octopus and squid) likely sense low-frequency sound below one kHz, with best sensitivities at lower frequencies (Budelmann 1992c; Mooney et al. 2010; Packard et al. 1990). Given this, false killer whale prey in designated critical habitat are likely to be exposed to and detect sounds emitted from Navy vessels. However, similar to the discussion in Section 9.1.3.1.1 focused on the impacts of vessel noise on ESA-listed fishes, because of the characteristics of vessel noise, sound produced from Navy vessels is unlikely to result in direct injury, hearing impairment, or other trauma to fishes or squid. Behavioral and/or physiological responses could occur. However, impacts from Navy vessel noise would be intermittent, temporary and localized, and such responses would not be expected to compromise the general health or condition of individuals. Instead, the only impacts expected from exposure to Navy vessel noise for fishes and squid may include temporary auditory masking, short-term physiological stress, or minor changes in behavior. For these reasons, exposure to vessel noise is not expected to result in detectable impacts to the quantity, quality, or availability of false killer whale prey. Therefore, the effects of vessel noise on the prey species characteristic of of the PBF for MHI IFKW designated critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Regarding sound levels that would not significantly impair false killer whales' use or occupancy, the final rule designating critical habitat (83 FR 35062) explains: "*scientific information also indicates that the introduction of a permanent or chronic noise source can degrade the value of habitat by interfering with the sound-reliant animal's ability to gain benefits from that habitat, impeding reproduction, foraging, or communication (i.e., altering the conservation value of the habitat)… chronic exposure to noise as well as persistent noise may impede the population's ability to use the habitat for foraging, navigating, and communicating, and may deter MHI IFKWs from using the habitat entirely.*" Thus, our analysis on whether Navy vessel noise would significantly impair MHI IFKW use or occupancy considers how the introduction of noise caused by Navy vessels may or may not impede the population's use of designated critical habitat for important biological functions to determine whether the introduction of noise from vessels alters the conservation value of the habitat. Our analysis of individual animal response to Navy vessels use can be used to indicate whether exposure to vessel noise could impair use or occupancy of the habitat at a population level.

A discussion on anticipated effects of noise from Navy vessels on marine mammals, including IFKWs, is included in section 9.1.1.1.1. In this section, we summarize that ESA-listed marine mammals in the action area (inclusive of marine mammals in MHI IFKW critical habitat) 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, in this section we summarize that the effects of any temporary masking specifically from Navy vessels on marine mammals, including IFKWs, is insignificant 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 (and in designated critical habitat). We do not anticipate Navy vessel noise would result in disruptions of normal behavior patterns or masking that could be meaningfully evaluated. We do not anticipate vessel noise to generate sounds that would significantly impair false killer whales' use or occupancy by inhibiting MHI IFKW's ability to receive and interpret sound for the purposes of navigation, communication, and detection of predators and prey. Therefore, effects of vessel noise on the sound level characteristic of MHI IFKW designated critical habitat are so minor that the effect cannot be meaningfully evaluated and we therefore consider them to be insignificant.

9.3.3.2 Physical Disturbance and Strike

False killer whale prey species, including some fish, have the potential to be susceptible to physical disturbance and strike from vessels, other in-water devices, or military expended materials. Consistent with the analysis for the ESA-listed fishes done during consultation and presented in section 9.1.3.3.1, we anticipate that MHI IFKW prey species would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). Further, prey species of MHI IFKWs (e.g., tuna, marlin, and mahi mahi) are not generally considered vulnerable to vessel strike when compared with some other large, slow-moving species that occur regularly at the surface such as ocean sunfish. For these reasons, it is extremely unlikely that a Navy vessel or in-water device associated with HSTT activities would strike MHI IFKW prey. The effects of strike on the prey species characteristic of MHI IFKW designated critical habitat is thus discountable.

Prey species may exhibit a temporary behavioral response to oncoming vessels or other in-water devices and regardless of the response, there is the potential for some type of stress or energetic cost as an individual fish must stop its current activity and divert its physiological and cognitive attention to responding to the vessel (Helfman et al. 2009). Potential implications of behavioral avoidance response to vessels was addressed above in Section 9.1.3.1. In this section, we concluded that the effects of behavioral response (i.e., physical disturbance) on fishes (i.e., MHI IFKW prey) from vessels was insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). For these same reasons, behavioral avoidance and associated stress responses from detection of vessels or other in-water devices is not expected to result in impacts to the quantity, quality, or availability of MHI IFKW prey. Therefore, the effects of such responses on the prey species characteristic of MHI IFKW designated critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.3.3.3 Explosives

Below we summarize the analysis on the potential effects of Navy explosive use on the following characteristics of the PBF of MHI IFKW designated critical habitat: 1) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and 2) sound levels that would not significantly impair false killer whales' use or occupancy.

As described previously in Section 6.1.6, explosives include, but are not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom.

The Navy was not able to provide specific estimates of the number and size of explosives that will be used within MHI IFKW critical habitat versus other portions of the action area. The Navy supplemental consultation package stated that across all bins, less than 30 percent of all explosives proposed for use in the action area will be used in the HRC (Navy 2018f). A subset of these explosives will be used in MHI IFKW critical habitat. The majority of Navy explosive use in the HRC occurs in designated areas outside of critical habitat designated for MHI IFKWs (Figure 79) (Navy 2018f). Further, most explosives used in the HRC would be lower explosive weight items in bins E1 and E2 (i.e., less than 0.5 lb net explosive weight), and moderate explosive weight items in bins E3 and E5 (i.e., less than 10 lb net explosive weight). Within MHI IFKW critical habitat, explosives would be used infrequently, during unit level training or testing activities (Navy 2018f). Finally, as shown in Section 3.4.2.2.2, the Navy will not conduct activities using explosives year-round in either the Hawaii Island or 4-Islands Region geographic mitigation areas. These areas encompass 42 percent (i.e., 19,410 km^2) of designated critical habitat for MHI IFKWs.

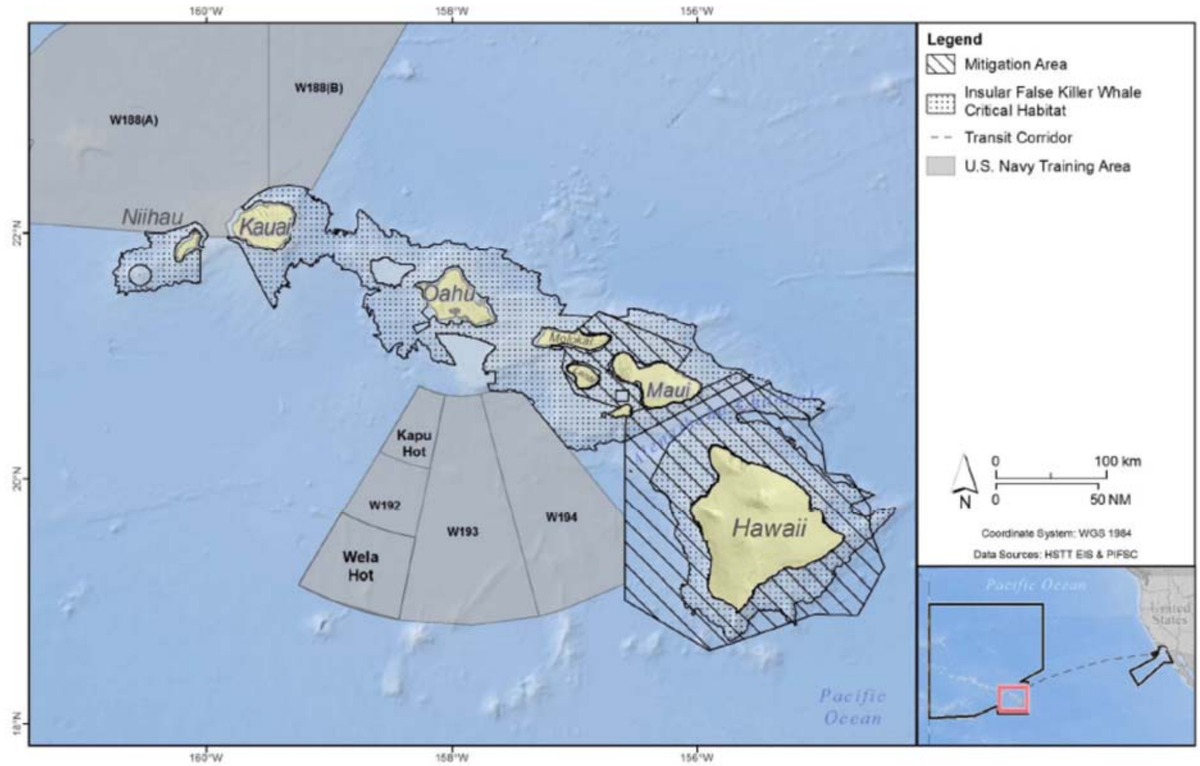


Figure 79. Main Hawaiian Islands Insular false killer whale designated critical habitat and Hawaii Range Complex sub-areas where most explosives are used during training and testing.

Prey Species

As documented more comprehensively in Section 9.1.3.1.5.1, fishes can experience a range of effects from exposure to impulsive sound such as those produced by explosives, including mortality, auditory injury, barotrauma, and behavioral changes. Explosives and other impulsive sources generally have an increased capacity to induce physical injuries in fishes, especially those with swim bladders (Casper et al. 2013a; Halvorsen et al. 2012b; Popper et al. 2014a) when compared with other sound sources. Fishes can survive and recover from some injuries, but in other cases, death can be instantaneous, occur within minutes after exposure, or occur several hours to days later. Other MHI IFKW prey items, such as squid, are also susceptible to effects from explosives. Similar to fishes, these animals may be injured or killed, or experience behavioral changes (e.g., McCauley et al. 2000c).

The factors described above regarding Navy explosive use in the HRC indicate that explosive use within designated critical habitat for MHI IFKWs would not be common and when it does occur, the most likely explosives that will be used will be of small net explosive weight. These smaller bins produce relatively smaller ranges to effects such as mortality or injury compared to larger bin sizes (See Table 98), thus reducing the potential that IFKW prey would incur impacts leading to fitness consequences from most explosives. For example, as indicated in Table 98, the range to injury from explosives in bin E2 for fishes with a swim bladder not involved in hearing is just over 500 m and the range to mortality is under 100 m (see Section 9.2.3 for information on how these ranges to effect were estimated). For bin E5 and fishes with a swim bladder not involved in hearing, the range to injury is 1,345 m and the range to mortality is 170 m. Table 97 and Table 98 list the ranges to injury and mortality for the other explosive bins that will be used by the Navy in the action area. MHI IFKW prey would need to be within these zones of impact at the instant an explosion occurred to experience injury or mortality.

False killer whale prey is widely distributed within and outside of critical habitat. The final biological report was unable to determine where prey resources of higher value exist for MHI IFKWs within or outside designated critical habitat (NMFS 2018a). While some instances of MHI IFKW prey injury or mortality could occur within designated critical habitat, the vast majority of prey within critical habitat will not be exposed to explosives due to the large area that has been designated critical habitat, the limited use of explosives in critical habitat, and that most explosives used in critical habitat will be from the smaller explosive bins with relatively shorter ranges to adverse effects. Following an explosion, 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 impacts to prey availability within an area would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected. Further, any prey species injured, but not killed, by an explosion could result in the prey item being more easily captured by an IFKW. 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). For all MHI IFKW prey species, behavioral effects resulting from reactions to sound created by the explosions will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-detonation behavior immediately following each explosion. For these reasons, the effects of explosive on the prey species characteristic of MHI IFKW designated critical habitat are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Sound Levels

Our analysis below summarizes the general characteristics of sound produced by explosives, available information on Navy explosive use within designated critical habitat, likely effects to MHI IFKWs habitat use from exposure to explosives, and the Navy's quantitative analysis estimating the number of instances in which explosive use in the HRC could be expected to result in impacts to IFKW use or occupancy of critical habitat.

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. In contrast to acoustic sources such as sonar or low-frequency sound from vessels, sound from explosives lasts a very brief period of time (i.e., microseconds). Sounds from explosives are transient, and do not persist in the marine environment. Further, Navy explosive activities typically consist of a single or multiple explosions occurring over a short period of time in a relatively small area. Additionally, as described above, explosive use within designated critical habitat for MHI IFKWs would not be common (e.g., see Figure 79) and when it does occur, the most likely explosives that will be used will be of small net explosive weight, resulting in relatively small zones of impact or sound propagation for each detonation. These factors greatly limit both the frequency and duration of sound exposure from explosives to the water column within MHI IFKW critical habitat.

A thorough discussion on the potential effects of explosives on marine mammals, including IFKWs, is in Section 9.2.1.2.1. This information is pertinent to evaluating how an activity, such as Navy training and testing using explosives, may affect MHI IFKW critical habitat because the characteristic of the PBF under consideration is how sound levels may impact the animals themselves within the habitat. That is, the characteristic is defined as "*…sound levels that would not significantly impair false killer whales' use or occupancy*" of the habitat. The final rule designating critical habitat explains: "*scientific information also indicates that the introduction of a permanent or chronic noise source can degrade the value of habitat by interfering with the sound-reliant animals ability to gain benefits from that habitat, impeding reproduction, foraging, or communication (i.e., altering the conservation value of the habitat)… chronic exposure to noise as well as persistent noise may impede the population's ability to use the habitat for foraging, navigating, and communicating, and may deter MHI IFKWs from using the habitat entirely.*" Thus, our analysis considers how the introduction of noise caused by Navy explosives may or may not impede the population's use or occupancy of designated critical habitat for important biological functions to determine whether the introduction of noise alters the conservation value of the habitat. Our analysis of individual animal response to Navy explosive use can be used to indicate whether these responses could impair use or occupancy of the habitat at a population level.

Available information on the effects of explosives on marine mammal behavior (See Section 9.2.1.2.1) 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 (see Section 9.2.1.2 for further discussion). As described in Sections 2.2 and 9.2.1.2, to estimate impacts from explosives associated with proposed training and testing activities, the Navy performed a quantitative analysis to estimate the number of instances that could result in effects to ESA-listed marine mammals (including MHI IFKWs) and the magnitude of those effects (e.g., injury, hearing loss, behavioral response). The quantitative analysis utilizes NAEMO and takes into account criteria and thresholds used to predict impacts in conjunction with spatial densities of species within the action area. A detailed explanation of this analysis is in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Navy 2018g). As described in Section 9.2.1.2.2, the Navy's analysis estimated only one instance annually where explosives would likely result in harassment of an IFKW (Table 88). The Navy did not provide information on whether this instance of harassment was likely to occur inside or outside designated critical habitat. Because most explosives, particularly those of higher net explosive weight, which would be more likely to result in adverse effects, will be used outside of critical habitat, it is likely that the instance of harassment will occur outside of critical habitat.

Additionally, based on best available information, we do not anticipate explosive use will lead to long duration abandonment or avoidance of any particular area within critical habitat, or of critical habitat as a whole. As noted in Section 9.2.1.1, when marine mammals have been observed to leave a certain area following acoustic exposure, they are likely to return after the period of exposure ends (e.g., Baird et al. 2016b; Tyack et al. 2011a). Even in intensively used training areas, such as those locations considered in this consultation in Southern California, photo identification results have indicated long-term residency of odontocetes considered particularly sensitive to disturbance from acoustic exposure (i.e., Cuvier's beaked whales) (Falcone and Schorr 2014; Falcone et al. 2009b). IFKWs are not known to be as sensitive to acoustic disturbance as beaked whales. Even with decades of Navy training and testing occurring in areas recently designated as critical habitat, as well as monitoring of IFKW use of this habitat, we do not have information to suggest that IFKWs are avoiding or abandoning any portions of critical habitat where explosives are used, or critical habitat as a whole, due to explosive use. Given this information and the anticipated frequency, duration, and sporadic nature of explosive use in designated critical habitat described above, we find it extremely unlikely that areas are being avoided to such an extent that it is affecting IFKW use or occupancy of critical habitat.

Due to the factors described above including the short duration of sounds emitted by explosives, the infrequent use of explosives by the Navy in MHI IFKW designated critical habitat, the widely dispersed nature of Navy explosive use in the HRC, and that the quantitative analysis estimated that only one IFKW may experience harassment from explosives annually, likely outside of designated critical habitat, and that disruption would be for a short duration, significant effects to use or occupancy MHI IFKW critical habitat due to noise generated by explosives are not anticipated. Thus, effects of explosives on the sound level characteristic of MHI IFKW designated critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.3.3.4 Sonar and Other Transducers

As described previously in Section 6.1.3 and Section 9.2.1.1, sonar and other transducers include a variety of acoustic devices used to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track submarines and high-frequency small object detection sonars used to detect mines. The analysis below describes the potential effects of Navy sonar and other transducer use on the following characteristics of the PBF of MHI IFKW designated critical habitat: 1) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and 2) sound levels that would not significantly impair false killer whales' use or occupancy. For the sound level characteristic, the final rule emphasizes whether the action would cause "significant impairment" to use and occupancy of the critical habitat. As noted in the final rule to designate critical habitat, "*the mere presense of noise, or even noise which might cause harassment of the species, does not necessarily result in adverse modification*."

