National Marine Fisheries Service
Endangered Species Act
Section 7 Biological Opinion

Title:	Reinitiation of the Biological Opinion on (1) U.S. Navy Training Activities in the Gulf of Alaska Temporary Maritime Activities Area (TMAA) and Western Maneuver Area (WMA); and (2) the National Marine Fisheries Service's Promulgation of Regulations and Issuance of a Letter of Authorization Pursuant to the Marine Mammal Protection Act for the U.S. Navy to "Take" Marine Mammals Incidental to TMAA and WMA Activities from December 2022 through December 2029
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1 INTRODUCTION

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed) or designated critical habitat that may be affected by the proposed action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.13(c)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitat, in accordance with the ESA Subsection 7(b)(3)(A), NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS), which exempts take incidental to an otherwise lawful action, and specifies the impact of any incidental taking, including necessary or appropriate reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures; and, in the case of the incidental take of marine mammals, specifies those measures that are necessary to comply with Section 101(a)(5) of the Marine Mammal Protection Act of 1972. 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 Federal action agencies for this consultation are the United States Navy (Navy) and NMFS's Permits and Conservation Division (Permits Division). The Navy proposes to conduct training activities in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) and Western Maneuver Area (WMA), collectively referred to as the GOA action area. 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 activities in the GOA action area. The regulations propose the issuance of a Letter of Authorization (LOA) that will authorize the Navy to "take" marine mammals incidental to its proposed action, pursuant to the requirements of the MMPA.

This consultation was completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. As a result, the 2019 regulations are once again in effect, and we are applying the 2019 regulations here. This consultation and biological opinion were initiated when the 2019 regulations were still in effect but completed after the July 5, 2022 order vacating them. For purposes of this consultation, we considered whether the substantive analysis and conclusions articulated in the biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

This biological opinion (opinion) and ITS were prepared by the NMFS Office of Protected Resources ESA Interagency Cooperation Division (hereafter referred to as "we" or "us"). This opinion reflects the best available scientific information on the status and life history of ESA-listed species, the stressors resulting from the proposed action, the likely effects of those stressors on ESA-listed species and their habitats, the consequences of those effects to the fitness and survival of individuals, and the risk that those consequences pose to the survival and recovery of the threatened or endangered populations they represent.

This document represents NMFS' opinion on the effects of the proposed GOA military training activities on endangered and threatened species and designated critical habitat, as well as the Permits Division's promulgation of regulations pursuant to the MMPA for the Navy to "take" marine mammals incidental to GOA training activities. These include: blue whale (*Balaenoptera musculus);* fin whale (*B. physalus*); gray whale (*Eschrichtius robustus*); humpback whale (*Megaptera novaeangliae*) – Mexico and Western North Pacific Distinct Population Segments (DPSs) and; North Pacific right whale (*Eubalaena japonica*); sei whale (*B. borealis*); sperm whale (*Physeter microcephalus*); Steller sea lion (*Eumetopias jubatus*) – Western DPS; leatherback sea turtle (*Dermochelys coriacea*); Chinook salmon (*Oncorhyncus tshawytscha*) – nine Evolutionary Significant Units (ESU); chum salmon (*O. keta*) – Columbia River and Hood Canal summer-run ESUs; coho salmon (*O. kisutch*) – four ESUs, sockeye salmon (*O. nerka*) – Ozette Lake and Snake River ESUs; steelhead (*O. mykiss*) – 11 DPSs, green sturgeon (*Acipenser medirostris*) – Southern DPS; and the designated critical habitats for humpback whale – Mexico and Western North Pacific DPSs.

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

1.1 Background

The Navy proposes to continue training activities within the GOA action area starting in December 2022 and continuing into the reasonably foreseeable future. These activities are hereafter referred to as "Phase III" activities. Navy training activities have been ongoing in this 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., in consultations that considered Phase I and Phase II Navy actions).

The activities considered in these prior consultations were similar to those proposed for GOA Phase III that are the subject of this consultation, and included the use of active sonar, explosives, and vessels. Where incidental take of ESA-listed marine mammals was anticipated, these prior 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 previous opinions concluded that the Navy's 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 the NMFS Permits Division regarding this consultation is summarized below:

- On September 11, 2020, the Navy provided us with the GOA Draft SEIS/OEIS V3 for review. NMFS provided comments to the Navy on this version.
- On September 14, 2020, the Navy provided us with an ESA section 7 consultation timeline (referred to by the Navy as a "stick chart") for the proposed action.
- On October 9, 2020, the NMFS Permit's Division received a complete application package from the Navy for the promulgation of regulations and an LOA for the incidental take of marine mammals due to Navy training activities in the GOA.
- From November 2020 through August 2021, we met with the Navy every two to three weeks to discuss and review the available data and proposed approach for analyzing the acoustic effects of Navy explosives on ESA-listed fish.
- On February 1, 2021, the Navy provided us with a draft GOA BA for section 7 consultation. NMFS provided comments to the Navy on this version on February 11, 2021.
- On March 1, 2021, we held a conference call with the Navy to discuss any unresolved issues related to the BA.
- On April 1, 2021 the Navy provided us with a revised GOA BA and requested reinitiation of formal section 7 consultation, and conference, for training activities in the GOA TMAA. The Navy letter indicated that the following reinitiation triggers were met: 1) new information on species hearing criteria, sound propagation in the model, densities, species presence, distribution, and provides the updated analysis resulting from these

improvements; 2) new acoustic exposures resulting from the changes (updates) to the platforms and systems used as part of the same activities; and 3) newly proposed humpback whale critical habitat not previously analyzed.

- On April 22, 2021, we sent an email to the Navy stating that we accepted the Navy's GOA BA in support of ESA section 7 consultation as complete. Since the Navy's proposed action is interrelated with the Permits Division’s proposed issuance of regulations in accordance with the MMPA, we indicated that we could not initiate formal section 7 consultation until we received and accepted as complete the Permits Division's initiation package, including the proposed rule.

- On May 27, 2021, we held a meeting with Protected Resources Division staff from the NMFS West Coast Regional Office and Alaska Regional Office to discuss Southern Resident killer whale determinations for section 7 consultations on actions in Alaska.

- On September 15, 2021, we sent the Navy a draft of the GOA Phase III biological opinion for their review.

- On November 17, 2021 the Navy briefed us on proposed changes to the GOA Training study area. The Navy proposed expansion of the study area from the current (42,146 nm^2) to include the WMA encompassing 185,806 nm^2. Limited activities are proposed for the WMA with no active sonar or explosives. The Navy also proposed to implement a new geographic mitigation area on the continental shelf and slope of the TMAA for no use of explosives during training below 10,000 feet altitude (including at the water surface).

- On December 10, 2021, the Navy provided us with their comments and edits on the draft biological opinion.

- On February 2, 2022, the Navy submitted to the NMFS Permits Division an updated application that described the addition of a WMA and the replacement of the Portlock Bank Mitigation Area with the larger Continental Shelf and Slope Mitigation Area (See Section 4.6.2).

- On March 3, 2022, the Navy sent us an addendum to their GOA Phase III BA, in the form of a Memo for the Record (dated March 2, 2022), which analyzed the effects to ESA-listed species from: 1) the addition of the Navy’s Continental Shelf and Slope Mitigation Area within the TMAA, and 2) the addition of the WMA and associated training activities in that region.

- On March 24, 2022, the Navy notified us that the GOA Final Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement

(OEIS) Version 2 was available for review. We reviewed the document but did not have any comments or follow up questions.

- On June 1, 2022, we sent the Navy the following revised draft sections of the biological opinion: Introduction (including Consultation History); Action Area; and Description of the Proposed Action. These represent the sections with the biggest changes since the previous version as a result of the Navy's March 2, 2022 addendum to their GOA Phase III BA.

- On June 15, 2022, the Navy responded to us with their comments on the revised draft sections of the biological opinion, including several updated figures and tables.

- On September 9, 2022 we received a Navy GOA Phase III consultation initiation package from the Permits Division, including the proposed rule for issuance of regulations in accordance with the MMPA.

- On September 9, 2022 we determined that the Permits Division initiation package was sufficient to initiate formal consultation. On September 12, 2022 we notified the Navy and the Permits Division that we were initiating formal ESA section 7 consultation.

2 THE ASSESSMENT FRAMEWORK

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

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

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

This ESA section 7 consultation involves the following steps:

Action Area (Section 3): We describe the action area with the spatial extent of the stressors from the action.

Description of the Proposed Action (Section 4): We describe the proposed action and those aspects (or stressors) of the proposed action that may have effects on the physical, chemical, and biotic environment. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

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

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

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

Effects of the Action (Section 8): We evaluate the effects of the action on ESA-listed species and designated critical habitat. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action.

During our evaluation, we determined that some stressors were not likely to adversely affect ESA-listed species (or categories of ESA-listed species; e.g., cetaceans, fishes; Section 8.1) and did not carry them forward for further evaluation. The stressors that we determined were likely to adversely affect ESA-listed species or critical habitats were carried forward for additional analyses (Section 8.2). For those stressors likely to adversely affect ESA-listed species (Section 8.2), we identify the number, age (or life stage), and gender if possible, of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong to the extent possible based on available data. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analysis.

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

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

Conclusion (Section 11): We state our conclusions regarding whether the action is likely to jeopardize the continued existence of ESA-listed species or result in the destruction or adverse modification of designated critical habitat. If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (see 50 C.F.R. §402.14(h)(2)).

Incidental Take Statement (Section 0): An Incidental Take Statement is included for those actions for which take of ESA-listed species is reasonably certain to occur in keeping with the revisions to the regulations specific to ITSs (80 FR 26832, May 11, 2015; ITS rule). The ITS specifies the impact of the take, necessary or appropriate 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)). The ITS must also include measures to ensure the action is carried out in compliance with any incidental take authorization provided under the MMPA, Section 101(a)(5). Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation (50 C.F.R. §222.102) to include acts that actually kill or injure wildlife and acts that may cause significant habitat modification or degradation that actually kill or injure fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. NMFS has not defined "harass" under the ESA in regulation. However, on December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering" (NMFS 2016b). For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed species.

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

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

2.1 Evidence Available for this Consultation

To conduct the analyses necessary for this opinion and to comply with our obligation to use the best scientific and commercial data available, we considered all lines of evidence available through published and unpublished sources. We conducted electronic literature searches throughout this consultation, including within the NMFS Office of Protected Resources' electronic library.

This opinion is based on information provided by the Navy during pre-consultation technical assistance and other supplemental information provided throughout the consultation process. We examined the Navy GOA Phase III Final Biological Assessment (Navy 2021), Navy Memo for the Record titled ESA Consultation Addendum Covering Changes in the GOA Proposed Action and Action Area (Navy 2022c), Final GOA Navy Training Activities SEIS/OEIS (Navy 2022a), Gulf of Alaska Navy Training Activities Supplement to the 2020 Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (Navy 2022b), literature cited in these documents, and other supplemental information provided throughout the consultation process. 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 activities occurring in the same geographic area. In addition, we engaged regularly with the Navy to discuss new science and technical issues as part of the ongoing adaptive management program for Navy training and incorporated new information obtained as a result of these engagements in this consultation.

This opinion also considers information provided by NMFS' Permits Division, including its request for section 7 consultation under the ESA, which included the proposed Federal regulations under the MMPA to authorize the incidental take of marine mammals, including ESA-listed marine mammals, specific to the proposed activities (80 FR 31737) and related draft letters of authorization.

Also considered were NMFS draft or final recovery plans and status reviews for the endangered or threatened species considered in this document, and publications that we identified, gathered, and examined from the public scientific literature, including new information that has become available since the issuance of the previous biological opinions mentioned above. These searches were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species, including both their survival and recovery, and the value of designated (or proposed) critical habitat for the conservation of ESA-listed species.

Collectively, we consider the foregoing to comprise the best scientific information available for the consultation and this biological opinion.

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

The sections below discuss NMFS' approach to analyzing the effects of sound produced by Navy training activities in the GOA TMAA on ESA-listed marine mammals, sea turtles, and fishes. No active sonar or explosives are proposed within the WMA. Acoustic stressors within the WMA would be limited to weapons noise, vessel noise, and aircraft noise. The estimates of the number of ESA-listed marine mammals exposed to sound from Navy training, as well as the magnitude of effects from these exposures (e.g., injury, hearing loss, behavioral response), are from the

Navy's acoustic effects analysis described in detail in the technical report Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training (Navy 2018c). 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] Our analysis of the effects of and potential consequences of such exposures is included in Section 0 of this opinion.