9.3.3.4.1 Prey Resources

As noted previously, false killer whale prey may include various tuna species, marlin species, jack species, mahi mahi, wahoo, moonfish, and squid (NMFS 2018a). The potential effects of Navy sonar on ESA-listed fishes was described in detail in Section 9.1.3.1.4. Similar effects would be anticipated to fishes that are prey to false killer whales. To summarize, direct injury from sonar and other transducers is extremely unlikely because the sound produced from sonar characteristically has lower peak pressures and slower rise times than other acoustic stressors that are known to injure fish (e.g., explosives). Direct injury from sound levels produced from the type of sonar the Navy uses has not been documented in fishes (Halvorsen et al. 2012e; Kane et al. 2010; Popper et al. 2014a; Popper et al. 2007; Popper et al. 2013). For the same reasons (i.e., low peak pressures, slow rise times), we would not anticipate Navy sonar sources would result in injury or mortality of squid.

Based on best available information regarding the hearing capabilities of almost all false killer whale prey species (see Figure 63), these animals would not likely be able to detect most mid- and high-frequency sonar sources used by the Navy. These are the most commonly used sources in the HRC and within designated critical habitat (Navy 2018f). False killer whale prey would be more likely to detect low-frequency sources, though these sources are used far less frequently in the HRC (and designated critical habitat). False killer whale prey that are able to detect low-frequency sonar could experience brief periods of masking, or exhibit brief behavioral reactions, and stress responses. Prey items located closer to the sonar sound source would likely experience more significant responses, whereas animals located further away from the source are less likely to react to the sound levels. However, because the Navy's sonar is moving, and false killer whale prey are also capable of moving away from the disturbance, the overall exposure duration is expected to be brief and if masking did occur, it would not occur for a significant amount of time and not prevent the animals from detecting biologically relevant cues at meaningful levels. Additionally, any physiological stress responses or behavioral reactions are expected to be temporary, lasting only a few seconds or minutes during sonar pings. For these reasons, no long-term consequences for any exposed prey items are expected. Because of this, false killer whale prey items exposed to Navy sonar would still be available in the environment for consumption by false killer whales following exposure. For this reason, the effects of Navy sonar and other transducer use on the prey resource characteristic of designated critical habitat for MHI IFKWs are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.3.3.4.2 Sound Levels

In this section, we evaluate if Navy sonar and other transducer use may result in sound levels within MHI IFKW designated critical habitat that would significantly impair the value of the habitat for IFKW use or occupancy. As presented in Section 9.2.1.1, exposure of marine mammals to sonar and other transducers could result in behavioral responses and sound-induced hearing loss (e.g., TTS), as well as other possible adverse effects (e.g., stress). When marine mammals experience these effects, their ability to carry out important life functions (e.g., foraging, navigating, or communicating) may be impaired for some period of time. Therefore, when Navy sonar is introduced into designated critical habitat for MHI IFKWs, this has the potential to degrade the value of that habitat for important life functions. In other words, introduction of sonar into designated critical habitat may cause disruptions in use or occupancy of critical habitat and thus dimish the value of critical habitat for conservation of the MHI IFKWs. As discussed below, our analysis focuses on the extent of this dimishment based on a number of factors. We consider general characteristics of sound produced by sonar and other transducers, available information on Navy sonar use within designated critical habitat (e.g., frequency and duration of use, spatial extent of sound propagation), potential and likely effects to IFKW habitat use or occupancy from exposure to sonar, and the Navy's quantitative analysis estimating the number of instances in which sonar use in the HRC could be expected to result in disruptions in the way IFKWs use or occupy critical habitat (i.e., instances of harassment). The focus of the sound level characteristic is on the quality of the habitat for IFKW use and occupancy. As noted in the final rule to designate critical habitat, "*the mere presence of noise, or even noise which might cause harassment of the species, does not necessarily result in adverse modification*." In this analysis, we use the number of instances of harassment (i.e., significant disruptions of normal behavior patterns) as evidence that sonar and other transducers impairs use or occupancy because harassment within critical habitat is evidence of degraded habitat for use and occupancy. When evaluating whether sonar has decreased the value of critical habitat for conservation, we also consider timing, frequency, and duration of the sound and its resulting impacts on the population, as well as the spatial extent of impacts when they occur relative to the area designated as critical habitat.

9.3.3.4.2.1 Exposure Analysis

Table 99 lists the Navy's proposed activities in the HRC portion of the action area, the number of each proposed activity, and each activity's typical duration. A subset of these activities would occur within designated critical habitat for MHI IFKWs or result in sound that propogates into critical habitat. The table also lists the sonar source bins that will be used in each exercise. As shown in the table and described previously (e.g., Section 6.1.3), the Navy proposes to use a variety of sonar sources of varying frequencies (though typically each source is operated over a narrow frequency) in the HRC and within MHI IFKW designated critical habitat. Note that Table 99 lists each proposed activity's duration, as opposed to the number of hours of sonar proposed for use during each activity. During an activity, sonar is only transmitted part of the time and when sonar is being used, it is duty-cycled such that they emit sound for a short period of time and then stop, usually for a much longer period of time in order for any return echoes to be received and interpreted. For example, the typical duty cycle with most tactical anti-submarine warfare is about once per minute with most active sonar pulses lasting no more than a few seconds (Navy 2013b). Sounds from sonar used by the Navy recur in the action area many times annually and into the reasonably foreseeable future, but are also transient, and do not persist in the marine environment at times when the sonar source is not being operated. In general, sonar use in the action area, within the HRC, and within MHI IFKW designated critical habitat is temporary and transitory, and the habitat exposed to sonar would be expected to very quickly return to its prior state when sonar is not being transmitted.

Table 99. Proposed Navy training and testing activities in the Hawaii Range Complex portion of the action area (Navy 2018f).

Event and Typical Bins	Annual HRC Quantity*	Typical Duration
Training		
Rim of the Pacific Exercise ASW2, ASW3, ASW4, HF1, HF3, HF4, M3, MF1, MF3, MF4, MF5, MF11	0 to 1 (i.e., every other year)	30 days
Fleet Exercise/ Sustainment Exercise ASW1, ASW2, ASW3, ASW4, HF1, LF6, MF1, MF3, MF4, MF5, MF11, MF12	1	Up to 10 days
Undersea Warfare Exercise ASW3, ASW4, HF1, LF6, MF1, MF3, MF4, MF5, MF11, MF12	3	4 days
Small Integrated Anti-Submarine Warfare (ex., Navy Undersea Warfare Training and Assessment Course Surface Warfare Advanced Tactical Training) ASW3, ASW4, HF1, MF1, MF3, MF4, MF5	1	varies
Medium Coordinated Anti-Submarine Warfare (ex., Submarine Command Course) ASW2, ASW3, ASW4, HF1, MF1, MF3, MF4, MF5, MF11	2	2-3 days
Small Coordinated Anti-Submarine Warfare (ex., Independent Deployer Certification Exercise/ Tailored Anti-Submarine Warfare Training) ASW2, ASW3, ASW4, HF1, MF1, MF3, MF4, MF5, MF11	2	2-3 days
Naval Surface Fire Support Exercise – at Sea (W188A outside of MHI IFKW CH) E5	15	8 hours
Anti-Submarine Warfare Torpedo Exercise – Helicopter MF4, MF5, TORP1	6	2-5 hours
Anti-Submarine Warfare Torpedo Exercise – Maritime Patrol Aircraft MF5, TORP1	10	2-8 hours
Anti-Submarine Warfare Torpedo Exercise – Ship ASW3, MF1, TORP1	50	2-5 hours
Anti-Submarine Warfare Torpedo Exercise – Submarine ASW4, HF1, MF3, TORP2	48	8 hours
Anti-Submarine Warfare Tracking Exercise – Helicopter	159	2-4 hours

Event and Typical Bins	Annual HRC Quantity*	Typical Duration
MF4, MF5		
Anti-Submarine Warfare Tracking Exercise – Maritime Patrol Aircraft MF5	32	2-8 hours
Anti-Submarine Warfare Tracking Exercise – Ship ASW3, MF1, MF11, MF12	224	2-4 hours
Anti-Submarine Warfare Tracking Exercise – Submarine ASW4, HF1, HF3, MF3	200	8 hours
Service Weapons Test HF1, MF3, MF6, TORP2, E11	2	8 hours
Civilian Port Defense –Homeland Security Anti-Terrorism/Force Protection Exercises (Pearl Harbor, HI only outside of MHI IFKW CH) HF4, SAS2, E2, E4	1	Multiple days
Marine Mammal Systems E6	10	Varies (hours)
Mine Countermeasure Exercise – Ship Sonar HF4, HF8, MF1K	30	<15 hours
Mine Countermeasures Mine Neutralization Remotely Operated Vehicle HF4, E4	6	1.5 to 4 hours
Mine Neutralization Explosive Ordnance Disposal (Puuloa only outside of MHI IFKW CH) E4, E5, E6	20	< 4 hours
Submarine Mine Exercise HF1	40	6 hours
Surface Ship Object Detection MF1K, HF8	42	< 15 hours
Underwater Demolition Qualification and Certification (Puuloa only outside of MHI IFKW CH) E6	25	Varies (hours)
Bombing Exercise Air-to-Surface E9, E10, E12	187	1 hour
Gunnery Exercise Surface-to-Surface Boat Medium-Caliber E1, E2	10	1 hour
Gunnery Exercise Surface-to-Surface Ship Large-caliber E5	32	< 3 hours
Gunnery Exercise Surface-to-Surface Ship Medium-Caliber E1, E2	50	2-3 hours
Integrated Live Fire Exercise (W188A outside of MHI IFKW CH)	1	6-8 hours

Event and Typical Bins	Annual HRC Quantity*	Typical Duration
Missile Exercise Air-to-Surface E6, E8, E10	10	1 hour
Missile Exercise Air-to-Surface Rocket (W188A outside of MHI IFKW CH) E3	227	1 hour
Missile Exercise Surface-to-Surface (W188A outside of MHI IFKW CH) E6, E10	20	2-5 hours
Kilo Dip MF4	60	1.5 hours
Submarine Navigation Exercise (Pearl Harbor HI) HF1, MF3	220	< 2 hours
Submarine Sonar Maintenance and Systems Checks (at-sea HRC) MF3	260	< 1 hour
Submarine Sonar Maintenance and Systems Checks (Pearl Harbor outside of MHI IFKW CH) MF3	260	< 1 hour
Submarine Under Ice Certification HF1	12	5 days
Surface Ship Sonar Maintenance and Systems Checks (at-sea HRC) MF1, MF9	75	< 4 hours
Surface Ship Sonar Maintenance and Systems Checks (Pearl Harbor outside of MHI IFKW CH) MF1, MF9	80	< 4 hours
Unmanned Underwater Vehicle Training –Certification and Development FLS2, M3, SAS2	25	2 days
Testing		
Anti-Submarine Warfare Torpedo Test MF5, TORP1	17-22	2-6 hours
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft ASW2, ASW5, MF5, MF6, E1, E3	54-61	4-6 hours
Air-to-Surface Bombing Test E9	8	2 hours
Air-to-Surface Gunnery Test E1	5	2-2.5 hours
Air-to-Surface Missile Test E6,E9,E10	18	2-4 hours

Event and Typical Bins	Annual HRC Quantity*	Typical Duration
Rocket Test E3	2	1.5-2.5 hours
Undersea Range System Test MF9	0-6	1.5 hours
Anti-Submarine Warfare Mission Package Testing ASW1, ASW2, ASW3, ASW5, MF1, MF4, MF5, MF12, TORP1	22	4-8 hours per day over 1-2 weeks
At-Sea Sonar Testing ASW3, ASW4, HF1, LF4, LF5, M3, MF1, MF1K, MF2, MF3, MF5, MF9, MF10, MF11	16-17	4 hours to 11 days
Countermeasure Testing ASW3, ASW4, HF5, TORP1, TORP2	8-12	4 hours to 6 days
Pierside Sonar Testing (Pearl Harbor outside MHI IFKW CH) HF1, HF3, HF8, M3, MF1, MF3, MF9	7	Intermittently over 3 weeks
Submarine Sonar Testing/Maintenance (at-sea HRC) HF1, HF3, M3, MF3	4	Intermittently over 3 weeks
Submarine Sonar Testing/Maintenance (Pearl Harbor outside MHI IFKW CH) HF1, HF3, M3, MF3	17	Intermittently over 3 weeks
Surface Ship Sonar Testing/Maintenance (at-sea HRC) ASW3, MF1, MF1K, MF9, MF10	3	Intermittently over 3 weeks
Surface Ship Sonar Testing/Maintenance (Pearl Harbor outside MHI IFKW CH) ASW3, MF1, MF1K, MF9, MF10	3	Intermittently over 3 weeks
Torpedo (Explosive) Testing ASW3, HF1, HF5, HF6, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2, E8, E11	8-11	1-2 days daylight only
Torpedo (Non-Explosive) Testing ASW3, ASW4, HF1, HF6, M3, MF1, MF3, MF4, MF5, MF6, TORP1, TORP2, TORP3	8-17	< 2 weeks
Mine Countermeasure Mission Package Testing HF4, SAS2, E4	19	1-2 weeks, intermittent use of systems
Mine Detection and Classification Testing HF1, HF8, MF1, MF5	2-4	< 24 days
Gun Testing – Large-Caliber E3	7-79	1-2 weeks
Gun Testing – Medium-Caliber E1	4-52	1-2 weeks
Missile and Rocket Testing E6	13-37	1 day to 2 weeks
Unmanned Surface Vehicle System Testing HF4, SAS2	3	< 10 days
Unmanned Underwater Vehicle Testing	3	< 35 days

Event and Typical Bins	Annual HRC Quantity*	Typical Duration
HF4, MF9		
Submarine Sea Trials – Weapons System Testing HF1, M3, MF3, MF9, MF10, TORP2	1	< 7 days
Surface Warfare Testing E1, E5, E8	9-72	7 days
Undersea Warfare Testing ASW4, HF4, HF8, MF1, MF4, MF5, MF6, TORP1, TORP2	7-23	< 10 days
Vessel Signature Evaluation ASW3	4-40	1-5 days typical, <20 max.
Insertion/Extraction M3,MF9	1	<30 days
Signature Analysis Operations HF1, M3, MF9	2	Multiple days
Acoustic and Oceanographic Research AG, ASW2, BB4, BB9, LF3, LF4, LF5, MF8, MF9, MF9, MF9, E3	2	<14 days
Long Range Acoustic Communications LF4	3	Year-round
Communications ASW2, ASW5, HF6, LF4	0-1	5 days, 6-8 hrs per day
Energy and Intelligence, Surveillance, and Reconnaissance Sensor Systems AG, HF2, HF7, LF4, LF5, LF6, MF10	11-15	5 days, 6-8 hrs per day
Vehicle Testing BB4, FLS2, FLS3, HF6, LF3, M3, MF9, MF13, SAS1, SAS2, SAS3	4	5 days, 6-8 hrs per day

**Note that the annual quantity presented here represents the maximum conducted each year and fewer activities may occur on an annual basis. The typical duration represents the period of the event, although the sensors (e.g., sonar source) are likely to be used much less and intermittently during this period.*

The Navy is unable to provide information on the specific quantities of anticipated sonar use for the duration of the five-year MMPA rule and the reasonably forseeable future within MHI IFKW designated critical habitat versus other portions of the action area given annual variation in individual unit training objectives, overall readiness and deployment cycles, and emergent variations in testing requirements (Navy 2018f). Similarly, the Navy is unable to provide specific information on the quantities of anticipated sonar that is likely to propagate into critical habitat from sources operated outside of critical habitat. Below we present information provided by the Navy on previous sonar use within the HRC and where available, sonar use specifically expected to occur within MHI IFKW designated critical habitat in the future. This information is summarized from the Navy's supplemental consultation package addressing impacts from Navy training and testing activities on IFKW designated critical habitat (Navy 2018f).

Across all bins, sonar use in the HRC represents less than 35 percent of the total proposed for use in the action area. A subset of this 35 percent would occur within designated critical habitat for MHI IFKWs. Within the HRC, the majority of sonars used would be mid and high frequency. Large scale training events (e.g., Rim of the Pacific [RIMPAC]) using the most powerful hull-mounted sonars would, in general, occur within designated HRC subareas outside of designated critical habitat (Figure 80) (Navy 2018f). Navy review of classified data for typical sources (MF1, MF4, MF5) from 2012 to 2017 demonstrated that most, but not all, was outside of designated critical habitat (Navy 2018f). Depending on proximity to critical habitat, in some circumstances, sonar use outside of MHI IFKW critical habitat could also result in sound transmission into the critical habitat. A large percentage of Navy designated subareas and the vast majority of seaspace where sonar use would occur lie outside of designated critical habitat (Figure 80).