2.2 Acoustic Effects Analysis for Marine Mammals

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

A summary of the quantitative analysis is provided below. A more detailed explanation of this analysis can be found in the Navy's technical report Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training (Navy 2018c). NMFS verified the methodology and data used by the Navy in this analysis and, unless otherwise specified in Section 0 of this opinion, accepted the Navy's quantitative analysis on exposure of marine mammals 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 to acoustic stressors from the proposed action. NMFS also finds that the estimates of take resulting from this analysis are reasonably certain to occur. In addition to marine mammals, NAEMO has also been used by the Navy to quantitatively estimate impacts to sea turtles in other Navy operating areas. However, a quantitative analysis of sea turtle impacts based on NAEMO was not conducted for the Navy's activities in the GOA due to the very rare occurrence of ESA-listed sea turtles (i.e., leatherbacks) in the action area. See Section 6.1.4 for a discussion of leatherback sea turtle occurrence in the action area and our effects determination for this species.

[1] The Navy's acoustic effects analysis did not estimate the number of ESA-listed fish exposed to GOA TMAA acoustic stressors.

2.2.1 Navy Acoustic Effects Model (NAEMO)

NAEMO calculates sound energy propagation from sonars and other transducers (as well as airguns and explosives) during naval activities and the sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals distributed in the area around the modeled naval activity. Each of the animat dosimeters records its individual sound "dose." The model bases the distribution of animats over the action area on the density values (see Section 2.2.3 below) in the U.S. Navy Marine Species Density Database Phase III for the Gulf of Alaska Temporary Maritime Activities Area (DON 2020), and distributes animats in the water column proportional to the known time that species spend at varying depths.

Physical environment data plays an important role in acoustic propagation of underwater sound sources used in the impact modeling process (Navy 2021). Physical environment parameters that influence propagation modeling include bathymetry, seafloor composition/sediment type, wind speed, and sound speed profiles. NAEMO accounts for environmental variability in sound propagation with both distance and depth, as well as boundary interactions, when computing the received sound level of the animats. The model conducts a statistical analysis based on multiple model runs to compute the potential acoustic effects on animals. The number of animats for which the thresholds of effects is exceeded is tallied to estimate the number of times marine mammals could be affected by the aspects of the proposed activity that generate sound.

Marine mammal data input to the NAEMO include densities (discussed above), group size, depth distribution, and (for mammals) stock breakouts (Navy 2021). Because many marine mammals are known to travel and feed in groups, species-specific group sizes are incorporated into animat distributions. Species specific group sizes are estimated using literature review, survey data, and density data, and uncertainty of group size estimates are statistically represented by the standard deviation. The model accounts for depth distributions by changing each animat's depth during the simulation process according to the typical depth pattern observed for each species**.** Depth distribution information was collected by a literature review and is presented as a percentage of time the animal typically spends within various depth bins in the water column. Many marine mammals species are divided into multiple stocks based on life history and genetic stock structure for management purposes. For some stocks there is enough survey information to support stock-specific density models. In these cases, a density layer for the stock is provided and is modeled independently of other stocks. In other cases, predicted impacts were assigned by stock, as opposed to the species as a whole(Navy 2021).

The model estimates the impacts caused by individual training 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 may be exposed to sound levels resulting in an effect. Therefore, the model estimates the annual number of exposures that may result in each type of effect but does not estimate the number of individual marine mammals that may be affected

(Navy 2018c). Some individuals may be exposed more than once per year but the model does not estimate whether a single individual is exposed multiple times.

As described further in Section 4.6.1, the Navy proposes to implement a series of procedural mitigation measures designed to minimize or avoid potentially injurious impacts on marine mammals and sea turtles. The Navy implements mitigation measures during training activities when a marine mammal or sea turtle is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to injury for sonar sources and much of the range to injury for explosives. The Navy designed the mitigation zones for most acoustic and explosive stressors according to its source bins. Sonars and other transducers are grouped 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.

NAEMO does not take into account mitigation measures or animal avoidance behavior when predicting impacts to marine mammals from acoustic stressors. Therefore, to account for the potential for mitigation measures to minimize potential impacts on marine mammals, the Navy quantifies the potential for mitigation to reduce model-estimated permanent threshold shift (PTS) to temporary threshold shift (TTS) for exposures to sonar and other transducers. Mitigation effectiveness is quantitatively assessed on a per-scenario basis using four factors: species sightability, observation area, visibility, and positive control of the sound source. Sightability of each species that may be present in the mitigation zone is determined by species-specific characteristics and the viewing platform. Observation area refers to 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. Positive control of the sound source is based on the ability to shut down the source in a timely manner to mitigate impacts. Considering these factors, only a portion of injurious exposures are considered mitigable. 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. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species in the vicinity of animals sighted at the ocean surface within the mitigation zone.

Although Navy impact analyses typically consider the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives, the Navy Acoustic Effects Model estimated zero mortality impacts for all marine mammal species in the TMAA. Therefore, mitigation for explosives is discussed qualitatively but was not factored into the quantitative analysis for marine mammals.

The Navy estimated the ability of Navy Lookouts to observe the range to PTS for each training event. Lookouts are personnel who are trained to implement the Navy's mitigation requirements by visually observing for marine mammals, sea turtles, as well as additional biological resources, such as birds, fish, jellyfish aggregations, or floating vegetation, depending on the activity and operating area. 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, and Cuvier's beaked whales and Blainville's beaked whales were occasionally observed breaching (Navy 2019; Navy 2021). These behaviors are visible from a great distance and likely increase sighting distances and detections of these species. Environmental conditions under which the training activity could take place are also considered, such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

To consider the benefits of procedural mitigation to marine mammals within the ESA impact estimates, the Navy conservatively factors mitigation effectiveness into its quantitative analysis process. The Navy's quantitative analysis assumes Lookouts will not be 100 percent effective at detecting all individual marine mammals within the mitigation zones for each activity. This is due to the inherent limitations of observing marine species and because the likelihood of sighting individual animals is largely dependent on observation conditions (e.g., time of day, sea state, mitigation zone size, observation platform) and animal behavior (e.g., the amount of time an animal spends at the surface of the water). This is particularly true for small marine mammals and marine mammals that display cryptic behaviors (e.g., surfacing to breathe with only a small portion of their body visible from the surface). Discussions about the likelihood that a Lookout would observe a marine mammal pertain specifically to animals that are available to be observed (i.e., on, above, or just below the water's surface).

A recent study by Oedekoven and Thomas (2022) was designed to evaluate the effectiveness of Navy Lookouts at detecting marine mammals before they entered a defined set of mitigation ranges (i.e., 200, 500, and 1,000 yards) during mid-frequency active sonar training activities. This study also compared lookout effectiveness with that of trained marine mammal observers (MMOs). Results of this study indicate that Navy Lookouts have approximately an 80 percent chance of failing to detect a pod of large baleen whales (rorquals) before they come closer than a mitigation range of 200 yards. The probability of a pod remaining undetected was greater for larger mitigation zones (i.e., 85 percent at 500 yards; 91 percent at 1,000). Oedekoven and Thomas (2022) also reported that trained MMOs (which consisted of two dedicated observers) performed considerably better than Navy Lookouts in detecting pods of large baleen whales (e.g., 49 percent chance of failing to detect a pod at 200 yards).

The Navy's quantitative analysis accounts for and quantifies the potential for animals to actively avoid potentially injurious sound sources. Marine mammals often avoid loud sound sources (e.g., those that could be injurious). Because marine mammals 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 swimming away to avoid repeated high-level sound exposures. Based on nominal marine mammal and sea turtle swim speeds (i.e., 3 knots) and normal operating parameters for Navy vessels (i.e., 10–15 knots), it was determined that an animal can easily avoid PTS zones within the timeframe it takes an active sound source to generate one to two pings from a moving vessel-based source (Navy 2018c). Animals present beyond the range to onset PTS for the first three to four pings are assumed to avoid any additional exposures at levels that could cause PTS. This equates to approximately 5 percent of the total pings or 5 percent of the overall time active. Therefore, based on the Navy quantitative approach to assessing acoustic impacts, 95 percent of marine mammals predicted to experience PTS due to sonar and other transducers are instead assumed to experience TTS (Navy 2018c).

A more detailed description of this process is provided in the Navy's technical report Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training (Navy 2018c).

2.2.2 Criteria and Thresholds to Predict Impacts to Marine Mammals

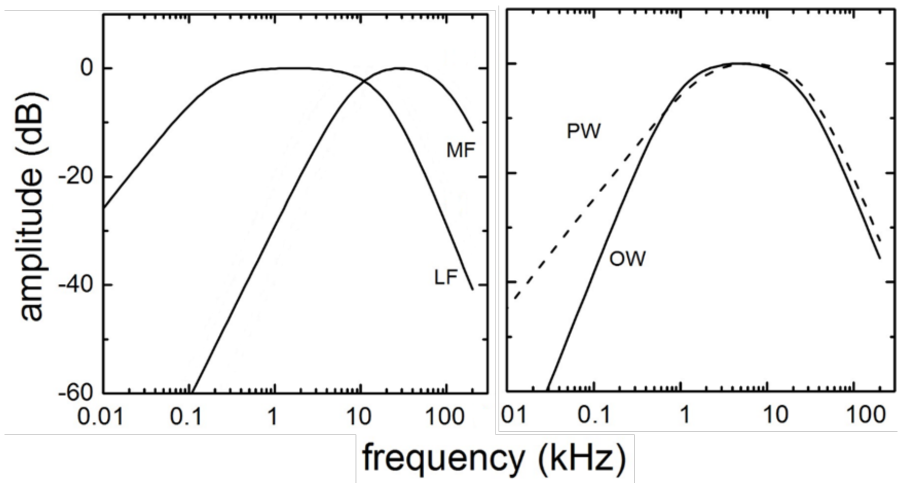
The Navy's quantitative acoustic effects analysis for marine mammals relies on information about the numerical sound and energy values that are likely to elicit certain types of physiological and behavioral reactions. The following section describes the specific criteria developed and applied for each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

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

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

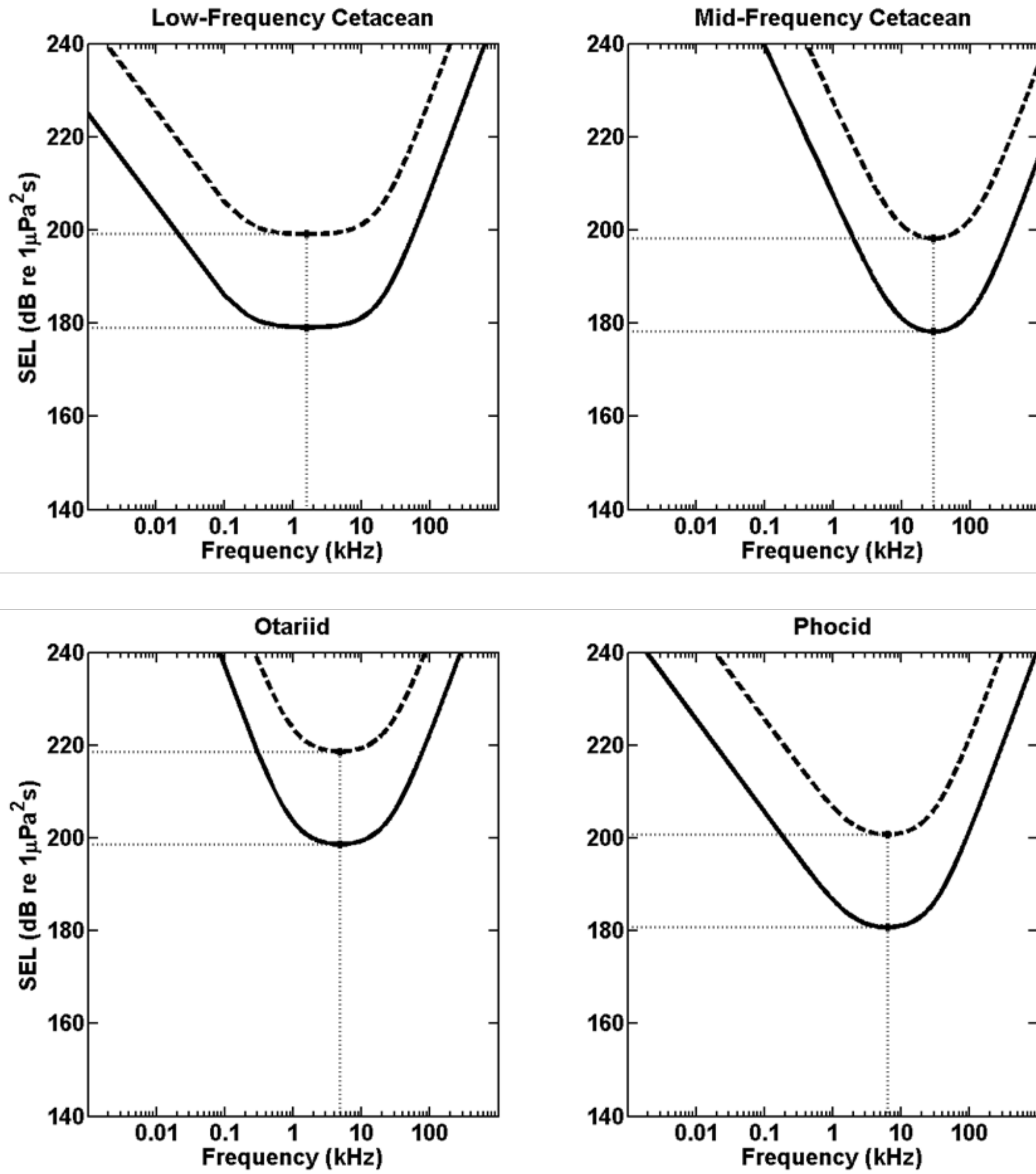
The marine mammal criteria and thresholds for non-impulsive and impulsive sources for hearing impairment, non-auditory injury, and mortality, as applicable, are described below. The Navy's quantitative acoustic effects analysis used dual criteria to assess auditory injury (i.e., PTS) to different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources: impulsive (explosives) and non-impulsive (sonar and other transducers). The criteria used in the analysis are described in NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2018b). The Technical Guidance also identifies criteria to predict TTS.