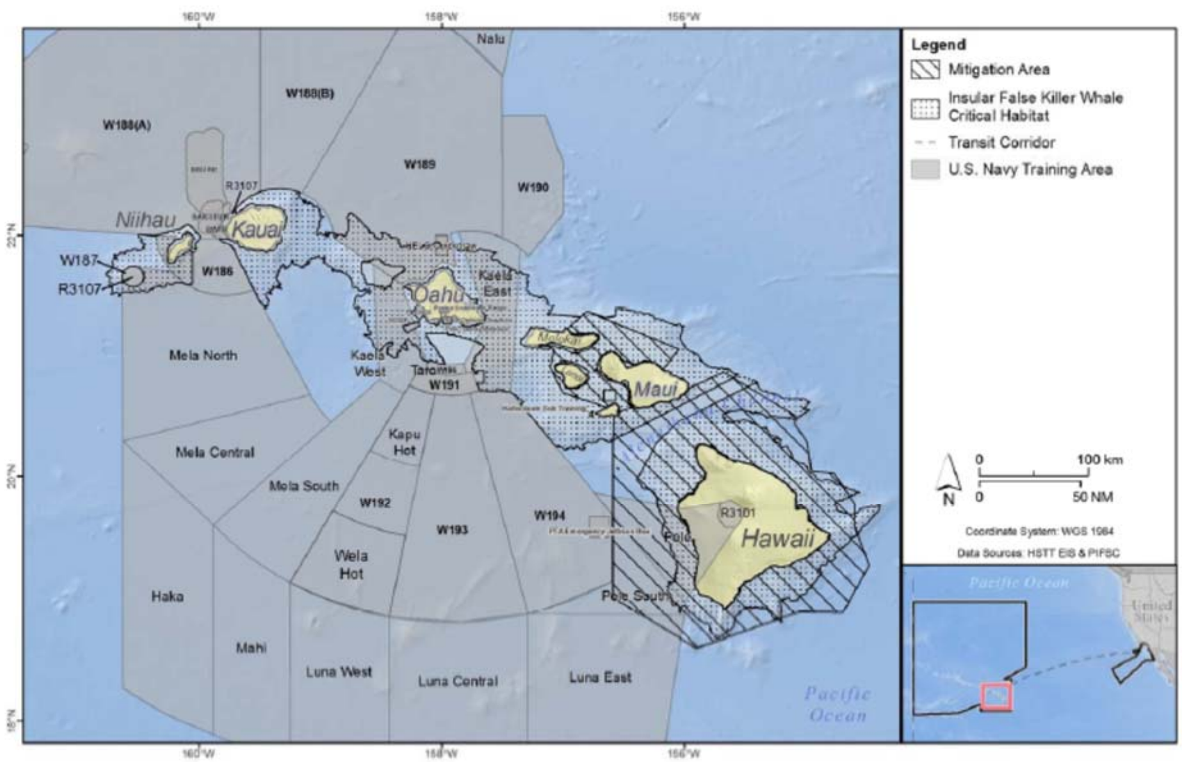


Figure 80. Main Hawaiian Islands Insular DPS false killer whale critical habitat and Hawaii Range Complex subareas used most often for anti-submarine warfare training and testing activities (Navy 2018f).

A thorough discussion on the potential effects of sonar on marine mammals, including IFKWs, is included in Section 9.2.1.1. This information is pertinent to evaluating how an activity, such as Navy training and testing using sonar, may affect MHI IFKW critical habitat because the characteristic of the PBF under consideration is how sound levels may impact the animals themselves within the habitat. That is, the characteristic is defined as "…*sound levels that would not significantly impair false killer whales' use or occupancy*" of the habitat. As presented in

Section 9.2.1.1, exposure of marine mammals to sonar and other transducers could result in behavioral responses and sound-induced hearing loss (e.g., TTS), as well as other possible adverse effects (e.g., stress). When marine mammals experience these effects, their ability to carry out important life functions (e.g., foraging, navigating, or communicating) is likely to be impaired for some period of time. Therefore, when Navy sonar is introduced into designated critical habitat for MHI IFKWs, this has the potential to degrade the value of that habitat for important life functions (i.e. dimish the value of critical habitat for conservation of the species). An understanding of how MHI IFKWs react to sound created by sonar in critical habitat is essential to applying the sound element of the PBF. Meaningful conclusions cannot be drawn without understanding behavioral response as it is the most important indicator of whether use or occupancy of critical habitat is impaired by sonar use. Our assumption is that if use or occupancy is impaired, then the value of critical habitat for conservation of the species is diminished.

As documented previously, sonar exposures are more likely to be consequential to the animal if they are for long durations or occur repeatedly (e.g., Southall et al. 2007a; Southall et al. 2016). Similarly, sonar use is more likely to result in significant impairment to the use or occupancy of the habitat at a population level if the habitat is subjected to long duration or repeated exposures. As documented in Table 99, Navy sonar use recurs multiple times annually within the HRC and within critical habitat and is anticipated to continue into the reasonably foreseeable future. The final rule designating critical habitat explains: "*scientific information also indicates that the introduction of a permanent or chronic noise source can degrade the value of habitat by interfering with the sound-reliant animals ability to gain benefits from that habitat, impeding reproduction, foraging, or communication (i.e., altering the conservation value of the habitat)…chronic exposure to noise as well as persistent noise may impede the population's ability to use the habitat for foraging, navigating, and communicating, and may deter MHI IFKWs from using the habitat entirely.*" Thus, our analysis considers how the introduction of noise caused by Navy sonar and other transducers may or may not impede the population's use or occupancy of designated critical habitat for important biological functions to determine whether the introduction of noise alters the conservation value of the habitat. Our analysis of individual animal response to Navy sonar use can be used to indicate whether behavioral disturbances could significantly impair use or occupancy of the habitat at a population level.

While a majority of Navy sonar use within the action area and within the HRC is anticipated to occur outside of MHI IFKW designated critical habitat, sonar and other transducers will be used in this area (See Table 99) and as described previously, such activities have the potential to result in impacts to the value of such habitats for IFKW use or occupancy. Additionally, in some cases, sonar use outside of critical habitat is likely to result in sound propagating into critical habitat, potentially resulting in impacts to the value of the habitat for IFKW use or occupancy. Table 77 in Section 9.2.1.1 presented information on the expected number of instances of harassment (e.g., behavioral disruptions) of IFKWs in the HRC annually from sonar and other transducers. A subset of these instances of harassment (i.e., 64 instances; Navy MFR, 16 November 2018) would occur in IFKW designated critical habitat. This represents the best available estimate of the number of instances in which disruptions of IFKW use (e.g., disruption of foraging, navigating, or communicating) or occupancy of critical habitat are likely to occur annually from Navy sonar and other transducers.[24] This estimate accounts for sonar operated within critical habitat, but also sonar operated in relatively close proximity that may propagate into the area. Based on the estimated abundance of IFKWs (i.e., 149 individuals) that spend all or a portion of their time in IFKW critical habitat, and the number of instances of behavioral disruption expected (i.e., estimates based on Navy modeling) to occur in critical habitat, an average of 0.43 disruptions of habitat use annually per animal is expected.[25] Table 100 lists the training and testing activities that the modeling indicated would result in at least one significant behavioral disruption of IFKWs in designated critical habitat.

Table 100. Estimated Main Hawaiian Islands Insular DPS false killer whale impacts (i.e., TTS and behavioral response) in designated critical habitat per year from sonar and other transducers during training and testing.

Activity	Bins	Event Length*	# annual modeled impacts in CH (TTS and Behavioral Response)**
Antisubmarine Warfare Tracking Exercise - Ship	ASW3, MF1, MF11, MF12	2-4 hrs	20.1
Unmanned Surface Vehicle System Testing	HF4, SAS2	<10 days	9.5
Antisubmarine Warfare Torpedo Exercise - Submarine	ASW4, HF1, MF3, TORP2	8 hrs	9.1
Submarine Mine Exercise	HF1	6 hrs	3.5
Surface Ship Sonar Maintenance	MF1, HF8	<4hrs	3.4
Surface Ship Object Detection	MF1K, HF8	0.5 hrs	3.2
Rim of the Pacific Exercise (alternating years)	ASW2, ASW3, ASW4, HF1, HF3, HF4, M3, MF1, MF3, MF4, MF5, MF11	30 days	1.6

**Event length indicates the duration of the activity. The length of time sonar is transmitting during the event will be less.*
***Note that the total does not add to 64 as the modeling indicated some activities would result in fractional impact estimates.*

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[24] The focus of the sound level characteristic is on the quality of the habitat for IFKW use and occupancy. As noted in the final rule to designate critical habitat, "the mere presense of noise, or even noise which might cause harassment of the species, does not necessarily result in adverse modification." In this analysis, we use the number of instances of harassment as evidence that sonar may impair use or occupancy because harassment is evidence of decrease in the value of the habitat for use and occupancy. When evaluating whether sonar has significantly impaired the value of critical habitat for conservation, we use this information and also consider timing, frequency, and duration of the sound and its disturbance of the population.

[25] Note that NMFS recognizes 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 IFKW critical habitat. Some individuals could experience a few more or less disruptions annually than what is estimated here. However, due to the limitations on acoustic exposure modeling capabilities, we are unable to identify which individuals from the 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 critical habitat will be exposed to and affected by Navy sonar annually. This estimate is presented to indicate the relative magnitude of likely exposures on an annual basis for animals within the population.

In addition to analysis of individual animal response to Navy sonar use, our analysis in this consultation also considers the temporal and spatial extent of sonar exposure to designated critical habitat. Table 44 in Section 6.1.3 presents information on the number of sonar hours proposed for use in the action area. When considering potential impacts to MHI IFKW designated critical habitat, we focus on mid-frequency and high-frequency sonars as those are the sources within the hearing range of the species (i.e., 150 Hz to 160 kHz). As stated above, the Navy estimates that across all bins, sonar use in the HRC represents less than 35 percent of the total proposed for use in the action area and no more than 30 to 45 percent of all sonar use within the HRC would occur in portions of the MHI IFKW designated critical habitat (Navy 2018f).

The spatial extent of sonar exposure to habitat during each hour of sonar use would vary depending on source level and propagation of the sound within the water column. Table 71 through Table 74 present information on the range to effects (i.e., distances to what could result in a significant behavioral disruption) for representative mid and high frequency sonars used in the action area. When considering the spatial extent of exposure to designated critical habitat, the cutoff distances described in Section 2.2.1.2.2 also must be considered and applied. For mid-frequency sonars, the maximum distance to a potentially significant behavioral disruption is the 20 km cutoff distance. For high-frequency sonars, the maximum distance to a potentially significant behavioral disruption is approximately 5.5 km. It is important to emphasize that these distances represent the maximum distance in which impacts to use or occupancy would be expected. At these larger distances, the likelihood of a significant behavioral disruption (and therefore impacts to use or occupancy) is relatively low for many sonars (e.g., there is a 20 percent probability of a behavioral response for odontocetes at approximately 17 km for sonar bin MF4). There would be an increased likelihood of significant behavioral disruptions (and therefore impacts to use or occupancy) at closer distances (e.g., at 948 m, there is a 58 percent probability of behavioral response for odontocetes for MF4). Designated critical habitat for MHI IFKWs encompasses approximately 45,859 km^2. Based on the range to effects and the size of designated critical habitat, only a very small percentage of critical habitat would be exposed to Navy sonar that could result in impacts to use or occupancy during each hour of use.

9.3.3.4.2.2 Response Analysis

During exposure in designated critical habitat, affected IFKWs may be utilizing the habitat to engage in any number of activities including, but not limited to, foraging, navigating, communicating, or resting. If IFKWs exhibited a behavioral response to Navy sonar that affected how the animals were utilizing the habitat, these activities would be disrupted and it may pose some energetic cost. However, as noted previously in Section 9.2.1.1.3, responses to Navy sonar (both in and outside of critical habitat) are anticipated to be short term and instances of hearing impairment are expected to be mild or moderate. Based on best available information that indicates marine mammals typically resume normal behavior quickly after the cessation of sonar exposure, we anticipate that exposed animals will be able to return to normal behavioral patterns after this short duration exposure ceases. For example, both Goldbogen et al. (2013a) and Melcon et al. (2012) indicated that behavioral responses to sonar were temporary, with whales resuming normal behavior quickly after the cessation of sound exposure. Further, responses were discernible for whales in certain behavioral states (i.e., deep feeding), but not in others (i.e., surface feeding). Baird et al. (2014b; 2017a; 2013b) tagged four shallow-diving odontocete species (including false killer whales) in the HRC off the Pacific Missile Range Facility before Navy training events using sonar. Consistent with most other studies looking at the response of marine mammals to sonar (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), none of the tagged animals demonstrated a large-scale or long-term avoidance response to the sonar as they moved on or near the training range where sonar was being used.

Additionally, based on best available information regarding exposure of IFKWs and other marine mammal species to Navy sonar, these short term responses are not anticipated to lead to long duration (e.g., more than one day) abandonment of any particular area within critical habitat, or of critical habitat as a whole. As noted in Section 9.2.1.1, when marine mammals have been observed to leave a certain area following acoustic exposure, they are likely to return after the period of exposure ends (e.g., Baird et al. 2016b; Tyack et al. 2011a). Even in intensively used sonar training areas, such as those locations considered in this consultation in Southern California, photo identification results have indicated long-term residency of odontocetes considered particularly sensitive to disturbance from acoustic exposure (i.e., Cuvier's beaked whales) (Falcone and Schorr 2014; Falcone et al. 2009b). IFKWs are not known to be as sensitive to acoustic disturbance as beaked whales. In contrast, evidence suggest MHI IFKWs are farely tolerant of disturbance from Navy sonar, perhaps because the animals in the population have been exposed to sonar multiple times on previous occasions (Baird et al. 2017b).

Regarding observations specific to IFKWs, tags were deployed on seven false killer whales prior to a training event using sonar in the HRC. Of those animals, two were identified as being IFKWs and the other five were from the Northwest Hawaiian Islands stock (R.W. Baird, pers. comm. to J.A. Rivers, Navy, October 26, 2018). Only one individual's movements in space and time lent itself to detailed analysis of exposure and response to mid-frequency active sonar. The false killer whale passed through the training event twice, transiting away from an area of relatively low exposure (estimated received level of mean = 90.9 dB re: 1 μPa rms) and toward the training event, receiving an estimated median received level of 156 dB re 1 μPa with a maximum estimated received level of 188 dB re 1 μPa (Baird et al. 2016b). The individual then moved away from the areas of sonar for several hours, then returned to this area of exposure to an estimated maximum mean received level of 150.8 dB, and then moved to an area of lower received levels. This exposure-response scenario is consistent with the discussion above in that short term responses were observed, but animals returned to the area following exposure. Also important to consider is that the Navy has been conducting training and testing activities in the HRC and within recently designated critical habitat for decades. Despite this, monitoring (e.g., Baird et al. 2014b; Baird et al. 2017a; Baird et al. 2013b) indicates that IFKWs continue to utilize these habitats.

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 of marine mammals to Navy sonar. With respect to the characteristic of the PBF related to sound levels, the duration and frequency of the sound source being utilized in or near designated critical habitat is important in evaluating the extent of potential impacts to use and occupancy (83 FR 35062). As listed in Table 100, most of the activities the modeling indicates are likely to result in significant disruptions of behavior patterns in designated critical habitat last less than one day. While these activities are anticipated to result in significant disruptions of behavior of the animals in designated critical habitat, and therefore disruptions of IFKW's use of the habitat, the short duration of these events limits the potential for these activites to result in long duration exposures to the animals or specific areas of designated critical habitat and, consistent with literature described previously on the response of marine mammals to sonar, we anticipate that exposed animals will be able to return to normal behavior patterns shortly after the exposure is over (minutes to hours; e.g., Goldbogen et al. 2013a; Silve et al. 2015). Some activities occurring in the action area (See Section 3.3, Table 11) and resulting in impacts to IFKWs (See Table 100), will last for longer durations. For example, as described further in Table 11, RIMPAC is expected to result in hundreds of hours of sonar activity involving multiple platforms (i.e., surface vessels, submarines, and aircraft) utilizing sonar. These exercises range in duration from two days to over ten, and therefore have the potential to result in sustained and/or repeat exposure. However, while MTEs may have a longer duration, they are not concentrated in small geographic areas over that time period. MTEs use thousands to tens of thousands of square miles of ocean space during the course of the event. As noted previously, while some portion of such exercises could occur in critical habitat, a majority would occur in more offshore training subareas of the HRC (Navy 2018f). This is particularly true for portions of the exercises that utilize the Navy's more powerful mid and high-frequency hull mounted sonar (Navy 2018f) that have higher likelihoods of resulting in significant behavioral disuptions. 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 (e.g., within a few square miles). Further, as described in the final biological report supporting the critical habitat designation (NMFS 2018a), MHI IFKWs circumnavigate the Main Hawaiian Islands and quickly move throughout their range (Baird et al. 2008; Baird et al. 2012c; NMFS 2018a). One individual moved from Hawaii to Maui to Oahu to Molokai, covering at least 449 km over a 96 hour period (Baird et al. 2010; NMFS 2018a; Oleson et al. 2010). Due to (1) the large area of habitat available to and utilized by MHI IFKWs (NMFS 2018a), (2) the relatively small area that will be affected by sonar at any given period of time, (3) that most Navy activities resulting in significant disruptions of habitat use last less than one day, and (4) that long duration (i.e., more than one day) 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), largely outside of designated critical habitat, there is a low likelihood that IFKWs and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity in critical habitat. Because of this, and the short duration of responses anticipated, we expect that effects to IFKW use or occupancy of designated critical habitat from Navy sonar will be temporary when they occur.