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



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

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



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 sound exposure level (SEL) threshold for TTS and PTS onset in the frequency range of best hearing. ESA-listed phocids are not present in the action area.

Figure 2. TTS and PTS exposure functions for sonar and other acoustic sources for marine mammals (Navy 2021).

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).

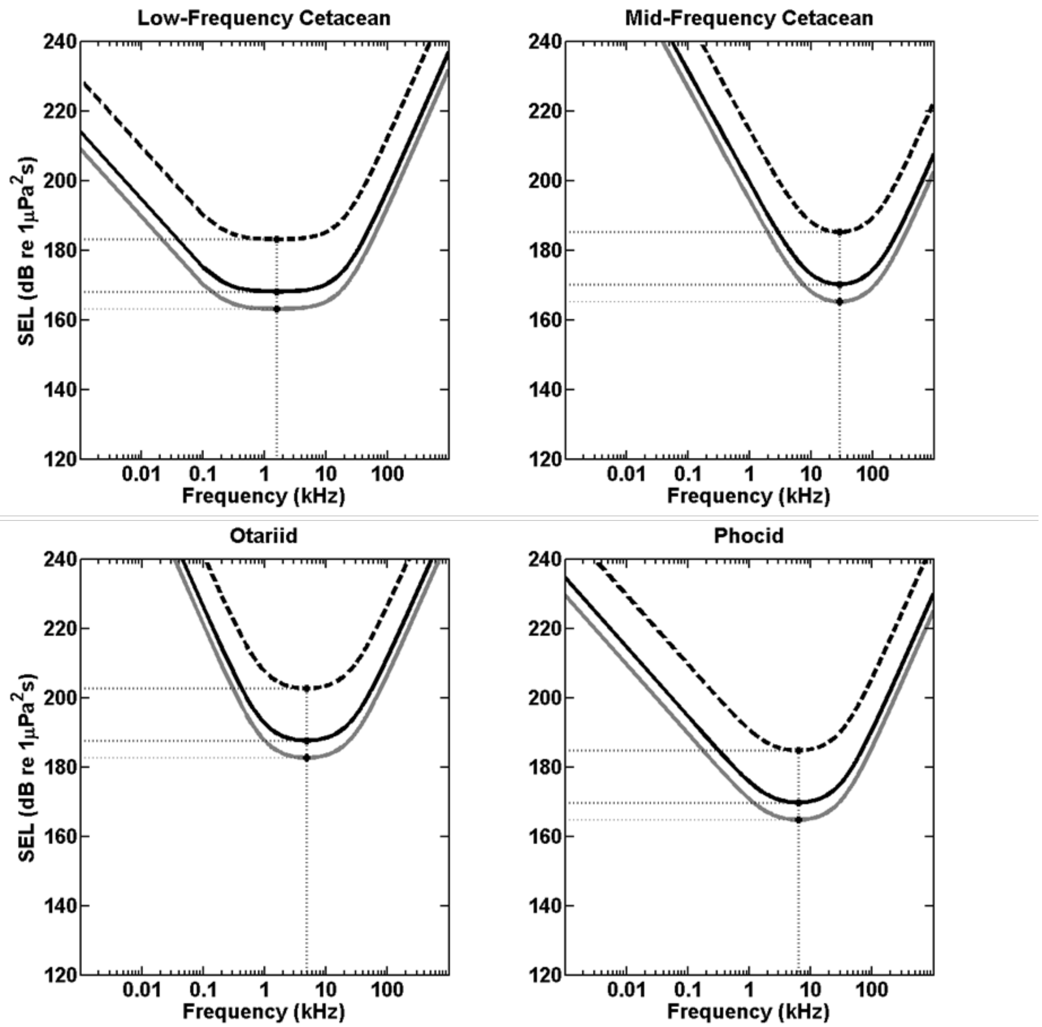
Functional Hearing Group	**TTS Threshold (SEL**cum **[weighted])**	**PTS Threshold (SEL**cum **[weighted])**
Low-Frequency Cetaceans	179	199
Mid-Frequency Cetaceans	178	198
Otariid Pinnipeds (Underwater)	199	219

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

The TTS and PTS exposure functions for marine mammals from non-impulsive sound sources are presented in Figure 2 above. Based on the exposure functions above, the marine mammal thresholds for non-impulsive acoustic sources are summarized in Table 1 above.

For impulsive sources (inclusive of explosives, airguns, and impact pile driving), the behavioral response (multiple detonations), TTS and PTS exposure functions for marine mammals are presented in Figure 3. Based on the exposure functions in Figure 3, the thresholds for onset of TTS and PTS for marine mammals from explosive are shown in Table 2 by functional hearing group.

In addition to TTS and PTS, Navy explosives also have the potential to result in non-auditory injury or mortality. Two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the “crack” or “stinging” sensation of a blast wave, compared to the “thump” associated with received impulse. Two sets of thresholds were used in the non-auditory injury assessment. The exposure thresholds were used to estimate the number of animals that may be affected during Navy training activities. The thresholds for the farthest range to effects are based on the received level at which one percent risk is predicted and are useful for informing mitigation zones (see third column of Table 3). Increasing animal mass (size) and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). The masses used for impact assessment assume marine mammal populations are 70 percent adult and 30 percent calf/pup. The derivation of these injury criteria and the species mass estimates are provided in the Navy’s technical report Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III; (Navy 2017a).



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

Figure 3. Behavioral, TTS, and PTS exposure functions for explosives (Navy 2021).

Table 2. Onset of TTS and PTS in marine mammals for explosives by functional hearing group.

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

Cumulative Sound Exposure Level (SELcum) thresholds in dB re 1 μPa2s (decibels referenced to 1 micropascal).

Table 3. Criteria to quantitatively assess marine mammal mortality and non-auditory injury due to underwater explosions.

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

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

2.2.2.2 Marine Mammal Criteria for Behavioral Response

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

Sonar – Marine Mammals

For Phase III activities, the Navy coordinated with NMFS scientists 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. (2007) severity scale. Low severity responses are those behavioral responses that fall within an animal’s range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Low severity responses include an orientation or startle response, change in respiration, change in heart rate, and change in group spacing or synchrony.

Moderate severity responses could become significant if sustained over a 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. Based on effects analyses conducted for previous Navy consultations, many of the behavioral responses estimated using the Navy’s quantitative analysis would likely be of moderate severity (defined for the purposes of this impact analysis as reaction levels four, five, and six based on the behavioral response severity scale described in Southall et al. 2007). What constitutes a long-duration response is different for each situation and species, although it is likely also 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:

- altered migration path;
- altered locomotion (speed, heading);
- altered dive profiles;
- stopped/altered nursing;
- stopped/altered breeding;
- stopped/altered feeding/foraging;
- stopped/altered sheltering/resting;
- stopped/altered 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 to be 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).

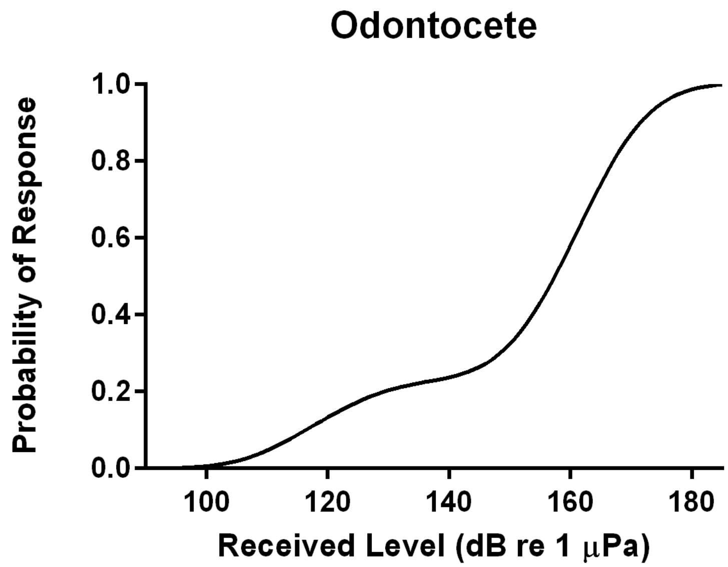


Figure 4. Behavioral response function for odontocetes showing probability of response as a function of received sound pressure level (Navy 2017a).

The analysis for active sonar used cutoff distances beyond which recent research suggests the potential for significant behavioral responses (and therefore harassment under the ESA) are 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 events that contain multiple platforms or tactical sonar sources that exceed 215 decibels (dB) micropascals (re 1 μPa) at 1 meter, this cutoff distance is substantially increased (i.e., doubled) from values derived from the literature. The use of multiple platforms (i.e., more than one vessel and/or aircraft) 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 activities involving these more intense sound sources.

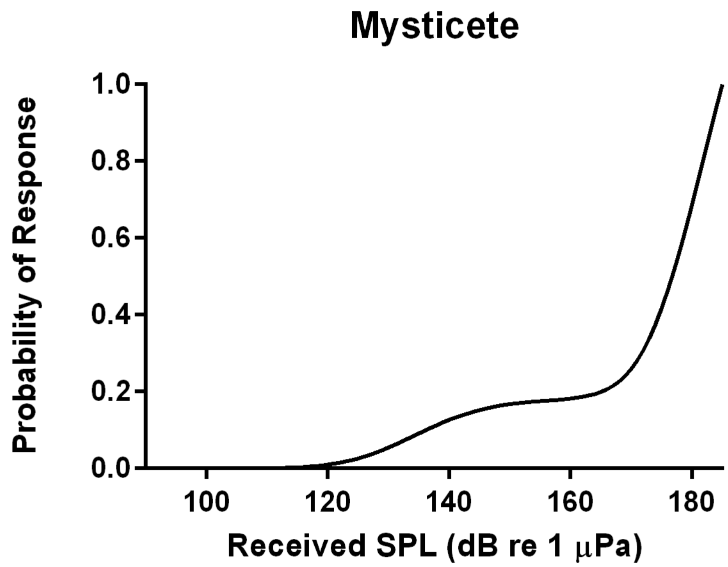


Figure 5. Behavioral response function for mysticetes (Navy 2017a).

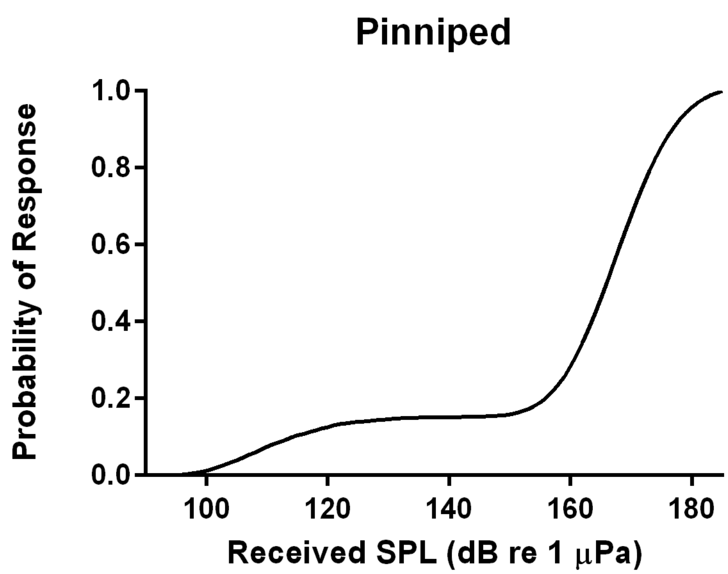


Figure 6. Behavioral response function for pinnipeds (Navy 2017a).

Table 4. Significant behavioral response cutoff distances by species group for moderate source level, single platform sonar events and for high source level[1], multi-platform sonar events (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.

Explosives Criteria – Marine Mammals

For Phase III consultations, the Navy developed explosive criteria for behavioral thresholds for marine mammals based on the hearing group's TTS threshold minus five dB (See Table 2 above for the TTS thresholds for explosives) for events that contain multiple impulses from explosives underwater (Table 5).

Table 5. Behavioral disturbance thresholds for marine mammals from multiple underwater explosives used for the quantitative analysis (Navy 2017a).

Functional Hearing Group	Sound Exposure Level (weighted)
Low-frequency cetaceans	163
Mid-frequency cetaceans	165
Otariid pinnipeds	183

Note: Weighted SEL thresholds in dB re 1 $\mu Pa^2 s$ underwater.

2.2.3 Marine Mammal Density Estimates

In this section, we provide the species density estimates that are used in Section 8.2.1 to quantify the effects of acoustic stressors on ESA-listed marine mammals. Marine mammal density estimates were taken directly from the U.S. Navy Marine Species Density Database Phase III for the Gulf of Alaska Training Maritime Activities Area*,* hereafter referred to as the Density Technical Report (DON 2020).

To characterize marine mammal densities in the GOA TMAA, the Navy compiled data from multiple sources and developed a protocol to select the best available density estimates based on species, area, and season. When multiple data sources were available, the Navy ranked density estimates based on a hierarchal approach to ensure that the most accurate estimates were selected (Navy 2021). The highest tier included peer-reviewed published studies of density estimates from spatial models, since these provide spatially explicit density estimates with relatively low uncertainty. Other preferred sources included peer-reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for NMFS marine mammal stock assessment reports (SARs). In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches including Relative Environmental Suitability models (Navy 2021). Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists. The resulting Geographic Information System database includes seasonal density values for every marine mammal species present within the action area, and density data are provided as a geographic grid of typically ten kilometers by ten kilometers. This database is described in the Navy's Density Technical Report (DON 2020). These data were used as an input into the NAEMO. Marine mammal density estimates that were used in NAEMO modeling for acoustic effects and our risk analyses on the effects of various stressors from Navy training activities are summarized in Table 6 below and shown spatially in Figure 7 through Figure 14. These estimated density values represent the months from April through October when the proposed Navy GOA activities would occur.

Table 6. Summary of marine mammal density values used for quantitative acoustic effects analysis (DON 2020).

Species	Location (Stratum)	April - October
Blue whale	Inshore	0.0001
	Offshore	0.0005
	Seamount	0.0014
	Slope	0.0005
Fin whale	Inshore	0.068
	Offshore	0.016
	Seamount	0.003
	Slope	0.013
Gray whale	0-2.25 nmi from shore	0.4857
	2.25-20 nmi from shore	0.00243
Humpback whale – Western North Pacific and Mexico DPSs combined	Inshore	0.093
	Offshore	0.001
	Seamount	0.001
	Slope	0.0002
North Pacific right whale	TMAA	0.00003
Sei whale	TMAA	0.00040
Sperm whale	Inshore	0.002
	Offshore	0.0013
	Seamount	0.00036
	Slope	0.0033
Steller sea lion – Western DPS	Continental Shelf to 500m isobath	0.057 (May-August)
		0.0678 (April, September-October)
	Beyond 500m isobath	0

Notes: Units for numerical values are animals/km^2. 0 = species is not expected to be present.

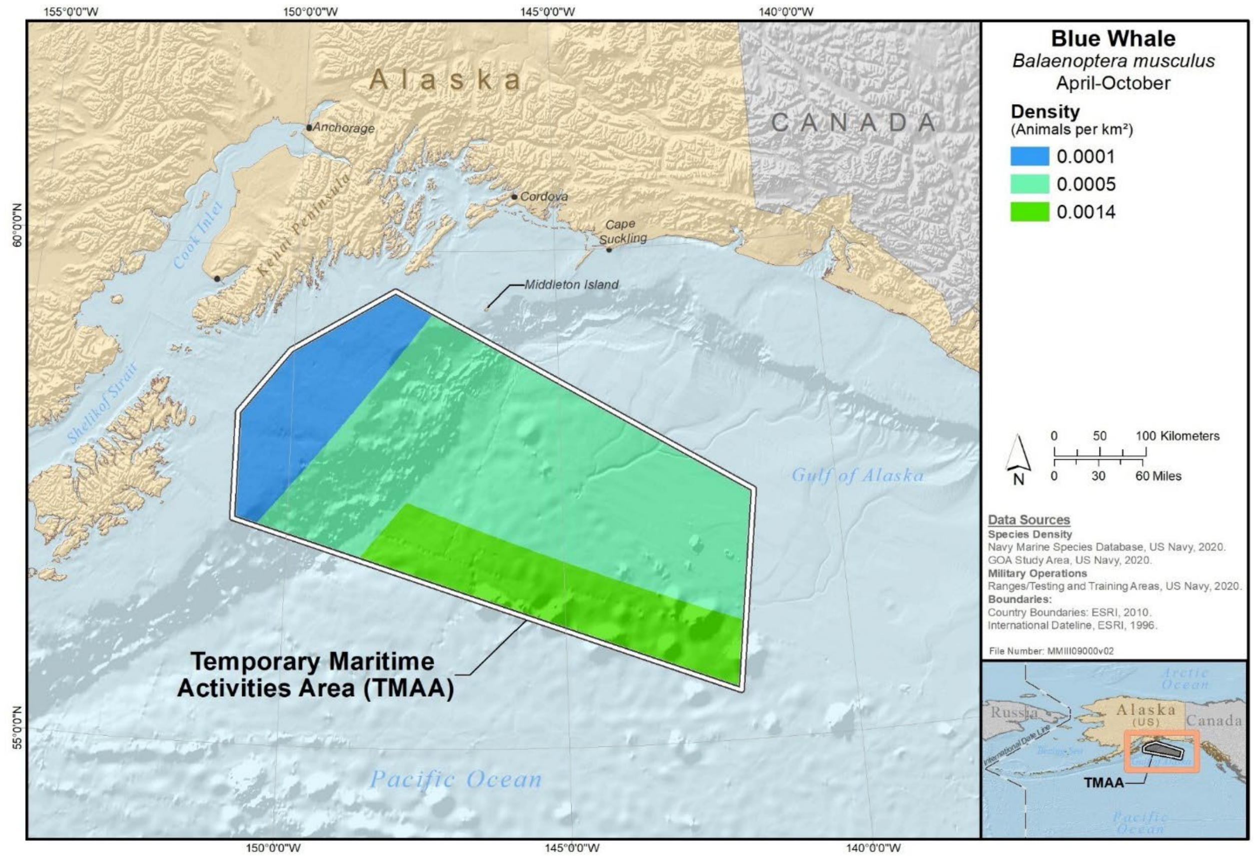


Figure 7. Density distribution of blue whale April through October (DON 2020).

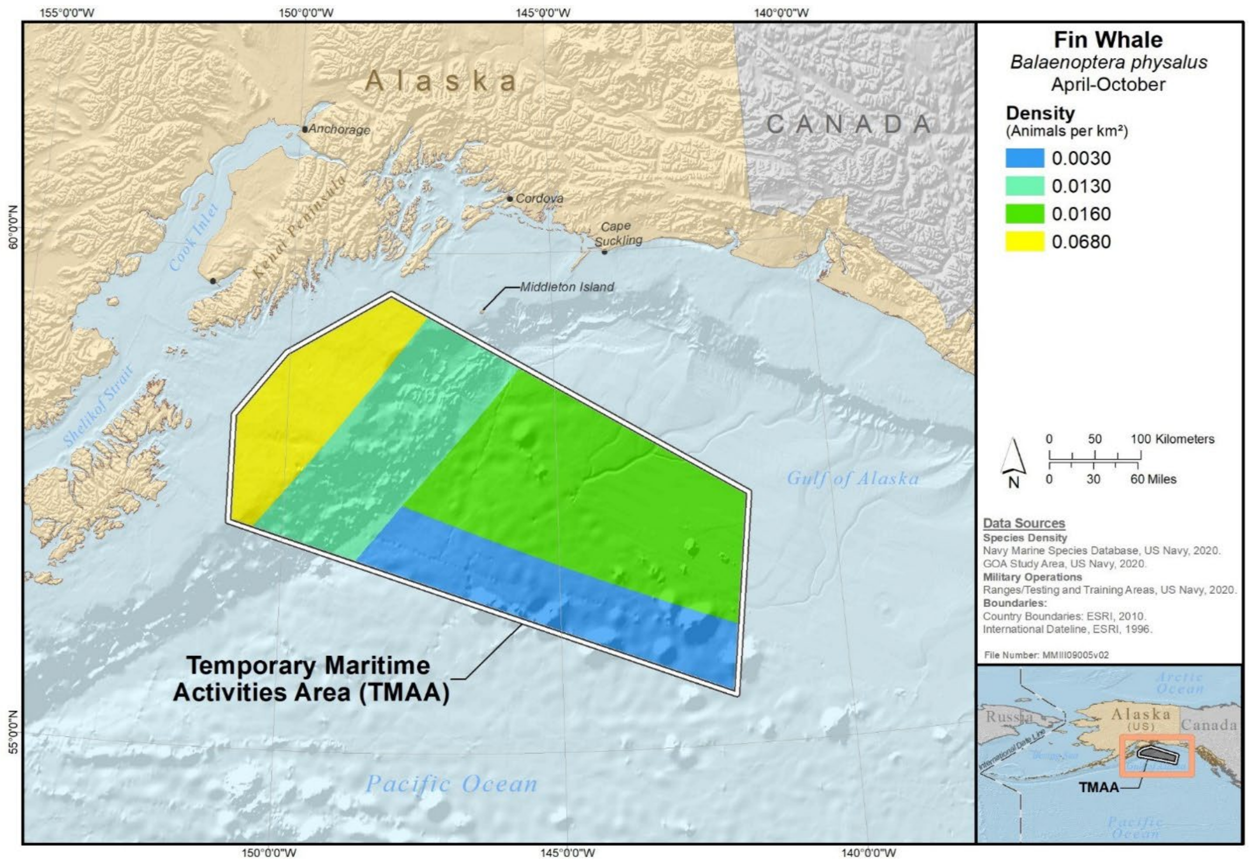


Figure 8. Density distribution of fin whale April through October (DON 2020)

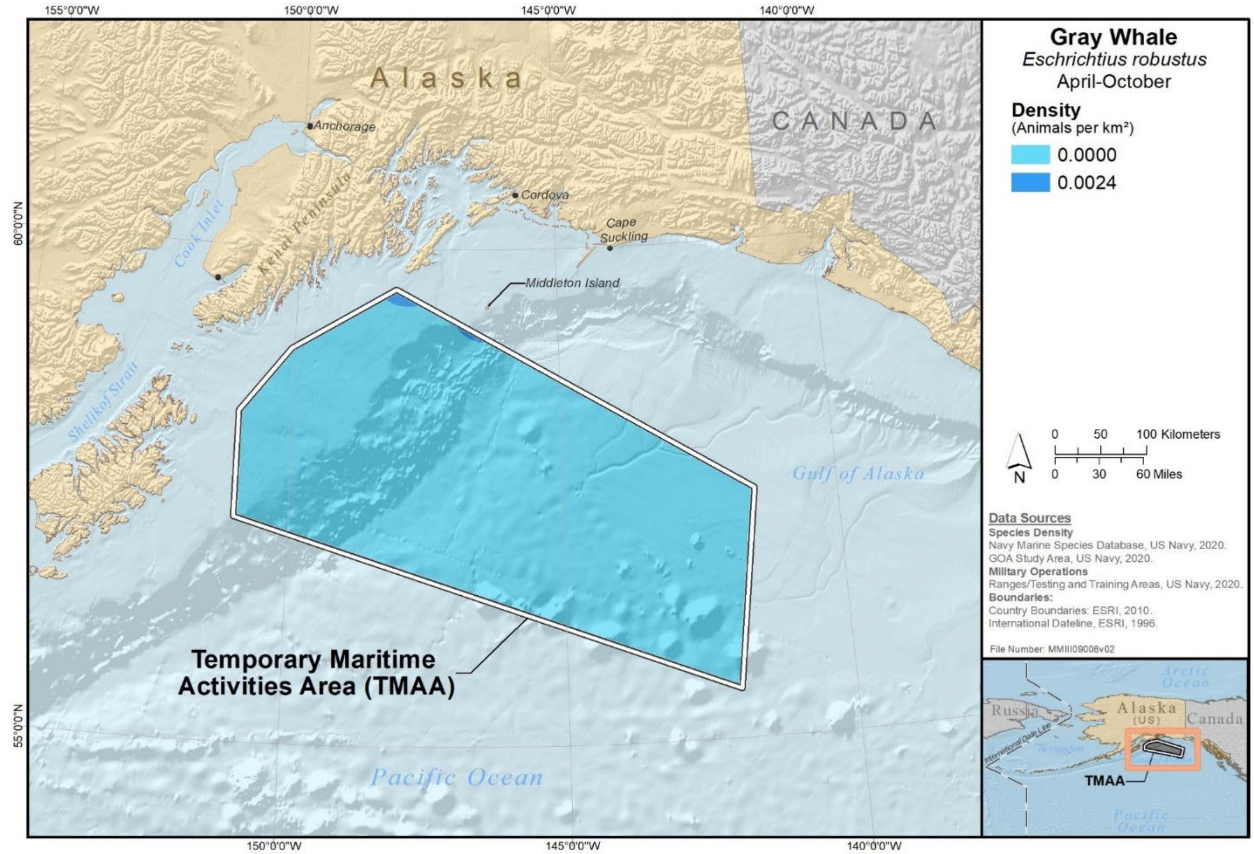


Figure 9. Density distribution of gray whale April through October (DON 2020).