The potential for masking is another important consideration when evaluating effects of anthropogenic noise on habitat use of marine mammals, including IFKWs. Masking was also discussed in Section 9.2.1.1.1.4 and 9.2.1.1.3 of this opinion. Some limited masking could occur due to the Navy's use of sonar and other transducers when animals are in close enough proximity. That is, if an animal is close enough to the source to experience 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. Because traditional military sonars typically have low duty cycles, the effects of such masking are expected to be limited. The typical duty cycle with most tactical anti-submarine warfare is about once per minute with most active sonar pulses lasting no more than a few seconds (Navy 2013b). This indicates biologically-relevant sounds for individuals in close proximity would only be masked intermittently for a short time. Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, but these effects would only happen close to the source. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high frequency acoustic sources such as pingers that operate at higher repetition, also operate at lower source levels. While the lower source levels of these systems limit the range of impact compared to more traditional systems, animals close to the sonar source could experience masking on a longer time scale than those exposed to traditional sonars. However, this effect would only occur if the animals were to remain in close proximity to the source. Since both the sonar source and the animal move within the environment, we do not anticipate animals would remain in close proximity to a source for an extended period of time. Additionally, most sonar sources used by the Navy operate over a narrow band of frequencies and therefore do not cover the full range of MHI IFKW hearing range. Based on these factors, we do not anticipate that Navy sonars will result in masking that could significantly impair IFKW habitat use or occupancy. Therefore, effects of any temporary masking on the sound level characteristic of MHI IFKW designated critical habitat are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

9.3.3.4.2.3 Risk Analysis

Based on the analysis presented above, we anticipate that sound from Navy sonar would be introduced into MHI IFKW designated critical habitat infrequently at levels would result in impairment of IFKW habitat use or occupancy (i.e., average of 0.43 disruptions per animal annually in critical habitat). We do not anticipate this species will experience long duration or repeat exposures within a short period of time in designated critical habitat due to the following: 1) the large area of habitat available to and utilized by the animals (NMFS 2018a), 2) the relatively small area that will be affected by sonar at any given period of time, (3) that most Navy activities resulting in in significant disruptions of habitat use last less than one day, and (4) that long duration (i.e., more than one day) 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), largely outside of designated critical habitat. This decreases the likelihood that IFKWs and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity (or subsequent activities) while within critical habitat. Based on the available literature that indicates infrequent exposures resulting in behavioral disruptions are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015a; NAS 2017; New et al. 2014; Southall et al. 2007f; Villegas-Amtmann et al. 2015), we do not expect this level of exposure to impact the fitness of exposed animals. As described above, we use our analysis of individual animal response to Navy sonar use to indicate whether behavioral disturbances could impair use or occupancy of the habitat at a population level. Based on the preceding analysis considering effects to individual animals, we do not anticipate Navy sonar use would impair use of occupancy of the habitat at a population level. Given that impairment of use and occupancy will not have population level consequences (and Navy training and testing occurs throughout the range of IFKWs and throughout all areas of designated critical habitat), we find that this is an indicator that diminshment of the value of critical habitat for conservation of the species should not be appreciable.

The limited duration of the disruption further supports the foregoing finding. Based on the best available information regarding exposure of IFKWs and other marine mammal species to Navy sonar (e.g., Baird et al. 2017; e.g., Baird et al. 2016; Falcone and Schorr 2014; Falcone et al. 2009b; Tyack et al. 2011), these short term disruptions of behavior are not anticipated to lead to long duration (e.g., more than one day) abandonment or avoidance of any particular area within critical habitat, or of critical habitat as a whole. Based on the range to effects values described previously and the extent of designated critical habitat, when sonar exposure does occur in portions of critical habitat, only a small portion of the habitat area will be exposed at levels that could result in impacts to use and occupancy, and the vast majority of critical habitat would remain available to the animals for undisrupted use and occupancy. Sounds from sonar used by the Navy are transient, and do not persist in the marine environment at times when the sonar source is not being operated. Even with decades of Navy sonar use within areas of recently designated critical habitat, as well as monitoring of IFKWs use of these habitats, we do not have information to suggest that these animals exhibit long duration avoidance of particular areas of critical habitat, or critical habitat as a whole, due to sonar use.

Scenarios where Navy sonar and other transducer use within the action area are likely to result in changes to the animal's use or occupancy of MHI IFKW critical habitat are anticipated to be sporadic and temporary. The Navy has been conducting training and testing activities in the HRC and within recently designated critical habitat for decades. Despite this, monitoring (e.g., Baird et al. 2014b; Baird et al. 2017a; Baird et al. 2013b) indicates that IFKWs continue to utilize these habitats. Further, for the Phase III MMPA rule and into the reasonably foreseeable future, the Navy proposed geographic mitigation for several areas in the HRC (see Section 3.4.2.2.2), much of which is encompassed by MHI IFKW designated critical habitat. These areas include some of the habitats most frequently used by MHI IFKWs in the Main Hawaiian Islands (Figure 74). This will minimize exposure of designated critical habitat and MHI IFKWs within critical habitat to sonar that could result in impairment of the use or occupancy of the habitat. For these reasons, while we have determined that MHI IFKW's use of designated critical habitat is likely to be disrupted intermittently in several locations, we do not anticipate that either individuals or the population would avoid or abandon use of the habitat for important biological functions.

10 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.

This section attempts to identify the likely future changes and their impact on ESA-listed species and their critical habitats in the action area. This section is not meant to be a comprehensive socio-economic evaluation, but a brief outlook on future changes in the environment. Projections are based upon recognized organizations producing best-available information and reasonable rough-trend estimates of change stemming from these data. However, all changes are based upon projections that are subject to error and alteration by complex economic and social interactions.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline (Section 7.3), most of which we expect will continue in the future. An increase in these activities could similarly increase their effect on ESA-protected resources and for some, an increase in the future is considered reasonably certain to occur. Given current trends in global population growth, threats associated with climate change, pollution, fisheries, bycatch, vessel strikes and approaches, and sound are likely to continue to increase in the future, although any increase in effect may be somewhat countered by an increase in conservation and management activities. In contrast, more historic threats such as whaling and sea turtle harvest are likely to remain low or potentially decrease. For the remaining 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 ESA-protected resources. Thus, this consultation assumed effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the status of the resources (Section 7.1.1) and Environmental Baseline sections.

11 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. In this section, we add the *Effects of the Action* (Section 9) to the *Environmental Baseline* (Section 7.3) and the *Cumulative Effects* (Section 9.3) 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 and Critical Habitat* (Section 7).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion. Where stressors were determined to have insignificant or discountable effects to certain or all species earlier in this opinion, those stressors will not cause adverse effects to individuals of those species or cause a population or species level effect.

11.1 Marine Mammals

Navy training and testing activities introduce a variety of stressors into the action area that are expected to result in effects to ESA-listed marine mammals. Our effects analysis determined that sonar and other transducers, explosives, and vessel strike are likely to adversely affect ESA-listed marine mammals. We determined that vessel strike is likely to result in mortality to three ESA-listed marine mammals in the action area over the five year period of the proposed MMPA rule and established that a range of impacts including temporary and permanent threshold shift, behavioral response, and stress are likely to occur due to exposure to Navy acoustic stressors during training and testing events. In this section, we discuss the likely consequences of these effects to the marine mammals that have been exposed, the populations those individuals represent, and the species those populations comprise.

Our effects analyses identified the probable risks the Navy training and testing activities and issuance of an MMPA rule and LOA to authorize take of marine mammals would pose to ESA-listed individuals that will be exposed to these actions. We measure risks to individuals of endangered or threatened marine mammals using changes in the individual's "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed marine mammals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the overall reproduction, abundance, or distribution of the populations those individuals represent or the species those populations comprise. As a result, if we conclude that listed animals are not likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed animals are likely to experience reductions in their fitness, we would assess the consequences of those fitness reductions for the population or populations the individuals in an action area represent.

As documented previously, many of the impacts resulting from the proposed action are from sounds produced during Navy training and testing activities in the action area. While this opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of some marine mammals; how these animals 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 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 could produce outcomes that have adverse consequences for individuals and populations of exposed species. Based on the best available information, we expect most exposures and potential responses of ESA-listed marine mammals to Navy acoustic stressors to have little effect on the exposed animals. As is evident from the controlled exposure experiments and opportunistic research on the effects of sonar presented previously, responses are expected to be short-term, with the animal returning to normal behavior patterns shortly after the exposure is over (e.g., Goldbogen et al. 2013b; Silve et al. 2015). However, 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. As described in further detail in Section 9.2.1.1.4, we would 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.

11.1.1 Blue Whale

As described further in Section 7.1.1, current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007). The best abundance estimate for blue whales in the Hawaii portion of the action area is 81 animals and the best abundance estimate in the Southern California portion of the action area is 1,647 animals (Calambokidis and Barlow 2013). Available information suggests increasing population growth rates in the eastern North Pacific (Calambokidis et al. 2009). Evidence suggests blue whale populations in the southern California portion of the action area may have reached carrying capacity (Monnahan et al. 2014b). Monnahan et al. (2014b) calculated that the population of blue whales in the Eastern North Pacific currently totals 2,138 individuals.

Blue whales are expected to experience TTS, behavioral response, and physiological stress in the Hawaii and Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 48 instances of harassment are reasonably certain to occur from Navy sonar annually in the Hawaii portion of the action area and 1,974 instances of harassment in the SOCAL portion. Blue whales are also expected to experience 13 instances of TTS and 1 instance of PTS during the five year period of the proposed MMPA rule due to explosives in SOCAL. No blue whale impacts from explosives are anticipated in the Hawaii portion of the action area. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual blue whales. Because we do not anticipate fitness consequences to individual blue whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of blue whales in the Pacific Ocean or rangewide from these effects.

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 effect aspects of the affected animal's life functions that do not overlap in time and space with the proposed action. As discussed previously in Section 9.2.1.2.4, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. Our exposure and response analyses indicate that one blue whale would experience PTS, but this PTS 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 blue 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), we would not expect such impacts to have meaningful effects at the population level. That is, individual whales affected could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of blue whales in the Pacific Ocean or rangewide.

Based on the best available information on the exposure of blue whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no injury or mortality this species is reasonably certain to occur from these stressors.

As detailed in Section 9.2.1.4, we anticipate one blue whale vessel strike to occur in the Southern California portion of the action area during the five-year period of the proposed MMPA rule. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual. The death of a male blue whale would have substantially less of an effect on the population than the loss of a female. Loss of a sexually mature female will have immediate effects on recruitment while lost reproductive potential from mortality of a juvenile female might not be realized for several years. Best available information suggests the rangewide blue whale population is at least 5,000 individuals and the blue whale population in the Eastern North Pacific is 1,647 individuals (Calambokidis and Barlow 2013). Assuming a balanced sex ratio, this means 2,500 females in the range-wide population and 823 females in the Eastern North Pacific population. In the worst-case scenario, the one blue whale expected to be struck in five years by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of the range-wide population by 0.04 percent and the Eastern North Pacific population by 0.12 percent. This is not an appreciable reduction in the numbers or the reproductive capability of blue whales in the Eastern North Pacific or rangewide. Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species in the Eastern North Pacific or rangewide. If the analyzed rate of vessel strike for this species was to recur in subsequent 5-year periods into the reasonably foreseeable future, based on the available information and this calculated rate of reduction in reproductive potential, we also believe it is unlikely that there would be an appreciable reduction to survival or reproduction rates or the species' ability to recover.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, Monnahan et al. (2014a) suggested that the blue whale population in the Eastern North Pacific, inclusive of the SOCAL portion of the action area, is at carrying capacity and recovered to pre-whaling levels. This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives in the North Pacific (e.g., HSTT; Northwest Training and Testing; Gulf of Alaska training) for many years. Because these activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future, this suggests blue whales are likely resilient to the impacts incurred from these activities. It's also worth noting here that for Phase III training and testing activities, the Navy will implement restrictions on sonar and explosive use in some southern California BIAs identified for this species (See Section 3.4.2.2.3), thereby reducing potential effects of Navy activities to this species in locations where we know they are likely to be foraging.

In summary, the impacts expected to occur and affect blue whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of the blue whale population in the Pacific Ocean. Because we do not anticipate impacts to the blue whale population in the Pacific Ocean, we also do not anticipate appreciable reductions in overall reproduction, abundance, or distribution of the blue whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of blue whales in the wild.

11.1.2 Fin Whale

As described further in Section 7.1.1, current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters inclusive of the action area. The Hawaii stock is estimated to consist of 154 individuals (Carretta et al. 2018c) and the California/Oregon/Washington stock is estimated to consist of 9,029 individuals. Indications of fin whale population recovery in the southern California portion of the action area date back to 1979 and there was a five-fold increase in fin whale populations along the U.S. west coast from 2005 to 2014 (Carretta et al. 2017c).

Fin whales are expected to experience TTS, behavioral response, and physiological stress in the Hawaii and Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 48 instances of harassment are reasonably certain to occur from Navy sonar annually in the Hawaii portion of the action area and 2,211 instances of harassment in the SOCAL portion. Fin whales are also expected to experience 14 instances of TTS and 1 instance of PTS during the five year period of the proposed MMPA rule due to explosives in SOCAL. No fin whale impacts from explosives are anticipated in the Hawaii portion of the action area. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual fin whales. Because we do not anticipate fitness consequences to individual fin whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of fin whales in the Pacific Ocean or rangewide from these effects. As also described for blue whales, we anticipate that the instance of PTS could result in a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance) to the affected animal, but we would not expect such impacts to have meaningful effects at the population level. For this reason, 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.

Based on the best available information on the exposure of fin whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality of this species is reasonably certain to occur from these stressors.

As detailed in Section 9.2.1.4, we anticipate two fin whale vessels strike to occur in the Southern California portion of the action area during the five-year period of the proposed MMPA rule. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual with the loss of a female having the potential to be more consequential to the population. Best available information suggests the fin whale population occurring in the southern California portion of the action area consists of 9,029 animals. Assuming a balanced sex ratio, this means 4,514 females in the population. In the worst-case scenario, the two fin whales expected to be struck in five years by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of the eastern north Pacific population by 0.02 percent. This is not an appreciable reduction in the numbers or the reproductive capability of fin whales in the southern California portion of the action area. The impact of this level of vessel strike would be even less consequential for the range-wide population. Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of the species in the southern California portion of the action area or rangewide. If the analyzed rate of vessel strike for this species was to recur in subsequent 5-year periods into the reasonably foreseeable future, based on the available information and this calculated rate of reduction in reproductive potential, we also believe it is unlikely that there would be an appreciable reduction to survival or reproduction rates or the species' ability to recover.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, the fin whale population along the U.S. west coast, inclusive of the SOCAL portion of the action area, is increasing in abundance. This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives in the North Pacific (e.g., HSTT; Northwest Training and Testing; Gulf of Alaska training) for many years. Because these activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future, this suggests fin whales are likely resilient to the impacts incurred from these activities.

In summary, the impacts expected to occur and affect fin whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of the fin whale population in the Pacific Ocean. Because we do not anticipate impacts to the fin whale population in the Pacific Ocean, we also do not anticipate appreciable reductions in overall reproduction, abundance, or distribution of the fin whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of fin whales in the wild.

11.1.3 Gray Whale – Western North Pacific DPS

As described further in Section 7.1.1, the best abundance estimate for the Western North Pacific DPS of gray whales is 140 whales. Only a subset of the population would be expected to occur in the action area (i.e., the subset of individuals that winters off the U.S. west coast). The majority of this species' range is outside of the action area.

Western North Pacific DPS gray whales are expected to experience TTS, behavioral response, and physiological stress in the Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of six instances of harassment are reasonably certain to occur from Navy sonar annually in SOCAL. No Western North Pacific DPS gray whale impacts from explosives are anticipated. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual gray whales. Because we do not anticipate fitness consequences to individual gray whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of Western North Pacific DPS gray whales from these effects. Based on the best available information on the exposure of Western North Pacific DPS gray whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no injury or mortality of this species is reasonably certain to occur from these stressors. In addition, based on the best available information on the exposure of Western North Pacific DPS gray whales to ship strike (See Section 9.2.1.4), no injury or mortality of this species is reasonably certain to occur from this stressor.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, the Western North Pacific DPS gray whale population, inclusive of the SOCAL portion of the action area, is thought to be increasing at 3.3 percent annually. This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives in the North Pacific (e.g., HSTT; Northwest Training and Testing; Gulf of Alaska training) for many years. These activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future.