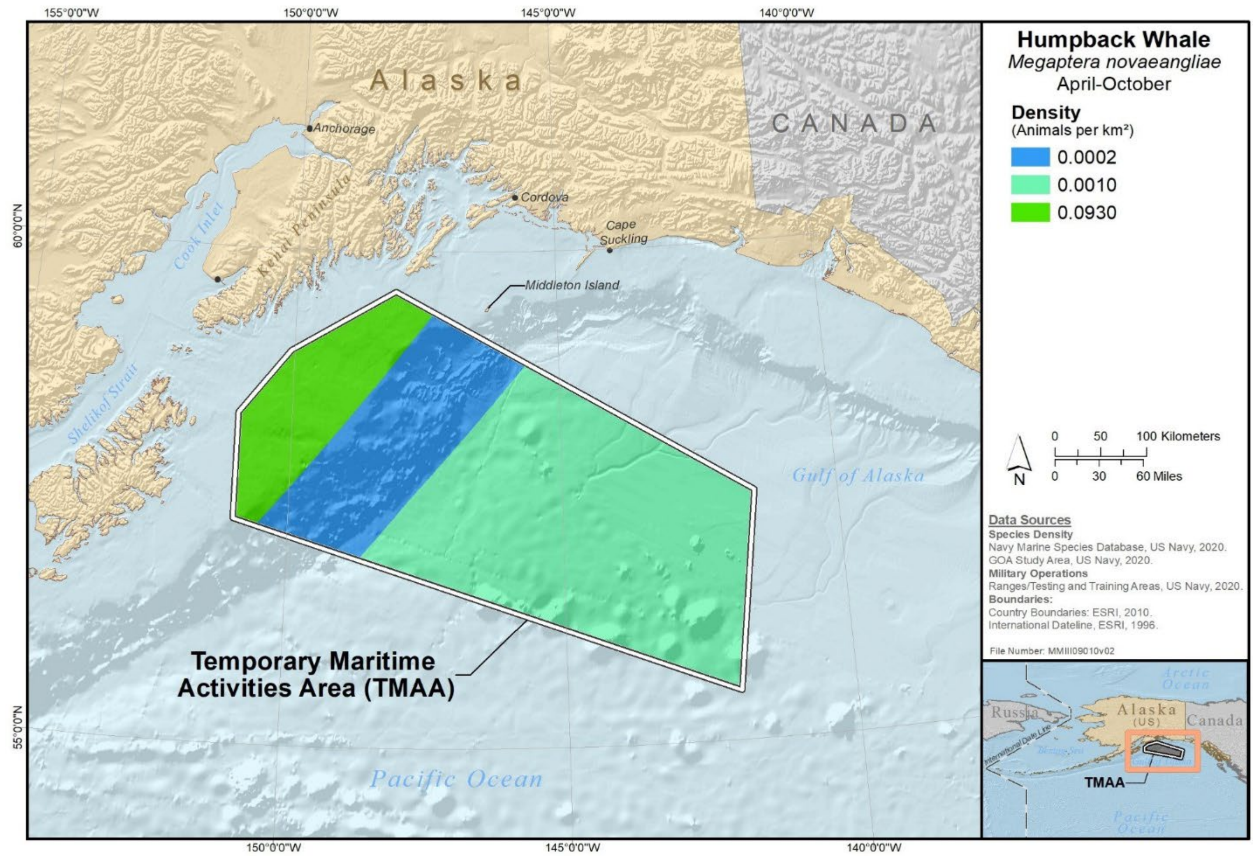


Figure 10. Density distribution of humpback whale (Western North Pacific and Mexico DPSs combined) April through October (DON 2020).

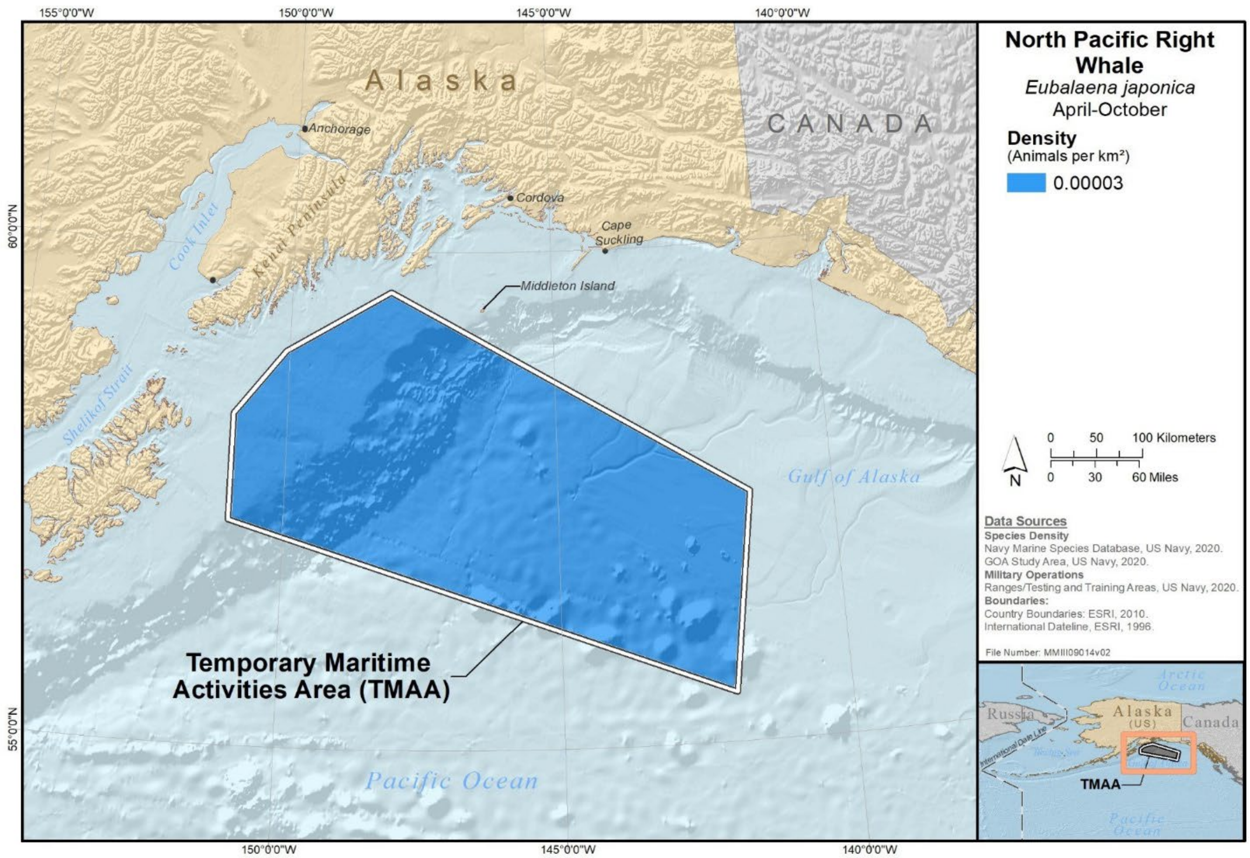


Figure 11. Density distribution of North Pacific right whale April through October (DON 2020).

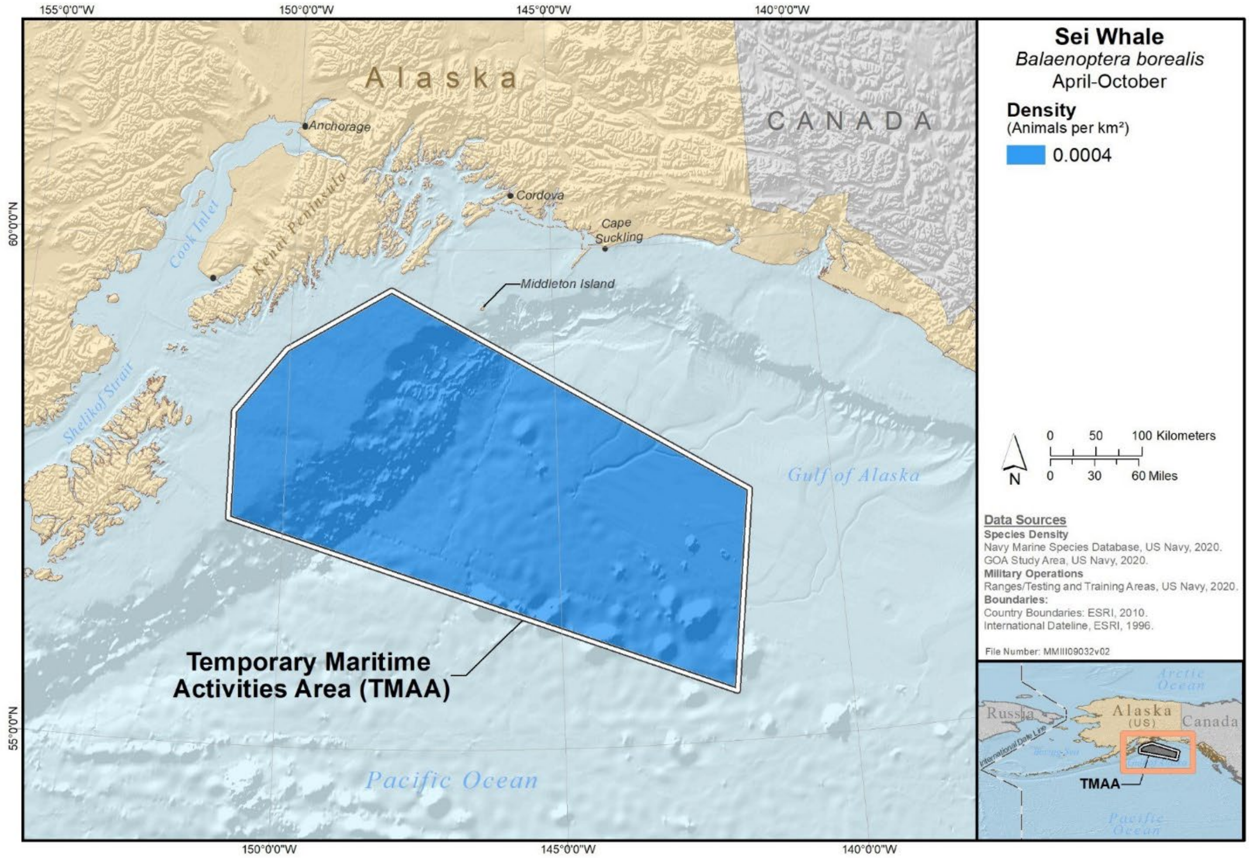


Figure 12. Density distribution of sei whale April through October (DON 2020).