In summary, the impacts expected to occur and affect Western North Pacific DPS gray whales in the action area are not anticipated to result in reductions in overall reproduction, abundance, or distribution of this population. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of Western North Pacific DPS gray whales in the wild.

11.1.4 Humpback Whale – Mexico DPS

As described further in Section 7.1.1, the current abundance estimate for the Mexico DPS of humpback whales is 3,264 animals (81 FR 62259). The final rule to designate 14 DPSs of humpback whales stated that there is not sufficient information to estimate population growth trends for this specific DPS. However, the rule does provide evidence of increasing humpback whale populations throughout this DPS's primary feeding areas. For this reason, the final rule stated that it was unlikely the Mexico DPS population is decreasing (81 FR 62259).

Mexico DPS humpback whales are expected to experience TTS, behavioral response, and physiological stress in the Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 1,101 instances of harassment are reasonably certain to occur from Navy sonar annually in the SOCAL portion of the action area. Mexico DPS humpback whales are also expected to experience 17 instances of TTS and 1 instance of PTS during the five year period of the proposed MMPA rule due to explosives in SOCAL. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual humpback whales. Because we do not anticipate fitness consequences to individual humpback whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of Mexico DPS humpback whales in the Pacific Ocean. As also described for blue and fin whales, we anticipate that the instance of PTS could result in a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance) to the affected animal, but we would not expect such impacts to have meaningful effects at the population level. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of Mexico DPS humpback whales.

Based on the best available information on the exposure of Mexico DPS humpback whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality of this species is reasonably certain to occur from these stressors.

As detailed in Section 9.2.1.4, we anticipate one Mexico DPS humpback whale vessel strike to occur in the Southern California portion of the action area during the five-year period of the proposed MMPA rule. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual with the loss of a female having the potential to be more consequential to the population. Best available information suggests the Mexico DPS humpback whale population consists of 3,264 animals. Assuming a balanced sex ratio, this means 1,632 females in the population. In the worst-case scenario, the humpback whales expected to be struck in five years by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of the Mexico DPS by 0.06 percent. This is not an appreciable reduction in the numbers or the reproductive capability of Mexico DPS humpback whales. Therefore, we conclude that this level of mortality is not an appreciable reduction in the numbers or reproductive capability of Mexico DPS humpback whales. If the anticipated rate of vessel strike for this species was to recur in subsequent 5-year periods into the reasonably foreseeable future, based on the available information and this calculated rate of reduction in reproductive potential, we also believe it is unlikely that there would be an appreciable reduction to survival or reproduction rates or the species' ability to recover.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, humpback whale populations in the North Pacific Ocean generally appear to be increasing in abundance (81 FR 62259). This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives in the North Pacific (e.g., HSTT; Northwest Training and Testing; Gulf of Alaska training) for many years. Because these activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future, this suggests humpback whales are likely resilient to the impacts incurred from these activities.

In summary, the impacts expected to occur and affect Mexico DPS humpback whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of this population. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of the Mexico DPS of humpback whales in the wild.

11.1.5 Humpback Whale – Central America DPS

As described further in Section 7.1.1, the current abundance estimate for the Central America DPS of humpback whales is 411 animals (81 FR 62259). The final rule to designate 14 DPSs of humpback whales stated that there is not sufficient information to estimate population growth trends for this specific DPS.

Central America DPS humpback whales are expected to experience TTS, behavioral response, and physiological stress in the Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 870 instances of harassment are reasonably certain to occur from Navy sonar annually in the SOCAL portion of the action area. Central America DPS humpback whales are also expected to experience 6 instances of TTS during the five year period of the proposed MMPA rule due to explosives in SOCAL. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral disturbance to result in fitness consequences to individual humpback whales. Based on the best available information on the exposure of Central America DPS humpback whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no injury or mortality of this species is reasonably certain to occur from these stressors. Because we do not anticipate fitness consequences to individual humpback whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of Central America DPS humpback whales in the Pacific Ocean. In addition, based on the best available information on the exposure of Central America DPS humpback whales to ship strike (See Section 9.2.1.4), no injury or mortality of this species is reasonably certain to occur from this stressor.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, humpback whale populations in the North Pacific Ocean generally appear to be increasing in abundance (81 FR 62259). This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives in the North Pacific (e.g., HSTT; Northwest Training and Testing; Gulf of Alaska training) for many years. Because these activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future, this suggests humpback whales are likely resilient to the impacts incurred from these activities.

In summary, the impacts expected to occur and affect Central America DPS humpback whales in the action area are not anticipated to result in reductions in overall reproduction, abundance, or distribution of this population. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of the Central America DPS of humpback whales in the wild.

11.1.6 Sei Whale

As described further in Section 7.1.1, the most recent abundance estimate for sei whales in the North Pacific Ocean is 29,632 animals (IWC 2016; Thomas et al. 2016). Specific to sei whales in the action area, data precludes assessing population trends for this species.

Sei whales are expected to experience TTS, behavioral response, and physiological stress in the Hawaii and Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 167 instances of harassment are reasonably certain to occur from Navy sonar annually in the Hawaii portion of the action area and 78 instances of harassment in the SOCAL portion. Sei whales are also expected to experience 1 instances of TTS during the five year period of the proposed MMPA rule due to explosives in SOCAL. No sei whale impacts from explosives are anticipated in the Hawaii portion of the action area. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual sei whales. Based on the best available information on the exposure of sei whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality of this species is reasonably certain to occur from these stressors. Because we do not anticipate fitness consequences to individual sei whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of sei whales in the North Pacific Ocean or rangewide from these effects. In addition, based on the best available information on the exposure of sei whales to ship strike (See Section 9.2.1.4), no injury or mortality of this species is reasonably certain to occur from this stressor.

In summary, the impacts expected to occur and affect fin whales in the action area are not anticipated to result in reductions in overall reproduction, abundance, or distribution of the fin whale population in the Pacific Ocean. Because we do not anticipate impacts to the fin whale population in the Pacific Ocean, we also do not anticipate reductions in overall reproduction, abundance, or distribution of the fin whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of fin whales in the wild.

11.1.7 Sperm Whale

As described further in Section 7.1.1, sperm whales are the most abundant of all the large whale species. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. There are insufficient data to estimate the population abundance of sperm whales for the entire North Pacific. Population estimates are available for the California/Oregon/ Washington stock, estimated to consist of 2,106 individuals, and the Hawaii stock, estimated to consist of 3,354 individuals.

Sperm whales are expected to experience TTS, behavioral response, and physiological stress in the Hawaii and Southern California portions of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 2,496 instances of harassment are reasonably certain to occur from Navy sonar annually in the Hawaii portion of the action area and 2,488 instances of harassment in the SOCAL portion. Sperm whales are also expected to experience 5 instances of TTS annually during the five year period of the proposed MMPA rule due to explosives in SOCAL. No sperm whale impacts from explosives are anticipated in the Hawaii portion of the action area. Based on the best available information on the exposure of fin whales to sonar and explosives, and as detailed in Section 9.2.1.2.2, no injury or mortality of this species is reasonably certain to occur from these stressors. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual sperm whales. Because we do not anticipate fitness consequences to individual sperm whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of sperm whales in the Pacific Ocean or rangewide from these effects.

We also anticipate a Navy vessel will strike one sperm whale over the five year period of the proposed MMPA rule, and during each subsequent five year period. As described in Section 9.2.1.4.2, we anticipate the animal impacted will die. Death would have a direct fitness consequence to the individual leading to lost reproductive potential that the individual might contribute to the population or sub-population. This lost reproductive potential will vary depending on the sex (male or female) and maturity of the individual. We do not know whether this vessel strike will occur in the Hawaii or Southern California portion of the action area, so we will evaluate the potential impact of this vessel strike on sperm whales in both Hawaii and Southern California. As stated previously, the most recent abundance estimate for sperm whales in the California/Oregon/ Washington stock, was 2,106 individuals. The most recent abundance estimate for the Hawaii stock is 3,354 individuals. The most recent rangewide abundance estimate is between 300,000 and 450,000 individuals (Whitehead 2009). Assuming a balanced sex ratio, this means at least 1,053 females in the California/Oregon/Washington stock, 1,677 females in the Hawaii stock (both of which are subsets of the population in the North Pacific), and 150,000 females likely exist rangewide. In the worst-case scenario, the one sperm whale expected to be struck in the five years of the MMPA rule by Navy vessels would be female of early reproductive age. This would reduce the reproductive potential of the California/Oregon/Washington stock by 0.09 percent, of the Hawaii stock by 0.06 percent, and of the rangewide population by 0.0007 percent. This is not an appreciable reduction in the numbers or the reproductive capability of sperm whales either in the North Pacific or range-wide.

In summary, the impacts expected to occur and affect sperm whales in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of the sperm whale population along the U.S. west coast or Hawaii. Because we do not anticipate impacts to the sperm whale population in the these areas, we also do not anticipate appreciable reductions in overall reproduction, abundance, or distribution of the sperm whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of sperm whales in the wild.

11.1.8 False Killer Whale – Main Hawaiian Islands Insular DPS

As described further in Section 7.1.1, the best abundance estimate for the MHI IFKWs is 149 individuals (Carretta et al. 2018c). Available data indicate the population is currently declining (Oleson et al. 2010; Carretta et al. 2018).

MHI IFKWs are expected to experience TTS, behavioral response, and physiological stress in the Hawaii portion of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 588 instances of harassment are reasonably certain to occur from Navy sonar annually in Hawaii. One instance of TTS from explosives is anticipated annually. Based on the best available information on the exposure of MHI IFKWs, and as detailed in Section 9.2.1.2.2, no injury or mortality of this species is reasonably certain to occur from these stressors. It is also noteworthy that the Navy's modeling to estimate exposure of marine mammals to sonar and explosives does not account for geographic mitigation proposed by the Navy (See Section 3.4.2.2.2) that will result in some of the highest use areas for MHI IFKWs being avoided during certain times of the year. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual false killer whales. Because we do not anticipate fitness consequences to individual whales from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of MHI IFKWs from these effects. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of MHI IFKWs in the wild.

11.1.9 Guadalupe Fur Seal

As described further in Section 7.1.1, the best abundance estimate for Guadalupe fur seals is 15,830 animals. Available data indicate the population is currently increasing at a rate of 10.3 percent per year (Carretta et al. 2017c).

Guadalupe fur seals are expected to experience TTS, behavioral response, and physiological stress in the Southern California portion of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 1,457 instances of harassment are reasonably certain to occur from Navy sonar annually in SOCAL. No instances of harassment from explosives are anticipated. Based on the best available information on the exposure of Guadalupe fur seals, and as detailed in Section 9.2.1.2.2, no injury or mortality of this species is reasonably certain to occur from these stressors. As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual Guadalupe fur seals. Because we do not anticipate fitness consequences to individual seals from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of Guadalupe fur seals from these effects. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of Guadalupe fur seals in the wild.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted in the action area for decades. Despite this, the Guadalupe fur seal population in increasing at an annual rate of 10.3 percent. This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives within this species' range (i.e., HSTT; Northwest Training and Testing) for many years. Because these activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future, this suggests Guadalupe fur seals are likely resilient to the impacts incurred from these activities.

11.1.10Hawaiian Monk Seal

As described further in Section 7.1.1, the best abundance estimate for Hawaiian monk seals is 1,324 animals (Carretta et al. 2018c). As detailed in the latest NMFS stock assessment report for this species, the recent observed abundance estimates for this species are encouraging. However, sufficient data area not available at this time to unequivocally conclude whether the rangewide (inclusive of Main and Northwestern Hawaiian Islands) Hawaiian monk seal population is declining, stable, or increasing (Carretta et al. 2018c). The 2016 stock assessment reported an increasing abundance trend for the Main Hawaiian Islands (Carretta et al. 2017c).

Hawaiian monk seals are expected to experience TTS, behavioral response, and physiological stress in the Hawaii portion of the action area from sonar and other transducers. Based on the Navy's modeling, a total of 196 instances of harassment are reasonably certain to occur from Navy sonar annually in Hawaii. A total of ten instances of harassment from explosives are anticipated annually, along with one instance of PTS. Based on the best available information on the exposure of Guadalupe fur seals, and as detailed in Section 9.2.1.2.2, no non-auditory injury or mortality of this species is reasonably certain to occur from these stressors.

As described in greater detail in Section 9.2.1.1.4 and 9.2.1.2.4, we do not anticipate instances of TTS and behavioral harassment to result in fitness consequences to individual Hawaiian monk seals. Because we do not anticipate fitness consequences to individual seals from instances of TTS and behavioral disruption, we also do not anticipate changes in the number, distribution, or reproductive potential of Hawaiian monk seals from these effects.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action. As such, PTS has the potential to effect aspects of the affected animal's life functions that do not overlap in time and space with the proposed action. As discussed previously in Section 9.2.1.2.4, permanent hearing impairment has the potential to affect individual seal survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual animal fitness. Our exposure and response analyses indicate that one Hawaiian monk seal would experience PTS annually, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy's mitigation. Affected Hawaiian monk seals could be less efficient at foraging, but because we anticipate only minor degrees of PTS, we expect affected Hawaiian monk seals will still be able to forage successfully. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of Hawaiian monk seals.

It is noteworthy that Navy training and testing activities similar to those proposed have been conducted around the Hawaiian Islands for decades. Despite this, the Hawaiian monk seal population in the Main Hawaiian Islands (i.e., the core Navy training and testing area that overlaps with this species' range; Figure 10) is showing encouraging signs of increasing abundance (e.g., Carretta et al. 2017c). This is despite extensive Navy training and testing activities occurring using vessels, active sonar, and explosives within this species' range for many years. Because these activities are the same or very similar to those proposed in the action area for the next five years and the reasonably forseeable future, this suggests Hawaiian monk seals may be resilient to any impacts incurred from these activities.

In summary, the impacts expected to occur and affect Hawaiian monk seals in the action area are not anticipated to result in reductions in overall reproduction, abundance, or distribution of the Hawaiian monk seal. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of Hawaiian monk seals in the wild.

11.2 Sea Turtles

The *Species Likely to be Adversely Affected* section described current sea turtle population statuses and the threats to their survival and recovery. The *Environmental Baseline* and *Cumulative Effects* identified past activities and those expected to generally continue into the foreseeable future within the action area that may impact ESA-listed sea turtles. In this section, we assess the likely consequences of the anticipated effects from our effects analysis to the sea turtles that have been exposed, the populations those individuals represent, and the species those populations comprise.

The major anthropogenic stressors that contributed to the sharp decline of sea turtle populations in the past include coastal development, direct harvest, commercial fisheries bycatch, and marine debris. Most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and sea turtles, loss of beach nesting habitats, as well as high bycatch pressure in commercial fisheries worldwide. Harvest of sea turtles has been greatly reduced in some locations, though it still occurs in other parts of the world, including areas in the Pacific Ocean. The North Pacific gyre, which encompasses much of the HSTT action area, is a regional hotspot for marine debris, which presents potentially lethal entanglement hazards and ingestion threats to sea turtles (Schuyler et al. 2016). While sea turtle populations are still at risk, efforts made over the past few decades to reduce the impact of these threats have slowed the rate of decline for many sea turtle populations. Increasing abundance trends have now been reported for several populations (or nesting sites) of ESA-listed sea turtles. Bycatch mitigation measures have reduced the incidental take of sea turtles in many U.S. commercial fisheries. The required use of circle hooks with mackerel-type bait in 2004 for Hawaii longline fishery reduced loggerhead and leatherback sea turtle interaction rates by approximately 80-90 percent (Gilman et al. 2007). TEDs, which are required in federal shrimp trawl fisheries, are estimated to have reduced mortality of sea turtles by approximately 95 percent in some regions (NMFS 2014b). Mitigation measures required in other federal and state fisheries (e.g., gill net, pelagic longline, pound nets) have also resulted in reduced sea turtle interactions and mortality rates (See Section 8.8.1 for details). Increased conservation awareness at the international scale has led to greater global protection of sea turtles. All six ESA-listed sea turtles are listed in CITES Appendix I and many countries now have regulations banning turtle harvest and export. Among the countries that still allow directed take of sea turtles, harvest has decreased by more than 60 percent over the past three decades (Humber et al. 2014). It is likely that some current threats to sea turtles will increase in the future. These include global climate change, marine debris (i.e., plastics), and habitat degradation. It is difficult to predict the magnitude of these threats in the future or their impact on sea turtle populations.

The Navy's proposed activities during the HSTT Phase III Program introduce a variety of stressors into the action area that are expected to result in adverse effects to the following ESA-listed sea turtles: Central North Pacific and East Pacific DPSs of green turtles; hawksbills; leatherbacks; North Pacific DPS of loggerhead; and Mexico's Pacific coast population and all other populations of olive ridley. The primary impacts on sea turtles resulting from the Navy's proposed action are from explosives and vessel strikes. Other potential stressors analyzed, including various acoustic sources (e.g., sonar, pile driving, small airguns, vessel and aircraft noise, and weapons noise), ingestion of expended materials, entanglement, energy stressors, and physical disturbance are not likely to adversely affect sea turtles given the (1) characteristics of these stressors, (2) frequency and expanse of the action area they would be dispersed in, and (3) densities of sea turtles, and likelihood that they would co-occur with Navy activities and encounter them. While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of sea turtles, such as how they use sound to perceive and respond to environmental cues, and how temporary changes to their acoustic soundscape could affect the normal physiology and behavioral ecology of these species.

Vessel strikes and encounters with underwater detonations (explosives) are expected to result in sublethal and lethal adverse effects to sea turtles. Those that are killed by vessel strike and removed from the population would result in decreased reproductive rates, while those that sustain non-lethal injuries could result in fitness consequences during the time it takes to fully recover, or have longer lasting impacts if permanently harmed.

Temporary hearing impairment and significant behavioral disruption from harassment could have similar effects, but given the duration of exposures, these impacts are expected to be short-term and a sea turtle's hearing is expected to return back to normal after some healing duration. There is no evidence that TTS results in energetic effects to individual sea turtles or would be likely to significantly reduce the viability of the population these individuals represent. Given that sea turtles do not rely on acoustic cues for most important life functions, it is anticipated that TTS would not result in fitness consequences to individuals or the populations to which they belong.

Behavioral responses of sea turtles to explosives could include startle reactions, disruption of feeding, disruption of migration, changes in respiration, alteration of swim speed, alteration of swim direction, and area avoidance. Any disruptions are expected to be temporary in nature, with the animal resuming normal behaviors shortly after the exposure. To result in significant fitness consequences, we would have to assume that an individual turtle detects and responds to the acoustic source, and that it could not compensate for lost feeding opportunities by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since foraging habitat would still be available in the environment following the cessation of acoustic exposure. Similarly, we expect temporary disruptions of migration and swim speed or direction to be inconsequential because they can resume these behaviors almost immediately following the cessation of the sound exposure. Further, these sorts of behavioral disruptions may be similar to natural disruptions such those resulting from predator avoidance, or fluctuations in oceanographic conditions. Therefore, behavioral responses of sea turtles to acoustic stressors are unlikely to lead to fitness consequences or have long-term implications for the population.

There is an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, and occur in locations where sea turtles are conducting critical activities at the time of exposure. The explosives associated with the proposed action are also expected to result in PTS and non-auditory injury, which could have fitness impacts on individual sea turtles. However, such effects are only predicted to occur in a very small number of green sea turtles from the Central North Pacific DPS. In addition, the Navy will implement mitigation measures (described in Section 3.4.2) which include several Lookout scenarios with large exclusion zones to minimize the impacts of explosives on sea turtles.

Our conclusions for each ESA-listed sea turtle species in the action area are discussed below.

11.2.1 Green Sea Turtle

The green sea turtle was listed under the ESA on July 28, 1978. On April 6, 2016, NMFS listed eleven DPSs of green sea turtles, including two DPSs listed as threatened that occur within the HSTT action area: Central North Pacific and East Pacific. 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. Directed harvest of eggs and turtles remains a major threat to their recovery. Incidental bycatch in fishing gear, ingestion of marine debris, and the loss of nesting habitat due to sea level rise also represent ongoing threats to green sea turtle populations.

Central North Pacific DPS

Green turtles in the Central North Pacific DPS are found in the Hawaiian Archipelago and Johnston Atoll. In addition to the general threats most sea turtle populations face, Central North Pacific DPS green sea turtles exhibit high rates of fibropapillomatosis disease (See *Environmental Baseline* Section 7.3). Fibropapillomatosis has been shown to result in reduced individual fitness and survival, although documented mortality rates in Hawaii are low. Fibropapillomatosis remains an ongoing threat to this DPS as the distribution, prevalence rate, severity, and environmental co-factors associated with the disease have the capacity to increase over time (Jones et al. 2015).

There are thirteen known nesting sites for the Central North Pacific DPS, with an estimated 3,846 nesting females (Seminoff et al. 2015). The largest nesting site for this DPS is at French Frigate Shoals, Hawaii, which hosts ninety-six percent of the nesting females for the DPS (Seminoff et al. 2015). In recent year the nesting abundance at East Island, French Frigate Shoals has increased by about five percent annually. Information on in-water abundance trends is consistent with the increase in nesting (Seminoff et al. 2015). Since French Frigate Shoals is outside of the action area, important reproductive habitat for the large majority of green sea turtle nesting females and hatchlings in this DPS would not likely be impacted by HSTT activities. Although ongoing threats persist (e.g., bycatch, disease, marine debris, and sea level rise), the increase in annual nesting abundance, continuous scientific monitoring, legal enforcement and conservation programs are all factors that favor the resiliency of the Central North Pacific DPS. A population viability analysis model based on 38 years (1975-2012) of nesting beach monitoring data predicted the following: there is 0 percent probability that this DPS will fall below the trend reference point (50 percent decline) at the end of 100 years; and there is a 0 percent probability that this population will fall below the absolute abundance reference (100 females/yr) at the end of 100 years. This model, based solely on nesting data, assumes all environmental and anthropogenic pressures will remain constant over the next 100 years.

Based on our *Effects Analysis* (Section 9.2.2), we estimate there would be 27 vessel strikes (20 lethal and 7 non-lethal) of Central North Pacific DPS green sea turtles annually under the proposed action. Since some of the turtles killed by vessel strike could be females, the proposed action may also result in a reduction in reproduction of this species. Loss of a sexually mature female will have immediate effects on recruitment while lost reproductive potential from mortality of a juvenile female might not be realized for several years. Chaloupka et al. (2008) reported no gender bias for green turtles stranded in Hawaii from 1982-2003 [exact binomial sex ratio test for P = 0.50 (or 50%), n = 1009, P = 0.71]. Therefore, we assume that 10 out of the estimated 20 lethal vessel strikes per year would be of females.

Based on historical data, green sea turtles that strand in Hawaii due to vessel strike range in carapace size from about 40 to 95 cm straight carapace length (Chaloupka et al. 2008). From Chaloupka et al. (2008), the median size of these stranded turtles was about 60 cm straight carapace length, which corresponds to an estimated age of 15-year-old (Balazs and Chaloupka 2004), and the 75th percentile was about 70 cm straight carapace length. The expected age at maturity for Hawaiian green sea turtles is estimated to range between 35–50 years, and expected size of first-time nesters is at least 80 cm straight carapace length (Balazs and Chaloupka 2004). Since 75 percent of stranded turtles were below 70 cm, we conservatively assume that about 25 percent of the ten females killed by vessel strike would be mature nesting females: i.e., 0.25 * 10 = 2.5, which we round up to three turtles. The remaining seven females killed by vessel strike each year would, therefore, be neritic juveniles or subadults. It is reasonable to assume that, due to natural (e.g., shark predation, disease) and anthropogenic (e.g., bycatch) mortality, not all of the juvenile and subadult turtles killed by vessel strike would have otherwise survived to the age of maturity. Annual survivorship of juvenile and subadult green sea turtles as reported in the literature typically ranges from about 0.85 to 0.90 (Seminoff et al. 2015). Conservatively assuming a 90 percent annual survivorship and a 20 year period to reach maturity (i.e., from 15 to 35 years old), we estimate that about 12 percent (i.e., 0.9^{20}) of juvenile and subadult turtles killed by vessel strike would have otherwise survived to the age of maturity. Applying the 12 percent survival rate to the estimated seven neritic juvenile/subadult females (0.12 * 7), yields (after rounding) one female that would have survived to maturity had it not been killed by a vessel strike. Adding this to the estimated three mature nesting females killed by vessel strike, we get a total of four nesting females (three current and one future) removed annually from the population as a result of vessel strike. This represents an annual loss of 0.1 percent of the estimated 3,846 nesting females (Seminoff et al. 2015) for the Central North Pacific DPS. We do not consider this to be an appreciable reduction in the numbers of female green sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. The anticipated loss of current and future reproductive potential is relatively small compared and would have a negligible effect on the recent increasing trend in nesting abundance reported for this DPS. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of this population of Central North Pacific DPS green sea turtles, we do not expect this level of mortality to impact the survival or recovery of this population.

Up to seven Central North Pacific DPS green sea turtles are also expected to experience sub-lethal effects from a vessel strike as a result of the proposed action. As discussed above for lethal strikes, most of these would be juveniles or subadults and about half would be females. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect the level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population.

From our *Effects Analysis* (Section 9.2.2), we also anticipate Central North Pacific DPS green sea turtles would experience behavioral responses, TTS, PTS and non-auditory injuries from exposure to explosives used during HSTT activities. Based on the Navy's quantitative model, we expect an annual average of seven exposures resulting in PTS, 20 resulting in TTS, one resulting in non-auditory injury, and 1,831 resulting in a short-term behavioral response. We anticipate that some individual green sea turtles could be exposed to explosives from the proposed action on multiple occasions within a given year or over their lifetime.

Although PTS and non-auditory injury could result in fitness impacts on individual sea turtles, such effects are only predicted to occur in a very small number (seven PTS and one non-auditory injury per year) of green sea turtles from the Central North Pacific DPS. We have no information to indicate that PTS results in an appreciable reduction in the survival or reproductive potential of individual sea turtles, and given the small number affected it is unlikely to have an appreciable impact at the population level for this DPS. As discussed previously, we have no information to suggest that TTS in sea turtles would result in fitness consequences to individuals or the populations to which they belong. Similarly, although a relatively large proportion of the adult green sea turtle population in Hawaii could experience a behavioral response from explosives, such responses are expected to be short-term, and are not anticipated to result in reduced fitness of individual turtles. In addition, since a very small proportion of nests occur in the action area (Frey et al. 2013; Kittinger et al. 2013), behavioral responses to explosives are not expected to appreciably impact green sea turtle reproductive behavior or nesting success. The effects of all other potential stressors (i.e., acoustic, energy, physical disturbance, entanglement, and ingestion) on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

The impacts expected to occur and affect Central North Pacific DPS green sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of Central North Pacific DPS green sea turtles in the wild.

Green Sea Turtle Eastern Pacific DPS

Green turtles in the East Pacific DPS are found from the California/Oregon border south to central Chile. The largest nesting site is at Colola, Mexico, which hosts fifty-eight percent of the nesting females for the DPS (Seminoff et al. 2015). The observed increases in nesting abundance at Colola, a stable trend at Galápagos, and record high numbers at sites in Costa Rica suggest that the population is resilient to future perturbations.

Within the action area, Eastern Pacific DPS green sea turtles primarily occur within San Diego Bay. Most turtles are year-round residents within the southern portion of San Diego Bay, although some individual turtles have been documented as leaving the bay for the open ocean. Based on monitoring surveys and strandings data, green sea turtle densities within the remainder of the SOCAL Range Complex are thought to be very low. As such, we find that the likelihood of an Eastern Pacific DPS turtle being exposed to explosives at levels resulting in adverse effects is so low as to be discountable. Our vessel strike analysis estimated there would be up to two vessel strikes (one lethal and one non-lethal) of Eastern Pacific DPS sea turtles annually under the proposed action. Since some of the turtles killed by vessel strike could be females, the proposed action may also result in a reduction in reproduction of this species. Loss of a sexually mature female would have immediate effects on recruitment while lost reproductive potential from mortality of a juvenile female might not be realized for several years. The effects of all other potential stressors on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

There are thirty-nine nesting sites for the East Pacific DPS, with an estimated 20,062 nesting females (Seminoff et al. 2015). The loss of one female green turtle in a given year due to vessel strike would reduce the reproductive potential of the Pacific population by about 0.005 percent (note: this is a conservatively high annual rate of potential reproductive loss since not all those killed would be females). We do not consider this to be an appreciable reduction in the numbers of female green sea turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of this population of green sea turtles, we do not expect this level of mortality to impact the survival or recovery of this population. Up to one green sea turtle is also expected to experience sub-lethal effects from a vessel strike as a result of the proposed action. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect this level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population.

The impacts expected to occur and affect Eastern Pacific DPS green sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of Eastern Pacific DPS green sea turtles in the wild.

11.2.2 Hawksbill Sea Turtle

The hawksbill 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 historical decline of hawksbill sea turtles is primarily attributed to centuries of exploitation for the species' ornate shell (Parsons 1972). The continuing demand for the hawksbills shells, as well as other products derived from the species, represents an ongoing threat to its recovery. Due to their preference to feed on sponges associated with coral reefs, hawksbill sea turtles are particularly sensitive to losses of coral reef communities. Threats from other manmade and natural sources remain, including poaching, incidental capture in commercial and artisanal fisheries, climate change, and coastal development.

From our *Effects Analysis* (Section 9.2.2) we estimated 21 hawksbill sea turtle exposures annually to explosives at levels that could result in short-term behavioral harassment effects. We anticipate that some individual sea turtles could be exposed to explosives from the proposed action more than once within a given year or over their lifetime. As discussed previously, behavioral responses from explosives are not anticipated to result in reduced fitness of individual turtles. It is unlikely (i.e., discountable) that any hawksbills would be exposed to explosives at levels resulting in hearing impairment (PTS or TTS), non-auditory injury or mortality. Based on our analysis, we also estimated there would be up to two vessel strikes (one lethal and one non-lethal) of hawksbill sea turtles annually under the proposed action. Since some of the hawksbills killed by vessel strike could be females, the proposed action may also result in a reduction in reproduction of this species. Loss of a sexually mature female will have immediate effects on recruitment while lost reproductive potential from mortality of a juvenile female might not be realized for several years. The effects of all other potential stressors on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

Based on surveys conducted at 88 nesting sites worldwide, approximately 25,500 female hawksbills nest annually (NMFS and USFWS 2013a). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where a greater proportion of the nesting sites are declining. However, the Pacific population still has the largest overall abundance of the three ocean basin populations. Major hawksbill nesting rookeries in the Pacific Ocean are located far from the action area in Australia, Indonesia, and Papua New Guinea (NMFS and USFWS 2013a). A very small number of hawksbills nest in Hawaii (less than 20 females per season).

An average of between 11,000 and 12,700 hawksbill nests are estimated to occur each year in the Pacific. On average hawksbill turtles nest every two or three years, and lay 4.5 nests each year (USFWS 2012). Conservatively assuming that most turtles nest every two years and assuming the lower estimate of the number of nests annually, this equates to a likely total population size of approximately 4,889 females (if we assume the turtles nest every 3 years, the total population size is approximately 9,778 females). The loss of one female hawksbill in a given year due to vessel strike would reduce the reproductive potential of the Pacific population by about 0.01 percent (note: this is a conservatively high annual rate of reproductive potential reduction since not all those killed would be females). We do not consider this to be an appreciable reduction in the numbers of female hawksbill turtles or the reproductive rate of the population, either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of this population of hawksbill sea turtles, we do not expect this level of mortality to impact the survival or recovery of this population. Up to one hawksbill is also expected to experience sub-lethal effects from a vessel strike as a result of the proposed action. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect this level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population. On average, we anticipate 21 hawksbills would also likely experience behavioral harassment each year, but the effects on individual sea turtles would be minor, short-term and are not expected to result in fitness consequences.

The impacts expected to occur and affect hawksbill sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of hawksbill sea turtles in the wild.

11.2.3 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.

From our *Effects Analysis* (Section 9.2.2) we estimated 193 leatherback sea turtle exposures annually to explosives at levels that could result in short-term behavioral harassment effects. We anticipate that some individual sea turtles could be exposed to explosives from the proposed action more than once within a given year or over their lifetime. As discussed previously, behavioral responses from explosives are not anticipated to result in reduced fitness of individual turtles. It is unlikely (i.e., discountable) that any leatherbacks would be exposed to explosives at levels resulting in hearing impairment (PTS or TTS), non-auditory injury or mortality. The effects of all other potential stressors analyzed in this opinion on leatherbacks were found to be either discountable or insignificant.

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 HSTT action area. Western Pacific leatherbacks nest in the Indo-Pacific, primarily in Indonesia, Papua New Guinea and the Solomon Islands. The current overall estimate for Papua Barat, Indonesia, Papua New Guinea, and Solomon Islands is 5,000 to 10,000 nests per year (Nel et al. 2013). Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Western Pacific leatherbacks have declined more than 80 percent since the 1980’s (Tapilatu et al. 2013). There are no known leatherback nesting beaches within the action area. Leatherbacks migrate from nesting beaches across the Pacific past Hawaii to feeding areas off the U.S. Pacific coast.

In summary, we anticipate a very 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 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 reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of leatherback sea turtles in the wild.

11.2.4 Loggerhead Sea Turtle – North Pacific DPS

The loggerhead sea turtle was first listed as threatened under the ESA in 1978. On September 22, 2011, the NMFS designated nine DPSs of loggerhead sea turtles, including the North Pacific

DPS, which was listed as endangered. Overall, Gilman (2009) estimated that the number of loggerheads nesting in the Pacific has declined by eighty percent in the past twenty years. Neritic juveniles and adults in this DPS are at risk of mortality from coastal fisheries in Japan and Baja California, Mexico. Habitat degradation in the form of coastal development and armoring pose an ongoing threat to nesting females.