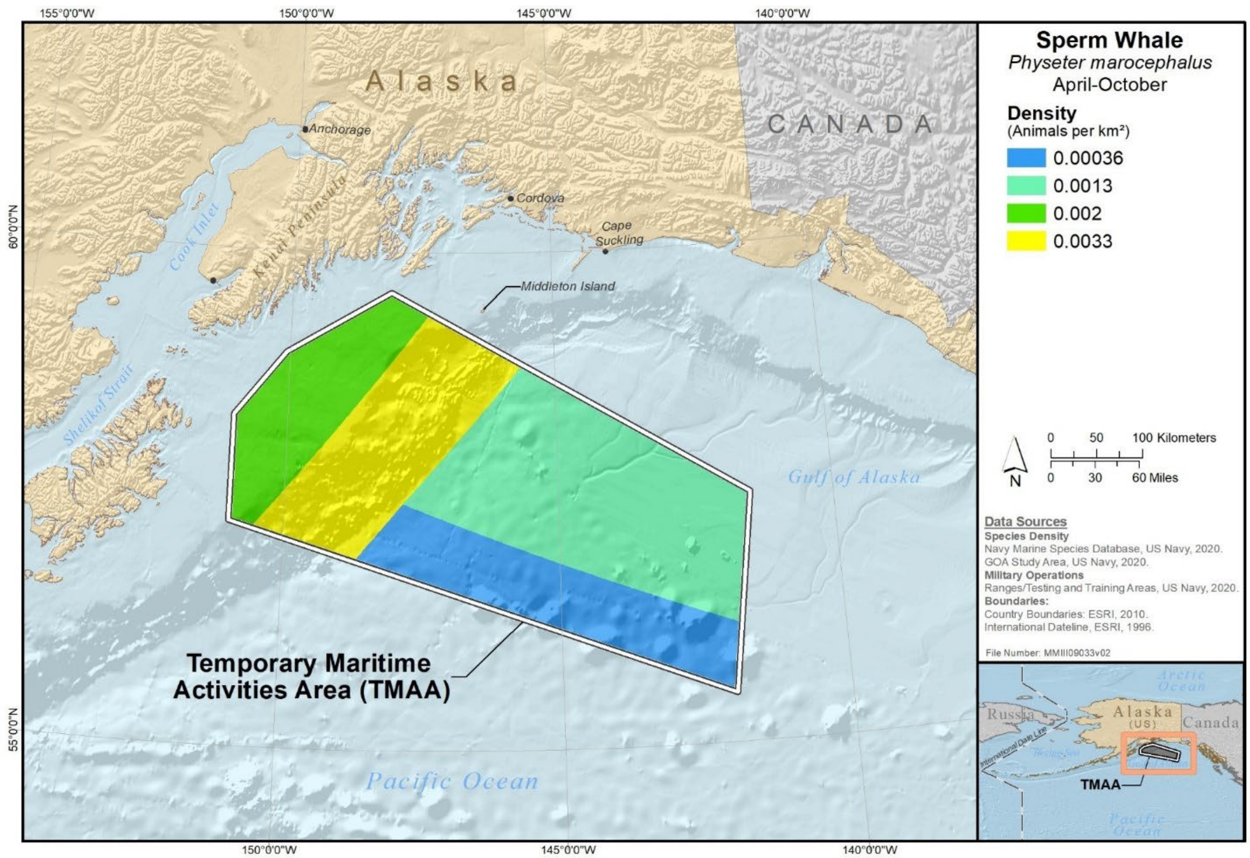


Figure 13. Density distribution of sperm whale April through October (DON 2020).

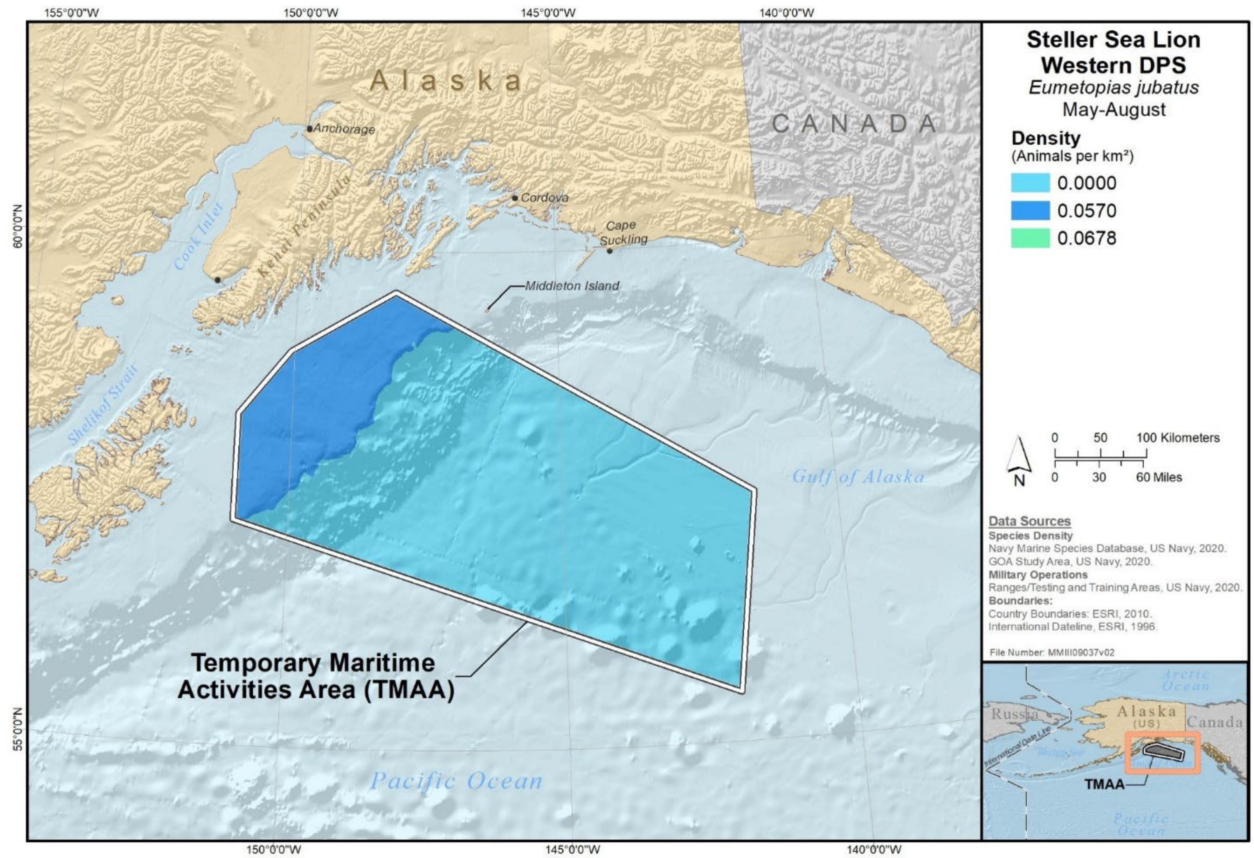


Figure 14. Density distribution of Steller sea lion April through October (DON 2020).

2.3 Criteria and Thresholds to Predict Impacts to Fishes

A description of fish hearing is provided in the Effects of the Action section below (see Section 8.1.2.1). For many of the acoustic stressors affecting fishes in the action area during GOA TMAA activities the Navy relied primarily on the recommendations in the 2014 ANSI Technical Report. The Navy worked with NMFS to develop thresholds or use thresholds developed by others, based on what NMFS considers to be the best available scientific information on the effects of anthropogenic sounds on fishes. None of the studies researching fish hearing have documented PTS impairment from various sound sources. This is attributed to the ability of fish to regenerate inner ear hair cells. Marine mammals and sea turtles are not known to have this ability. Hearing loss in fish is considered recoverable, although the rate of recovery is based upon the degree of the TTS sustained. Thus, auditory impairment in fish is considered recoverable over some duration; and auditory impairment thresholds are based solely on the onset of TTS for fish.

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

2.3.1 Sonar – Fishes

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 Technical Report (Popper et al. 2014a). While the recommended threshold for onset of TTS in this fish hearing group would be low frequency sonar exposure levels greater than 210 dB SEL_{cum} (re 1 μPa^2-s), the Navy's proposed action does not include any activities involving low frequency sonar. TTS has not been observed from exposure to mid-frequency active sonar in fish species with a swim bladder that is not involved in hearing. Fishes within this hearing group, which include all ESA-listed fish considered in this consultation, do not sense pressure well and typically cannot hear at frequencies above two kilohertz (kHz) (Halvorsen et al. 2012; Popper et al. 2014a). Therefore, no criteria have been proposed for fishes with a swim bladder that is not involved in hearing from exposure to mid-frequency active sonar.

2.3.2 Explosives – Fishes

For effects of explosives on fish, we used the mortality criteria provided in the 2014 ANSI Guidelines (Popper et al. 2014a), which also divides fish according to presence/absence of a swim bladder and if the swim bladder is involved in hearing (described above). The 2014 ANSI Technical Report do not suggest numeric thresholds for injury or TTS due to explosives (only mortality). Therefore, we used the impact pile driving and airgun injury thresholds suggested by the ANSI Technical Report as surrogates for explosives. These criteria are used for this consultation as numeric thresholds for injury and TTS in fishes with swim bladders. We conservatively assume that 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 life stages. For fish with a swim bladder, the 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 for injury, or greater than 186 dB SEL_{cum} dB re 1 μPa^2-s for TTS as indicated in Table 7. As discussed in Section 8.2.2, the Navy used these exposure criteria to develop ranges to effects for fish mortality and injury from explosives.

Table 7. Sound exposure criteria used for mortality and injury in fishes.

Fish Hearing Group	Onset of Mortality	Onset of Injury	TTS
	SPL_{peak}	SPL_{peak}	(SEL_{cum})
Fishes with a swim bladder not involved in hearing	229	> 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.

In addition to sound pressure levels, we also considered effects from particle motion of fish. Fishes with swim bladders within the action area such as salmonids have a swim bladder that is distant from the ear and does not contribute to sound pressure reception. These fishes are primarily particle motion detectors. Particle motion is the back and forth motion of the component particles of the medium, measured as the particle displacement, velocity, or acceleration. While it is clear that the use of particle motion for establishing criteria is something that should be done in the future, the lack of data on how particle motion impacts fishes as well as the lack of easily used methods to measure particle motion currently precludes the evaluation of particle motion in our acoustic effects analysis (Hawkins et al. 2020).

3 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 encompasses the TMAA, the WMA, and the adjacent areas where effects of stressors from Navy training activities could be experienced.

The TMAA is a temporary area that is established in conjunction with the Federal Aviation Administration during the April to October timeframe for one exercise period of up to 21 days. The TMAA is a surface, undersea space, and airspace maneuver area within the Gulf of Alaska for ships, submarines, and aircraft to conduct required training activities. The TMAA overlies a majority of Warning Area (W)-612 located over Blying Sound, towards the northwestern quadrant of the TMAA. The TMAA is a polygon that roughly resembles a rectangle oriented from northwest to southeast, approximately 300 nautical miles in length by 150 nautical miles in width, located south of Prince William Sound and east of Kodiak Island. The TMAA's northern boundary is located approximately 24 nautical miles south of the shoreline of the Kenai Peninsula, which is the largest proximate landmass. The only other shoreline close to the TMAA is Montague Island, which is located 12 nautical miles north of the TMAA. The approximate middle of the TMAA is located 140 nautical miles offshore.

As described in the 2016 Final Gulf of Alaska SEIS/OEIS, the Navy rarely, if ever, operates near the corners or edge of the TMAA (Navy 2016). To ensure that the Navy is able to conduct realistic training, Navy units must maintain sufficient room to maneuver. Therefore, training activities typically take place some distance away from the TMAA boundary to ensure sufficient sea or air space is available for tactical maneuvers. The Navy also does not typically train next to any limiting boundary because it precludes tactical consideration of the adjacent sea space and airspace beyond the boundary from being a potential threat axis during activities such as anti-submarine warfare training. It is also the case that Navy training activities will generally not be located where it is likely there would be interference from civilian vessels and aircraft that are not participating in the training activity. The nearshore boundary of the TMAA is the location for multiple commercial vessel transit lanes, ship traffic, and low-altitude air routes. This level of civilian activity may otherwise conflict with Navy training activities if those Navy activities were located at that margin of the TMAA and as a result such an area is generally avoided. Given the proximity to Kodiak Island and Kenai Peninsula, the nearshore margin of the TMAA is only likely to involve training activities such as Visit, Board, Search, and Seizure training events that do not include sonar or explosives (Navy 2016; Navy 2022a).

The WMA is a newly proposed vessel and aircraft maneuvering area south and west of the TMAA which significantly increases the size of the GOA action area. The WMA provides the Navy with an additional 185,806 nm^2 of surface, sub-surface, and airspace training area to the existing TMAA (42,146 nm^2). The total GOA action area with both the WMA and TMAA is approximately 227,952 nm^2. The need for the expanded action area was identified during the

May 2021 Northern Edge exercise, which found that aircraft and vessel maneuvers, which were limited to the TMAA, did not provide realistic scenarios for the training occurring within the TMAA. The WMA training area would provide airspace for multiple air lanes and sea space for increased training complexity. The proposed WMA follows the bottom of the slope at the 4,000 meter contour line and was configured to minimize potential overlap and impacts to ESA-listed species critical habitat, biologically important areas (BIAs), migration routes, and primary fishing grounds (Figure 15).