From our *Effects Analysis* (Section 9.2.2) we estimated 182 loggerhead sea turtle exposures annually to explosives at levels that could result in short-term behavioral harassment effects. We anticipate that some individual sea turtles could be exposed to explosives from the proposed action more than once within a given year or over their lifetime. As discussed previously, behavioral responses from explosives are not anticipated to result in reduced fitness of individual turtles. It is unlikely (i.e., discountable) that any loggerheads would be exposed to explosives at levels resulting in hearing impairment (PTS or TTS), non-auditory injury or mortality. The effects of all other potential stressors analyzed in this opinion on loggerheads were found to be either discountable or insignificant.

The North Pacific Ocean DPS has a nesting population of about 2,300 nesting females (Matsuzawa 2011). Loggerhead abundance on foraging grounds off the Pacific Coast of the Baja California Peninsula, Mexico, was estimated to be 43,226 individuals (Seminoff et al. 2014). We anticipate a very small number of individual loggerheads, relative to the population size, would be affected by the proposed action. In addition, 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 or reduced fitness of individual loggerhead sea turtles.

The impacts expected to occur and affect North Pacific DPS loggerhead sea turtles in the action area are not anticipated to result in reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of North Pacific DPS loggerhead sea turtle in the wild.

11.2.5 Olive Ridley Sea Turtle

The olive ridley was listed under the ESA on July 28, 1978. The species was separated into two listing designations: endangered for breeding populations on the Pacific coast of Mexico, and threatened wherever found except where listed as endangered (i.e., in all other areas throughout its range).

From our *Effects Analysis* (Section 9.2.2) we estimated 96 olive ridley sea turtle (from both ESA-listed populations combined) exposures annually to explosives at levels that could result in short-term behavioral harassment effects. We anticipate that some individual sea turtles could be exposed to explosives from the proposed action more than once within a given year or over their lifetime. As discussed previously, behavioral responses from explosives are not anticipated to result in reduced fitness of individual turtles. It is unlikely (i.e., discountable) that any olive ridleys would be exposed to explosives at levels resulting in hearing impairment (PTS or TTS), non-auditory injury or mortality. Based on our analysis, we also estimated there would be up to two vessel strikes (one lethal and one non-lethal) of olive ridley sea turtles (from both ESA-listed populations combined) annually under the proposed action. Since some of the olive ridleys killed by vessel strike could be females, the proposed action may also result in a reduction in reproduction of this species. Loss of a sexually mature female will have immediate effects on recruitment while lost reproductive potential from mortality of a juvenile female might not be realized for several years. The effects of all other potential stressors on sea turtles analyzed in this opinion were found to be either discountable or insignificant.

Mexico's Pacific Coast Breeding Population

In the first half of the twentieth century, there was an estimated ten million olive ridleys nesting on the Pacific coast of Mexico. Olive ridleys became targeted in a fishery in Mexico and Ecuador, which severely depleted the population. By 1969 there was an estimated one million olive ridleys. Ongoing threats to this population include incidental capture in fisheries, exposure to pollutants and climate change. Despite severe population declines, the olive ridley breeding populations on the Pacific coast of Mexico appear to be resilient, as evidenced by the increasing population. There are six primary arribada nesting beaches in Mexico, the largest being La Escobilla, with an increasing abundance trend and an estimated one million nesting females annually (NMFS and USFWS 2014). At-sea estimates of olive ridleys off of Mexico and Central America also support an increasing population trend. The loss of one female olive ridley in a given year due to vessel strike would have no appreciable impact on the numbers of females or the reproductive potential of the Mexico Pacific breeding population (i.e., one out of one million), either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of this population, we do not expect this level of mortality to impact the survival or recovery of this population. Up to one olive ridley is also expected to experience sub-lethal effects from a vessel strike as a result of the proposed action. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect this level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population. On average, we anticipate 96 individuals from this population would also likely experience behavioral harassment each year. This conservatively assumes all olive ridley exposed to explosives would be from the Mexico Pacific breeding population. This still represents a very small proportion of the total population, and the effects on individual sea turtles would be minor, short-term and are not expected to result in fitness consequences.

The impacts expected to occur and affect olive ridley Mexico Pacific breeding population sea turtles in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of the olive ridley Mexico Pacific breeding population sea turtle in the wild.

All Other Breeding Populations

The olive ridley is thought to be the most abundant sea turtle in the world. There is no global estimate of olive ridley abundance, and we rely on nest counts and nesting females to estimate abundance in each of the ocean basins, described below. However, Eguchi et al. (2007) estimated a weighted average of the yearly abundance estimates as 1.39 million (confidence interval: 1.15 to 1.62 million). Despite large declines in recent decades, the species' large population size allows some resilience to future perturbation.

As with the Mexico Pacific breeding population, the loss of one female olive ridley per year throughout the remainder of its range would have no appreciable impact on the numbers of females or the reproductive potential of the population, either on an annual basis or continuing into the reasonably foreseeable future. Because we do not expect this level of mortality to result in an appreciable reduction in the numbers or reproductive rate of this population, we do not expect this level of mortality to impact the survival or recovery of this population. Up to one olive ridley is also expected to experience sub-lethal effects from a vessel strike as a result of the proposed action. Injury from a vessel strike may result in temporary reduced fitness until the injury heals or potentially have longer term consequences for serious injuries. Nonetheless, we do not expect this level of injured sea turtles to result in an appreciable reduction in the reproductive rate of this population. On average, we anticipate 96 individuals from this population would also likely experience behavioral harassment each year. This conservatively assumes all olive ridley exposed to explosives would be from breeding populations other than the Mexico Pacific population. This still represents a very small proportion of the total population and the effects on individual sea turtles would be minor, short-term and are not expected to result in fitness consequences.

The impacts expected to occur and affect olive ridley sea turtles (from all breeding population other than Mexico) in the action area are not anticipated to result in appreciable reductions in overall reproduction, abundance, or distribution of this species. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of the olive ridley sea turtle from all breeding populations (other than Mexico's) in the wild.

11.3 Fishes

All of the anticipated adverse impacts to ESA-listed fishes in the action area resulting from the Navy's proposed action are from explosives. Other stimuli described in this biological opinion are not likely to adversely affect fishes given the characteristics of these stressors, frequency and expanse of the action area they would be dispersed in, the distribution and lifestage of fishes, and likelihood of co-occurrence with Navy activities in the action area.

While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the abundance and behavior of fishes when exposed to explosives. Fish that are killed and removed from the population would decrease reproductive rates, and those that sustain non-lethal injuries could have fitness consequences during the time it takes to fully recover, or have long lasting impacts if permanently harmed and could also decrease reproduction rates. Temporary hearing impairment and significant behavioral disruption could have similar effects, but these impacts are expected to be temporary and a fish's hearing is expected to return back to normal after some healing duration. While this may have an energetic cost to the individual for the time it takes to heal, we do not anticipate fitness consequences to an individual fish from temporary hearing loss over the long-term. Fish could have a diminished ability to detect threats in their environment, or have temporary reduction in foraging efforts or other life functions while they recover. This would be intensified if sustained periods of harassment or multiple exposures occurred. These periods of behavioral responses that may result in avoiding or leaving the immediate area during Navy activities. This could cause individuals to expend more energy seeking suitable habitat elsewhere, having the potential to result in reduced growth rates, older age to maturity, and lower lifetime fecundity. However, because Navy activities are episodic and temporary, we would not expect the most severe effects to be realized at a magnitude that would reduce an individual's fitness from temporary behavioral responses. Therefore, these temporary effects are expected to exert significantly less adverse effects on any individual than severe injuries and permanent non-lethal injuries.

In this, section we assess the likely consequences of these effects to the fishes that have been exposed, the populations those individuals represent, and the species those populations comprise. The *Species and Critical Habitat Likely to be Adversely Affected* section described current ESA-listed fish population statuses and the threats to their survival and recovery.

11.3.1 Steelhead – Southern California DPS

As described in Section 7.1.1, Southern California DPS steelhead persist in very low numbers in their historical range, inclusive of the Southern California portion of the action area. The most recent monitoring data available for the Southern California steelhead DPS is from watersheds north of the HSTT action area (i.e., Santa Ynez River, Ventura River, Santa Clara River, Topanga Creek, Malibu Creek). Surveys indicated that very small (less than 10 fish), but consistent, runs of the species occur on an annual basis (Ford 2011). Of the streams that drain into the action area, only one has been documented in recent years to contain steelhead (i.e., San Mateo Creek). A combination of persistent anthropogenic threats, mostly in freshwater spawning and rearing habitats and including fish passage barriers, continue to hinder this species' recovery.

Despite this population's anticipated low abundance in the action area, we determined that a small number of individual Southern California DPS steelhead are likely to be exposed to and adversely affected by Navy explosive use. We determined that outmigrating smolts or returning adults could be exposed to these stressors when travelling through the action area. Information is not available to estimate the likely number of individual Southern California DPS steelhead that are likely to be killed, injured, experience TTS, or behavioral disruption from these activities. However, as discussed further in Section 9.2.3.3, only a very small percentage of individuals from this population are anticipated to be exposed to and affected by this stressor. Most of this species' life history is spent outside of the action area either in freshwater habitats or in northern latitude offshore areas where individuals will not be exposed to Navy explosives. Because Navy explosive use is intermittent with effects that do not span a large area (e.g., most explosives used in the action area have a range to mortality of less than 200 m), we anticipate that most steelhead migrating through the action area would not co-occur with explosive stressors within the range to adverse effects described earlier in this opinion.

Although the population of Southern California DPS steelhead is low, the loss of a small percentage of this population spread across a number of years is not expected to appreciably decrease the reproductive potential of this DPS. Since no spawning or freshwater rearing habitat will be affected by the Navy's proposed activities, impacts on spawning survival and survival from egg to juvenile are not expected. In addition, it is presumed adult salmon not harmed or killed could continue to spawn in future years and produce juveniles to replace any individuals lost during Navy activities. Therefore, the abundance, distribution, and reproduction of Southern California DPS steelhead is not likely to be appreciably reduced by Navy training and testing activities in the action area. Therefore, we do not anticipate the Navy's activities to reduce appreciably the likelihood of survival or recovery of Southern California DPS steelhead in the wild.

11.3.2 Scalloped Hammerhead Shark – Eastern Pacific DPS

As described in Section 7.1.1, though overall abundance data for the Eastern Pacific DPS scalloped hammerhead shark is lacking, populations appear to be on the decline, most notably due to both legal and illegal capture in fisheries south of the action area (78 FR 20717).

Despite this population's anticipated low abundance in the action area (See discussion in Section 9.2.3.3), we determined that a small number of individual Eastern Pacific DPS scalloped hammerhead sharks are likely to be exposed to and adversely affected by Navy explosive use. If individual sharks were within close enough proximity to a blast they could suffer mortality, injury, or short term behavioral disruptions. Information is not available to estimate the likely number of individual Eastern Pacific DPS scalloped hammerhead sharks that are likely to be killed, injured, or experience behavioral disruption from explosives due to lack of information on location and abundance of this species in the action area during Navy training and testing activities. However, as discussed further in Section 9.2.3.3, only a very small percentage of individuals from this population are anticipated to be exposed to and affected by explosives. The SOCAL Range Complex is at the northern extent of this species' range and very few individuals have been documented occurring in southern California waters. Most scalloped hammerheads from the Eastern Pacific DPS likely do not occur in southern California waters during any portion of their life history. It is presumed any adult scalloped hammerheads not harmed or killed could continue to reproduce in future years and produce juveniles to replace any individuals lost during Navy activities. Moreover, due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the Navy ranges where these sharks may occur, individual sharks are unlikely to be exposed multiple times within a short period of time. Any behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time. However, these temporary effects are not expected to be persistent, and would return to normal shortly after the explosives exposure. We do not anticipate behavioral disruptions will have fitness consequences to affected individuals.

In summary, based on the best available information, the loss of a small percentage of this population spread across a number of years is not expected to appreciably decrease the reproductive potential of this DPS. Therefore, the abundance, distribution, and reproduction of Eastern Pacific DPS scalloped hammerhead sharks is not likely to be appreciably reduced by Navy training and testing activities in the action area. Therefore, we do not anticipate the Navy's activities to reduce appreciably the likelihood of the survival or recovery of Eastern Pacific DPS scalloped hammerhead sharks in the wild.

11.3.3 Oceanic Whitetip Shark

As documented in Section 7.1.1, though global population abundance for this species is unavailable, best available scientific and commercial data indicate this species has undergone significant historical declines throughout its range. For example, the Final Rule to list this species as threatened presented data indicating oceanic whitetip comprised 20 percent of the total shark catch in the tropical tuna purse seine fishery in the early 2000s, but from 2005 to 2009, the proportion of scalloped hammerhead sharks was less than 2 percent (83 FR 4153). The Final Rule lists continued fishing pressure and associated mortality as the greatest threat to the recovery of this species.

Despite this population's anticipated low abundance in the action area (See discussion in Section 9.2.3.3), we determined that a small number of individual oceanic whitetip sharks are likely to be exposed to and adversely affected by Navy explosive use in both the Southern California and Hawaii portions of the action area. Most oceanic whitetip sharks in the Pacific Ocean likely do not occur at any time within the action area and would not be susceptible to Navy explosive use. If individual sharks were within close enough proximity to a blast they could suffer mortality, injury, or short term behavioral disruptions. Information is not available to estimate the likely number of individual oceanic whitetip sharks that are likely to be killed, injured, or experience behavioral disruption from these activities due to lack of information on location and abundance of this species in the action area during Navy training and testing activities. However, as discussed further in Section 9.2.3.3, only a very small percentage of individuals from this population are anticipated to be exposed to and affected by these stressors. Any adult oceanic whitetip sharks not harmed or killed could continue to reproduce in future years and produce juveniles to replace any individuals lost during Navy activities. Moreover, due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the Navy ranges where these sharks may occur, individual sharks are unlikely to be exposed multiple times within a short period of time. Any behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time. However, these temporary effects are not expected to be persistent, and would return to normal shortly after the explosives exposure. We do not anticipate behavioral disruptions will have fitness consequences to affected individuals.

In summary, based on the best available information, the loss of a small percentage of this population spread across a number of years is not expected to appreciably decrease the reproductive potential of this species. Therefore, the abundance, distribution, and reproduction of oceanic whitetip sharks is not likely to be appreciably reduced by Navy training and testing activities in the action area. Therefore, we do not anticipate the Navy's activities to reduce appreciably the likelihood of the survival or recovery of oceanic whitetip sharks in the wild.

11.3.4 Giant Manta Ray

We determined that a small number of individual giant manta rays are likely to be exposed to and adversely affected by Navy explosive use. If individual giant manta rays were within close enough proximity to a blast, they could suffer mortality, injury, or short term behavioral disruptions. As described in Section 9.2.3.3, information is not available to estimate the number of giant manta rays that are likely to be injured or killed from explosives due to the lack of density or abundance information on these species in the action area. However, we anticipate a very small percentage of the Pacific Ocean population to be exposed and adversely affected. Giant manta rays are thought to be rare in southern California waters where the higher percentage of explosives are used. Additionally, the Navy will not conduct activities using explosives in the only location within the action area where this species is known to congregate (i.e., within the HRC along the Kona coast of Hawaii Island). Additionally, Navy explosive use is dispersed throughout the very large action area, infrequent, and lasts for a short period of time. This information suggests instances where giant manta rays are exposed and adversely affected by explosives would be very rare.

Any adult giant manta rays not harmed or killed could continue to reproduce in future years and produce juveniles to replace any individuals lost during Navy activities. Moreover, due to spatial extent of the action area, and infrequent occurrence and short duration of explosives used throughout the Navy ranges where these rays may occur, individual rays are unlikely to be exposed multiple times within a short period of time. Any behavioral or stress responses may have an energetic cost to the individual for the time it takes to recover, and therefore a reduced ability to detect threats in their environment, or carry out other important life functions during that time. However, these temporary effects are not expected to be persistent, and would return to normal shortly after the explosives exposure. We do not anticipate behavioral disruptions will have fitness consequences to affected individuals.

In summary, based on the best available information, the loss of a small percentage of this population spread across a number of years is not expected to appreciably decrease the reproductive potential of this species. Therefore, the abundance, distribution, and reproduction of giant manta rays is not likely to be appreciably reduced by Navy training and testing activities in the action area. Therefore, we do not anticipate the Navy's activities to reduce appreciably the likelihood of the survival or recovery of giant manta rays in the wild.

11.4 Designated Critical Habitat

As described in Section 9.3.1, the effects of the action on the physical and biological features of black abalone critical habitat are discountable. Therefore, Navy training and testing activities in the action area are unlikely to diminish the value of critical habitat for the conservation of black abalone and the proposed action is not likely to destroy or adversely modify the critical habitat that has been designated for the species. In Section 9.3.2, we determined that the effects of the action on the physical and biological features of Hawaiian monk seal critical habitat are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated). For this reason, Navy training and testing activities in the action area are unlikely to diminish the value of critical habitat for the conservation of Hawaiian monk seals and the proposed action is not likely to destroy or adversely modify the critical habitat that has been designated for the species.