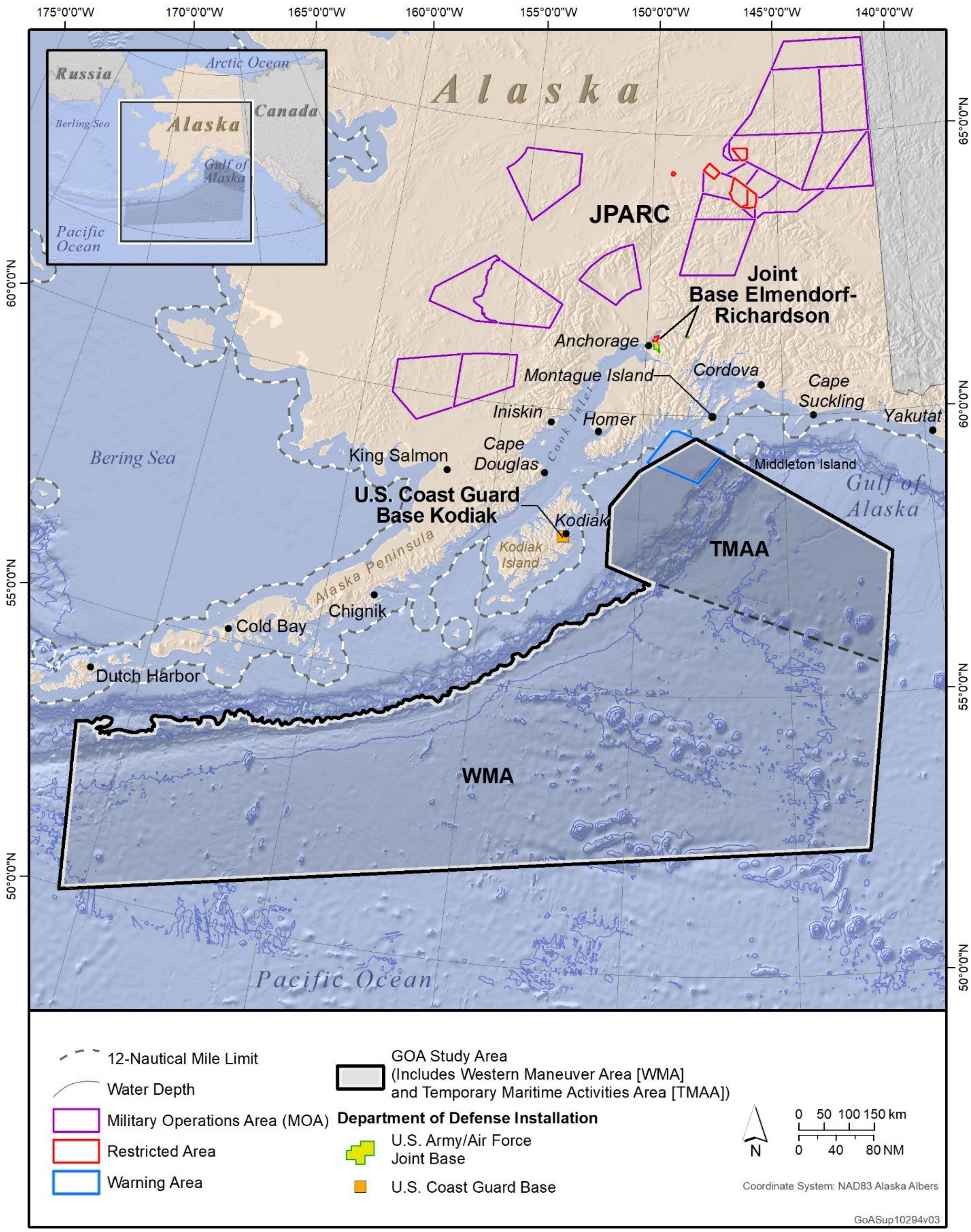


Figure 15. Navy GOA Phase III action area, including the TMAA and the WMA.

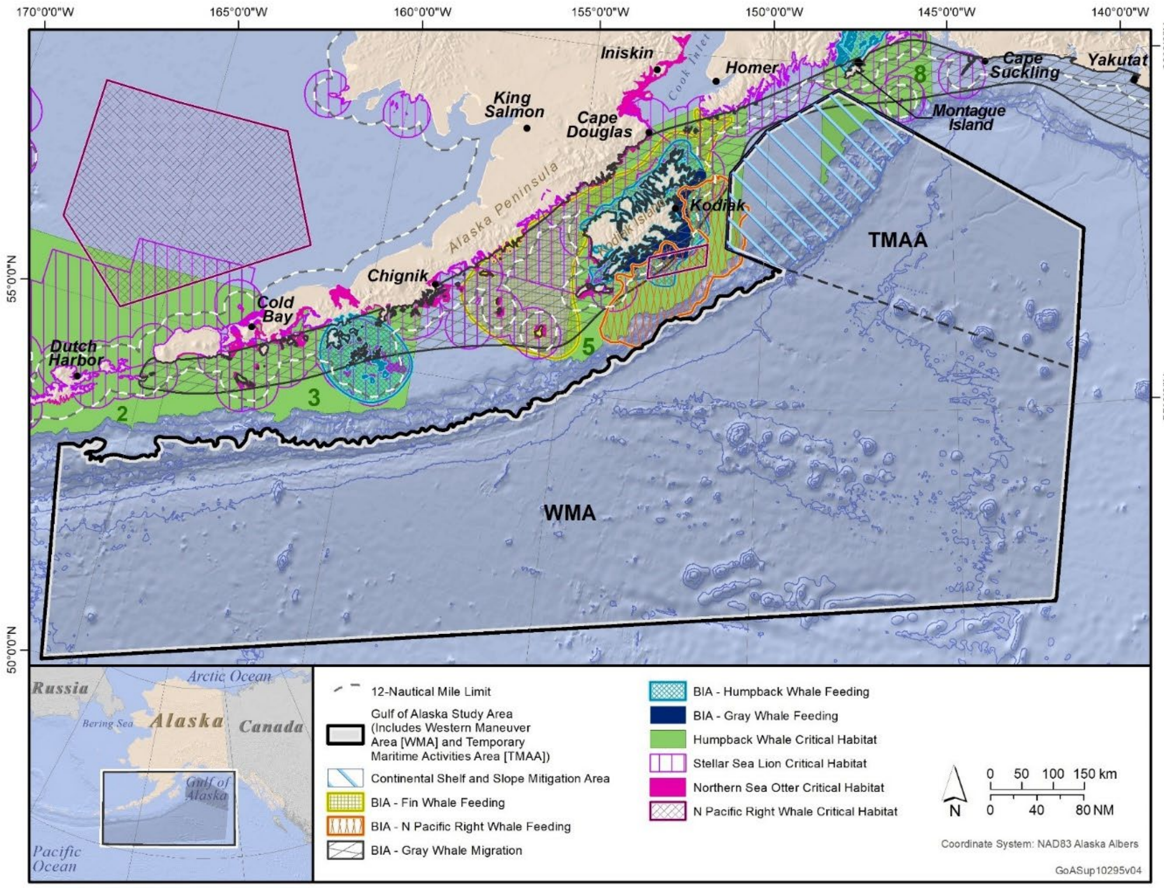


Figure 16. Map showing the location of the proposed WMA in relation to Biologically Important Areas and Critical Habitat.

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

The Navy proposes to conduct military readiness training activities in the GOA action area. Within the TMAA, these military readiness activities include the use of active sonar and explosives within established operating and warning areas and are representative of training the Navy has been conducting in the TMAA for decades. While the specified activities have not changed from GOA Phase II, there are changes in the platforms and systems used in those activities, as well as changes in the bins (source classifications) used to analyze the activities. For example, two new sonar bins were added (MF12 and ASW1) and another bin was eliminated (HF6) due to changes in platforms and systems. Activities in the WMA are described in Section 4.4, and would not include the use of sonar or explosives. The purpose of the military readiness activities the Navy conducts in the GOA action area is to achieve and maintain fleet readiness and to meet the Navy's Title 10 mission to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. The activities covered are major joint training exercises (often called Northern Edge) in Alaska and off the Alaskan coast that involve the Departments of the Navy, Army, Air Force, and Coast Guard participants coordinated to demonstrate and evaluate the ability of the services to engage in a conflict and carry out plans in response to a threat to national security. The proposed action is to conduct a joint exercise over a maximum of 21 consecutive days on an annual basis from April through October in the GOA action area.

The Permits Division proposes to promulgate regulations and issue and LOA pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the Navy to "take" marine mammals incidental to GOA TMAA/WMA activities from December 2022 through December 2029. The purpose of the MMPA regulations and the Permits and Conservation Division's LOA is to allow the Navy to "take" marine mammals incidental to military readiness activities in the Gulf of Alaska TMAA/WMA conducted through October 2029 in a manner that is consistent with the requirements of the MMPA and implementing regulations.

This consultation considers the MMPA regulations and LOA issuance for the Navy to "take" marine mammals incidental to GOA TMAA/WMA activities, including any modifications that may result from this ESA consultation.

NMFS recognizes that while Navy training 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 activities proposed by the Navy during the seven-year period of NMFS' proposed incidental take authorization pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed in this opinion.

For the training activities considered during consultation, Naval personnel (Sailors and Marines) first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and expeditionary warfare) and the community's unique requirements (Navy 2021). Personnel then train within their warfare community at sea in preparation for deployment.

The sections below (Sections 4.1 through 4.6) provide greater detail on the Navy's proposed training in the GOA action area. We present information on the locations where activities are proposed to occur, describe the specific types of activities proposed, and present information on the levels of activities proposed in the different locations. We then present information on the standard operating procedures (Section 4.4) and mitigation measures (i.e. conservation measures to protect and conserve listed species) (Section 4.6) that will be implemented by the Navy as part of the training activities and required by the NMFS Permits Division as part of the proposed MMPA regulations and LOA issuance for the Navy to "take" marine mammals incidental to training activities. We conclude this section by describing the NMFS Permits Division's action under the authority of the MMPA. The primary sources of information for this section were the Navy GOA Phase III Final Biological Assessment (Navy 2021), Navy Memo for the Record titled ESA Consultation Addendum Covering Changes in the GOA Proposed Action and Action Area (Navy 2022c), Final GOA Navy Training Activities Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/OEIS) (Navy 2022a) and NMFS' proposed rule for its promulgation of regulations and issuance of a letter of authorization pursuant to the MMPA for the U.S. Navy (NMFS 2022e).

4.1 Primary Mission Areas

The Navy categorizes its activities into functional warfare areas called primary mission areas. Activities occurring within the GOA action area generally fall into the following six primary mission areas:

- Air warfare
- Surface warfare

- Anti-submarine warfare
- Electronic warfare
- Navy special warfare
- Strike warfare

Most training activities proposed by the Navy are categorized into one of these primary mission areas. Activities that do not fall within these areas are listed as "other activities" below. Each warfare community (surface, subsurface, and aviation) may train in some or all of these primary mission areas.

A more detailed description of the sonar, munitions, targets, systems and other material used during training activities within these primary mission areas is provided in Appendix A (Navy Activity Descriptions) of the Final GOA Navy Training Activities SEIS/OEIS (Navy 2022a).

4.1.1 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.

4.1.2 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.

4.1.3 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 detection and classification of 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. 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.

4.1.4 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.

4.1.5 Navy Special Warfare

Special warfare operations entail the personnel insertion/extraction from an objective area by small boats or subsurface platforms.

4.1.6 Strike Warfare

Strike warfare includes air-to-ground bombing exercises and personnel recovery.

4.2 Proposed Training Activities

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

The training activities proposed by the Navy are briefly described in Table 8. This table is organized according to primary mission areas and includes the activity name and a short description. 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 do not include any new activities from those that have historically occurred in the GOA TMAA.

Table 8. Representative training activities occurring in the action area.

Activity Name	Activity Description
Anti-Air Warfare (AAW)	
Air Combat Maneuver (ACM)	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercise	Train surface and air assets in coordination and tactics for defense of the strike group or other Naval Forces from airborne threats.
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Surface ship crews defend against threat missiles and aircraft with missiles.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A])	Surface ship crews defend against threat aircraft or missiles with guns.
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Aircrews defend against threat aircraft with missiles.
Anti-Surface Warfare (ASUW)	
Visit, Board, Search, and Seizure	Teams of personnel are deployed from ships at sea into small zodiac boats to board and inspect ships and vessels suspected of carrying contraband.
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing aircrews simulate firing precision-guided missiles using captive air training missiles against surface targets. There is no firing of explosive missiles.
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.
Gunnery Exercise (Surface-to-Surface) (GUNEX [S-S])	Ship and small boat crews engage surface targets with ship's small-, medium-, and large-caliber guns. Some of the small- and medium-caliber gunnery exercises analyzed include those conducted by the U.S. Coast Guard.
Maritime Interdiction	A coordinated defensive preplanned attack against multiple sea-borne and air targets using airborne and surface assets.
Sea Surface Control	Airborne assets investigate surface contacts of interest and attempt to identify, via onboard sensors or cameras, the type, course, speed, name, and other pertinent data about the ship of interest.