As described in Section 7.2.7, designated critical habitat for MHI IFKWs includes waters from the 45 m depth contour to the 3,200 m depth contour around the Main Hawaiian Islands. Parts of the designation are excluded for national security or economic reasons. The final rule to designate critical habitat identified one PBF, with four characteristics. The final rule also identified several activities that may threaten the PBF such that special management considerations or protections may be required. Major categories of activities included, but were not limited to, in-water construction (including dredging), energy development (including renewable energy projects), and some military readiness activities. Note that, as described in Section 3.4.2, the Navy proposes to implement a variety of conservation measures aimed at minimizing impacts to marine mammals and certain habitat areas from the military readiness activities that are the subject of this consultation.

In Section 9.3.3, we determined that the effects of vessel noise, physical disturbance and strike, and explosives on the PBF for MHI IFKW designated critical habitat were either insignificant or discountable. We determined that sonar and other transducers will result in some impacts to the PBF, specifically to the ability of IFKWs to use or occupy designated critical habitat. The discussion below evaluates whether sound levels resulting in impacts to MHI IFKW use or occupancy would be introduced into the critical habitat such that the effects of the action will appreciably diminish the value of critical habitat for the conservation of MHI IFKW. When evaluating whether sonar has appreciably decreased the value of critical habitat for conservation, we consider timing, frequency, and duration of the sound and its resulting impacts on the population, as well as the spatial extent of impacts when they occur, relative to the area designated as critical habitat.

We anticipate that sound from Navy sonar would be introduced into MHI IFKW designated critical habitat infrequently at levels would result in impacts to IFKW habitat use or occupancy (i.e., average of 0.43 disruptions per animal annually in critical habitat). Additionally, we do not anticipate this species will experience long duration or repeat exposures within a short period of time in designated critical habitat due to the following: 1) the large area of habitat available to and utilized by the animals (NMFS 2018a), 2) the relatively small area that will be affected by sonar at any given period of time, (3) that most Navy activities resulting in in significant disruptions of habitat use last less than one day, and (4) that long duration (i.e., more than one day) 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), largely outside of designated critical habitat. This decreases the likelihood that IFKWs and Navy activities will co-occur for extended periods of time or repetitively over the duration of an activity (or subsequent activities) while within critical habitat. Based on the available literature that indicates infrequent exposures resulting in behavioral disruptions are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015a; NAS 2017; New et al. 2014; Southall et al. 2007f; Villegas-Amtmann et al. 2015), we do not expect this level of exposure to impact the fitness of exposed animals. As described previously, we use our analysis of individual animal response to Navy sonar use to indicate whether behavioral disturbances could impair use or occupancy of the habitat at a population level. Based on the preceding analysis considering effects to individual animals, we do not anticipate Navy sonar use would impair use of occupancy of the habitat at a population level. Consideration of behavioral response to individual animals as well as the population are important to our understanding of whether there will be disruptions of use or occupancy of the area, and if so whether the disruptions will dimish the value of habitat for conservation of the species in a meaningful way.

Additionally, based on best available information regarding exposure of IFKWs and other marine mammal species to Navy sonar (e.g., Baird et al. 2017; e.g., Baird et al. 2016; Falcone and Schorr 2014; Falcone et al. 2009b; Tyack et al. 2011), these short term disruptions of behavior are not anticipated to lead to long duration (e.g., more than one day) abandonment or avoidance of any particular area within critical habitat, or of critical habitat as a whole. When sonar exposure does occur in portions of critical habitat, only a small portion of the habitat area will be affected and the vast majority of critical habitat would remain available to the animals for undisrupted use and occupancy. Sounds from sonar used by the Navy are transient, and do not persist in the marine environment at times when the sonar source is not being operated. Even with decades of Navy sonar use within areas of recently designated critical habitat, as well as monitoring of IFKWs use of these habitats, we do not have information to suggest that these animals exhibit long duration avoidance of particular areas of critical habitat, or critical habitat as a whole, due to sonar use.

As described above, evidence of individual responses to noise created by Navy sonar and other transducers within or affecting critical habitat, as well as consideration of the temporal and spatial extent of impacts, indicates that, while sound from sonar and other transducers may impact the value of critical habitat for conservation of the species, it is unlikely that the population's use or occupancy of critical habitat would be impaired to an extent that the conservation value of the critical habitat would be appreciably diminished. Scenarios where Navy sonar and other transducer use within the action area are likely to result in changes to the animal's use or occupancy of MHI IFKW critical habitat are anticipated to be sporadic and temporary. The Navy has been conducting training and testing activities in the HRC and within recently designated critical habitat for decades. Despite this, monitoring (e.g., Baird et al. 2014b; Baird et al. 2017a; Baird et al. 2013b) indicates that IFKWs continue to utilize these habitats. Further, for the duration of the Phase III MMPA rule and into the reasonably foreseeable future, the Navy proposed geographic mitigation for several areas in the HRC (see Section 3.4.2.2.2), much of which is encompassed by MHI IFKW designated critical habitat. These areas include some of the habitats most frequently used by MHI IFKWs in the Main Hawaiian Islands (Figure 74). This will minimize exposure of designated critical habitat and MHI IFKWs within critical habitat to sonar that could result in impairment of the use or occupancy of the habitat. For these reasons, while we have determined that MHI IFKW's use of designated critical habitat is likely to be disrupted intermittently at varying locations both annually and into the reasonably foreseeable future, we do not anticipate that either individuals or the population would avoid or abandon use of the habitat for important biological functions. As a result, introduction of noise by Navy sonar is unlikely to appreciably diminish the value of critical habitat for the conservation of MHI IFKWs.

12 Conclusion

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the blue whale, fin whale, Western North Pacific DPS gray whale, Mexico DPS humpback whale, Central America DPS humpback whale, sei whale, sperm whale, MHI IFKW, Guadalupe fur seal, Hawaiian monk seal, green sea turtle – Central North Pacific DPS. green sea turtle – East Pacific DPS; olive ridley sea turtle – Mexico's Pacific coast population, olive ridley sea turtle – all other populations, hawksbill sea turtle, leatherback sea turtle, loggerhead sea turtle – North Pacific DPS, Southern California DPS steelhead, Eastern Pacific DPS scalloped hammerhead shark, oceanic whitetip shark, and giant manta ray. It is also NMFS' biological opinion that the proposed action is not likely to result in destruction or adverse modification of designated critical habitat for black abalone, Hawaiian monk seals, or MHI IFKWs.

13 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. In the case of threatened species, section 4(d) of the ESA leaves it to the Secretary's discretion whether and to what extent to extend the statutory 9(a) ''take'' prohibitions, and directs the agency to issue regulations it considers necessary and advisable for the conservation of the species. At the time of this consultation, take prohibitions have not been extended to the threatened oceanic whitetip shark or giant manta ray. However, consistent with *CBD v. Salazar*, 695 F.3d 893 (9th Cir. 2012), we assessed the amount or extent of take to these threatened species that is anticipated incidental to Navy training and testing activities and include this information in the ITS. Inclusion of these species in the ITS serves to assist the action agency with monitoring of take and provides a trigger for reinitiation if levels of estimated take are exceeded.

"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. NMFS had not yet defined "harass" under the ESA in regulation, but has 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." We considered NMFS' interim definition of harassment in evaluating whether the proposed activities are likely to result in harassment of ESA-listed species. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from Section 9 liability for prohibited take, and identifying reasonable and prudent measures that will minimize the impact of anticipated incidental take.

Further, 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 become effective only upon the issuance of MMPA authorization to take the marine mammals identified here. Absent such authorization, this ITS is inoperative for ESA-listed marine mammals.

13.1 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 actions. Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take.

The following tables list the anticipated take from training and testing activities by species and the interrelated and interdependent actions of issuance of a five-year regulation and LOAs by NMFS' Permits Division to authorize take of marine mammals pursuant to the MMPA.

Table 101. The number of lethal and non-lethal takes of threatened and endangered marine mammals and sea turtles likely to occur annually as a result of the proposed Navy training and testing activities in the action area.

ESA-Listed Species	Impulsive and Non-Impulsive Acoustic Stressors				Vessel Strike*	
	Harassment (TTS / Behavioral)	Harm (PTS)	Harm (Slight Lung Injury)	Mortality	Mortality	Harm(non-lethal injuries)
Marine Mammals						
Blue Whale	1,229 / 806	1	-	-	1	-
Fin Whale	1,417 / 856	1	-	-	2	-
Gray Whale – Western North Pacific DPS	4 / 2	-	-	-	-	-
Humpback Whale – Mexico DPS	920 / 198	1	-	-	1	-
Humpback Whale – Central America DPS	594 / 282	-	-	-	-	-
Sei Whale	173 / 73	0	-	-	-	-
Sperm Whale	86 / 4,903	0	-	-	1	-
False Killer Whale – Main Hawaiian Islands Insular DPS	17 / 572	0	-	-	-	-
Guadalupe Fur Seal	15 / 1,442	0	-	-	-	-
Hawaiian Monk Seal	62 / 143	1	-	-	-	-
Sea Turtles						
Green Sea Turtle – Central North Pacific DPS	20 / 1,831	7	1	-	100	34
Green Sea Turtle – Eastern Pacific DPS	-	-	-	-	3	1
Hawksbill Sea Turtle	0 / 21	-	-	-	4	2
Olive Ridley Sea Turtle	0 / 96	-	-	-	2	1
Loggerhead Sea Turtle – North Pacific DPS	0 / 182	-	-	-	-	-
Leatherback Sea Turtle	0 / 193	-	-	-	-	-

**The numbers presented for marine mammals and sea turtles for vessel strike represent total exempted over a five-year period. For marine mammals, as described in Section 9.2.1.4, a total of three large whale vessel strikes are anticipated over the five year period of the MMPA rule (from December 2018 to December 2023) and each subsequent five year period into the reasonably foreseeable future. During each five year period, up to one blue whale, one humpback whale – Mexico DPS, and one sperm whale vessel strike is exempted and up to two fin whale vessel strikes are exempted. The total number of vessel strikes exempted of these species combined is three during each five year period.*

When it is not possible or practicable to specify the amount or extent of take, a surrogate may be used if we: describe the causal link between the surrogate and take of the listed species, explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and set a clear standard for determining when the level of anticipated take has been exceeded. 50 C.F.R. 402.14(g)(7). As described previously in Section 9.2.3, due to the lack of available density and abundance information in the action area for ESA-listed fishes, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take (i.e., in the form of mortality, injury, TTS, and behavioral disruption) of ESA-listed fish species (Southern California DPS steelhead, Eastern Pacific DPS scalloped hammerhead shark, oceanic whitetip shark, giant manta ray) or to monitor take-related impacts in terms of individuals of these species. Therefore, the surrogate for the incidental take of ESA-listed fishes is the distance to reach effects in the water column that correlates with injury and sub-injury from explosives in those areas occupied by fishes (See Section 9.2.3.1).

Activity Levels as Indicators of Take for Marine Mammals, Sea Turtles, and Fishes

As discussed in this opinion, the estimated take of ESA-listed sea turtles and marine mammals from acoustic stressors is based on Navy modeling, which represents the best available means of numerically quantifying take. As the level of modeled sonar or explosive use increases, the level of take is likely to increase as well. For non-lethal take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of HSTT 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 sonar or 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 Incidental Take Statement that requires the Navy to report to NMFS any exceedance of activity 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. Exceedance of an activity level will require the Navy to reinitiate consultation.

The estimated take of ESA-listed sea turtles from ship strike is based on available strandings information and the relative proportion of all vessel activity (e.g., commercial fishing vessels, non-fishing commercial vessels, recreational boats, cargo ships, ferries, cruise ships, and military vessels) within different portions of the action area attributed to Navy vessel activity. Feasible monitoring techniques for detecting and calculating actual sea turtle take (either lethal or nonlethal) from either civilian or Navy ship strike do not exist. It should be noted that the ratio of Navy vessels in the action area is significantly less than civilian vessels and boats. Furthermore, even if minor changes to Navy vessel quantities occur, the corresponding overall vessel activity levels remain relatively the same for the foreseeable future based on scheduling needs, deployment cycles, and other logistic considerations (e.g., fuel allocation, personnel availability, etc.). As described in the preceding paragraph, the Navy already reports annual sonar and explosive use to NMFS as a surrogate for authorized annual take as well as an indicator for overall Navy activity levels including vessel movements. Therefore, we can equate annual reporting of Navy activities (sonar, explosives) as a reasonable metric to evaluate if sea turtle ship strike has likely been exceeded. If annual Navy use of sonar and explosives fall below those levels considered in this opinion, then we can reasonably assume Navy vessel activity was also within the same level as analyzed and that sea turtle ship strike risk has not changed.

For ESA-listed fish species, it is not possible, nor would it be an accurate representation of potential effects, to express the amount of anticipated take of ESA-listed fish species or to monitor take-related impacts in terms of individuals of these species due to the lack of data on fish abundance in the action area. As the level of Navy explosive use increases, the level of take of ESA-listed fishes is likely to increase as well. Feasible monitoring techniques for detecting and calculating actual take of ESA-listed fishes at the scale of HSTT 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 activity levels, 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 Incidental Take Statement that requires the Navy to report to NMFS any exceedance of explosive activity use specified in the preceding opinion 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 will require the Navy to reinitiate consultation.

13.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence or recovery of any ESA-listed species or result in the destruction or adverse modification of designated critical habitat.

13.3 Reasonable and Prudent Measures

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, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures 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.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 C.F.R. 402.14 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and minimize the impact of that take on ESA-listed species. The reasonable and prudent measures are nondiscretionary, and must be undertaken by the Navy and NMFS' Permits Division so that they become binding conditions for the exemption in section 7(o)(2) to apply.

NMFS has determined the following reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take of threatened and endangered species during the proposed action:

1. The Navy and NMFS Permits Division shall minimize effects to ESA-listed marine mammals, sea turtles, and fishes from the use of active sonar, explosives, and vessels 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, sea turtles, and fishes from the use of sonar and other transducers, explosives, and vessels during training and testing activities. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOA.

13.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Navy and NMFS Permits Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the Navy or NMFS Permits Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

1) The following terms and conditions implement reasonable and prudent measure 1:

   a) The Navy shall implement all mitigation measures as specified in the final MMPA rule and LOA, and as described in this opinion in Section 3.4.

   b) NMFS Permits Division shall ensure that all mitigation measures as prescribed in the final rule and LOA, and as described in Section 3.4 of this opinion are implemented by the U.S. 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 may include reviewing the feasibility of potential new measures to increase mitigation effectiveness (e.g., thermal detection of protected species).

2) The following terms and conditions implement reasonable and prudent measure 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 active sonar hours and in-water 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 five year period of the MMPA regulations and LOAs.

b) 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 five-year period of the MMPA regulations and LOAs.

c) The Navy and NMFS Permits Division 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.

d) In the event that Navy personnel (uniformed military, civilian, or contractors while conducting Navy work) discover a live or dead stranded marine mammal or sea turtle within the action area or on Navy property, the Navy shall report the incident to NMFS immediately or as soon as operational security considerations allow.

e) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(d) suggest investigation of the associated of 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 sound sources and 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 (7) business days after the request.

14 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).

1. The Navy should assess the future practicability of expanding the mitigation areas in the HRC to encompass more areas identified as high use areas for MHI IFKWs. The Navy should consider the information presented in Baird et al. (2015a) and more recent data that refines our understanding of the areas of high use.
2. The Navy should monitor and provide annual reports to NMFS ESA Interagency Cooperation Division on the total hours and counts of active sonar and in-water explosives used in MHI IFKW designated critical habitat to inform future consultations regarding the nature and extent of Navy training and testing in this area.
3. The Navy should consider investing in research that aims to identify the physical and biological features of MHI IFKW high use areas and how these features differ from low use areas.
4. The Navy should continue the development of autonomous marine mammal detection technologies to reduce the risk of vessel strike.
5. 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.
6. The Navy should implement measures to better understand the effectiveness of mitigation proposed by the Navy during sonar and explosive use for minimizing impacts to ESA-listed species.
7. The Navy should continue to invest in the improvement of medium and longer term tagging technology and assist researchers in trying to use telemetry data and on/off range sonar information to determine the behavioral responses of animals to exposures to Navy sonar during actual training and testing activities.
8. The Navy should continue to conduct behavioral response studies aimed at obtaining response data that is more consistent with the received sound levels, distances, and durations of exposure that animals are likely to receive incidental to actual training and testing activities.
9. The Navy should coordinate with NMFS' regional science centers or other entities on availability of data on abundance and distribution of ESA-listed fish in the action area in order to incorporate into density models in the future.
10. The Navy should implement measures to further minimize the marine debris generated during training and testing.

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 and NMFS Permits Division should notify the ESA

Interagency Cooperation Division of any conservation recommendations they implement in their final action.

15 Reinitiation Notice

This concludes formal consultation on the Navy's proposed Phase III HSTT activities and NMFS' promulgation of regulations and issuance of incidental take authorizations pursuant to the MMPA. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking 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 ESA-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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