Activity Name	Activity Description
Anti-Submarine Warfare (ASW)	
Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter crews search for, detect, and track submarines.
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Maritime patrol aircraft crews employ sonobuoys to search for, detect, and track submarines.
Tracking Exercise – Maritime Patrol Aircraft (Multi-static Active Coherent [MAC]) (TRACKEX MPA MAC)	Maritime patrol aircraft crews search for, detect, and track submarines using MAC sonobuoys.
Tracking Exercise – Surface (TRACKEX – Surface)	Surface ship crews search for, detect, and track submarines.
Tracking Exercise – Submarine (TRACKEX – Sub)	Submarine crews search for, detect, and track submarines and surface ships.
Electronic Combat (EC)	
EC Exercises	Aircraft fly threat profiles against ships so that the ship's crews are trained to detect electronic signatures of various threat aircraft and counter the jamming of the ship's own electronic equipment by the simulated threat.
Chaff Exercises	Ships, fixed-winged aircraft, and helicopters deploy chaff to disrupt threat targeting and missile guidance radars and to defend against an attack.
Counter Targeting Exercises	A coordinated, defensive activity utilizing surface and air assets, that attempts to use jamming and chaff to show a false force presentation to inbound surface-to-surface platforms.
Naval Special Warfare (NSW)	
Special Warfare Operations	Training involves specialized tactics, techniques, and procedures, employed in training events that could include insertion/extraction activities using parachutes, rubber boats, helicopters, and other equipment.
Strike Warfare (STW)	
Air-to-Ground Bombing Exercise	Fixed-winged strike fighter aircraft deliver bombs and rockets against land targets.
Personnel Recovery	Train aircrews to locate, protect, and evacuate downed aviation crew members.
Other Training Activities/ Support Operations	
Deck Landing Qualifications	Trains helicopter crews to land on ships underway at sea.

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 seven-year period, beginning in December 2022. 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.

Table 9 and Table 10 provide a comparison of ongoing maximum annual GOA Phase II activity levels (from a previous consultation) with the Navy's proposed training activity levels for GOA Phase III (this consultation). These tables include the event location, source bins used, number of events per year, and maximum levels of sonar (hours) and ordnance used (by bin type), if any. The majority of training for Phase III would occur only in the TMAA (approximately 70 percent in the TMAA and 30 percent in the WMA). The use of sonar or explosives only occur in the TMAA.

Table 9. Gulf of Alaska training activity levels.

Range Activity	2016 Gulf of Alaska Final EIS/OEIS Alternatives (Assessed in the Environmental Baseline)				Changes to the Action in the 2022 Gulf of Alaska Final Supplemental SEIS/SOEIS				
	Platform	System or Ordnance	Location	Alternative 1	Platform	System or Ordnance	Location	Number of events (yearly) or Number of Sonar hours/ items (yearly)[5]	Required re-analysis utilizing NAEMO
AIR WARFARE (AW)									
Aircraft Combat Maneuvers	EA-6B, EA-18G, FA-18, F-16, F-15, F-22, E-2	None	TMAA, Air Force SUA[1]	300 sorties	No Change				No
Air Defense Exercise	FA-18, F-16, F-15, F-22, EA-6B, EA-18G, E-2, P-3C, P-8 MMA, CVN, CG, DDG	None	TMAA	4 events	No Change				No
Surface-to-Air Missile Exercise	CVN, CG, DDG	Sea Sparrow Missile, Standard Missile 1, or RAM *Targets:* BQM-74E	TMAA	3 events	No Change				No
Surface-to-Airgunnery Exercise	CG, DDG, AOE	5-inch/54BLP, 20 mm CIWS, 7.62 mm. *Targets:* Towed TDU-34	TMAA	3 events	No Change				No
Air-to-Air Missile Exercise	FA-18, F-16, F-15, F-22, E-2, EA-6B, EA-18G	AIM-7, AIM-9, AIM-120 *Targets:* TALD or LUU-2B/B	TMAA, Air Force SUA[1]	3 events	No Change				No
SURFACE WARFARE (SUW)									
Maritime Security Operations	MH-60S, RHIB, NSW Personnel	None	TMAA	12 events	Maritime Security Operations was previously two separate activities: Visit, Board, Search, and Seizure; and Maritime Interdiction. The two activities have been combined in the GOA Phase III SEIS/OEIS to align with current Navy naming conventions. The previous 12 events were combined with the old Maritime Interdiction for a new total of 26 under Maritime Security Operations				No

Air-to-Surface Missile Exercise	MH-60R/S, FA-18, F-16, F-15, F-22, EA-6B, EA-18G	None	TMAA	2 events	No Change				No
Air-to-Surface Bombing Exercise	FA-18, F-16, F-15, F-22	MK-82 (live), MK-83 (live), MK-84 (live), BDU-45 (inert), MK-58 marine marker	TMAA	18 events	No Change				Yes
Air-to-Surface Gunnery Exercise	MH-60R/S	GAU-16 (0.50 cal) or M-60 (7.62 mm) machine gun *Targets:* HSMST, Trimaran, SPAR, Surface Target Balloon	TMAA	7 events	No Change				No
Surface-to-Surface Gunnery Exercise	CVN, CG, DDG, AOE	5 inch/54 BLP, 20 mm CIWS, 25 mm, 7.62 mm, 57 mm, .50 cal *Targets:* HSMST, Trimaran, SPAR, Surface Target Balloon	TMAA	6 events	No Change				Yes
Sea Surface Control	FA-18, EA-6B, EA-18G, E-2, P-3C, P-8 MMA, CG, DDG	None	TMAA	6 events	No Change				No
ANTI-SUBMARINE WARFARE (ASW)									
ASW Tracking Exercise – Helicopter	MH-60R	*Targets*: SSN, MK-39 EMATT Sonobuoys: AN/AQS-22, SSQ-36 BT, SSQ-53 DIFAR (passive), SSQ-62 DICASS (active), SSQ-77 VLAD Other: MK-58 marine marker	TMAA	22 events	No Change	Same; however, removed SSQ-62 DICASS as all MF5 bin buoys are now accounted for in ASW Tracking – MPA	No Change	210 dips (increase of 18 dips due to modeling changes)	Yes
ASW Tracking Exercise – Maritime Patrol Aircraft (MPA)	P-3C, P-8 MMA	*Targets*: SSN, MK-39 EMATT Sonobuoys: SSQ-36 BT, SSQ-53 DIFAR (passive), SSQ-62 DICASS (active), SSQ-77 VLAD Other: MK-58 marine marker	TMAA	13 events	No Change			252 DICASS buoys (decrease of 14 buoys due to modeling changes)	Yes

ASW Tracking Exercise – Extended Echo Ranging (EER) (includes IEER & MAC)	P-3C, P-8 MMA	SSQ-110A EER/IEER, SSQ-125 MAC, SSQ-77 VLAD	TMAA	2 events	No Change	Same; however, removed all SSQ-110A EER/IEER.	No Change	80 MAC buoys were modeled	Yes
ASW Tracking Exercise – Surface Ship	DDG	SQS-53C, SQS-56 MFA sonar *Targets*: SSN, MK-39 EMATT	TMAA	2 events	No Change	Same; however, removed all SQS-56 MFA sonar hours and added them to SQS-53 hours total. Added SQL-25 NIXIE as none were modeled in previous EIS/OEIS.	No Change	619 hours MF1 + MF11 bins (decrease of 2 hours, previously 578 hours of MF1 and 52 hours of MF2, ASW3), NIXIE = 546 hours (NIXIE was not modeled in previous EIS/OEIS)	Yes
ASW Tracking Exercise – Submarine	SSBN, SSGN	*Targets*: MK-39 EMATT	TMAA	2 events	SSN	No Change		48 hours of MF3 (same as before), 24 hours of HF1 (same as before)	Yes
ELECTRONIC WARFARE (EW)									
EC Exercises	EA-6B, EA-18G, E-2, P-3, EP-3, CVN, CG, DDG	None	TMAA, Air Force SUA[1]	5 events	No Change				No
Chaff Exercises	EA-6B, EA-18G, P-3, EP-3, FA-18, CVN, CG, DDG, AOE	Chaff	TMAA, Air Force SUA[1]	2 events	No Change				No
Counter Targeting Exercises	EA-6B, EA-18G, P-3, EP-3, FA-18, CVN, CG, DDG, AOE	None	TMAA	4 events	No Change				No
NAVAL SPECIAL WARFARE (NSW)									
Special Warfare Operations	C-130, MH-60S, SDV, RHIB, NSW Personnel	None	TMAA, Air Force SUA[1] Army Trainin	10 events	No Change				No

			g Lands[1]			
STRIKE WARFARE (STW)						
Air-to-Ground Bombing Exercise	FA-18, F-16, F-15, F-22, EA-6B, EA-18G, E-2	MK-82/83/84 (live/inert), BDU-45 (inert), CATM-88C (not released)	Air Force SUA[1], Army Training Lands[1]	150 sorties	No Change	No
Personnel Recovery	CVN, CG, DDG, AOE, E-2, MH-60S, RHIB, NSW Personnel	None	Air Force SUA[1], Army Training Lands[1]	4 events	No Change	No
SUPPORT OPERATIONS						
Deck Landing Qualifications	Helicopters (Air Force, Army, Coast Guard – various)	None	TMAA	6 events	No Change	No

[1] Activities within and upon these areas are covered under separate NEPA analysis.

[2] A sortie is defined as a single activity by one aircraft (i.e., one complete flight from takeoff to landing).

[4] SSN, as a firing platform, was included in original activity description but left off of original table.

[5] ASW is depicted in hours to be consistent with the new modeling technique. Although ASW is modeled as a scenario (multi-day) vice individual events, the hours per event have been provided for clarity.

Notes: AIM = Air Intercept Missile; ASW = Anti-submarine Warfare; BDU = Bomb Dummy Unit; BQM = Aerial Target Drone Designation; cal = caliber; CATM = Combat Arms and Training Maintenance; CG = Cruiser; CVN = Aircraft Carrier, Nuclear; CIWS = Close-in Weapons System; DDG = Destroyer; DICASS = Directional Command Activated Sonobuoy System; DIFAR = Directional Frequency and Ranging; EIS/OEIS = Environmental Impact Statement/Overseas Environmental Impact Statement; EMATT = Expendable Mobile ASW Training Target; EPA = Environmental Protection Agency; Gulf of Alaska = Gulf of Alaska; HARM = High Speed Anti-radiation Missile; HSMST = High Speed Maneuverable Surface Target; IEER = Improved Extended Echo Ranging; MAC = Military Operations in Urban Terrain Assault Course; MFA = Mid-frequency Active; mm = millimeters; MMA = Multi-mission Maritime Aircraft; MPA = Maritime Patrol Aircraft; n/a = not applicable; NAEMO = Navy Acoustic Effects Model; Navy = United States Department of the Navy; NEPA = National Environmental Policy Act; RAM = Rolling Airframe Missile; RHIB = Rigid Hull Inflatable Boat; SDV = Sea, Air, Land Delivery Vehicle; SSBN = Ship, Submersible, Ballistic, Nuclear (submarine); SSGN = Guided Missile Submarine; SSN = Nuclear-Powered Fast Attack Submarine; SUA = Special Use Airspace; TALD = Tactical Air-Launched Decoy; TDU = Target Drone Unit; TMAA = Temporary Maritime Activities Area

Table 10. GOA Phase III proposed training activity levels compared to the GOA Phase II activity levels analyzed in the 2017 biological opinion.

Range Activity	*No. of events (annual)*	
	Ongoing GOA Phase II Activity Levels	*Proposed GOA Phase III Activity Levels*
Air Warfare		
Aircraft Combat Maneuver	300 sorties	300 sorties
Air Defense Exercise	4 events	4 events
Surface-to-Air Gunnery Exercise	3 events	3 events
Air-to-Air Missile Exercise	3 events	3 events
Surface-to-Air Missile Exercise	3 events	3 events
Surface Warfare		
Maritime Security Operations (includes Visit, Board, Search, and Seizure and Maritime Interdiction activities from Phase II)	26 events	26 events
Air-to-Surface Bombing Exercise	18 events	18 events
Air-to-Surface Gunnery Exercise	7 events	7 events
Surface-to-Surface Gunnery Exercise	6 events	6 events
Air-to-Surface Missile Exercise	2 events	2 events
Sea Surface Control	6 events	6 events
Anti-Submarine Warfare		
Tracking Exercise – Helicopter	22 events	22 events
Tracking Exercise – Maritime Patrol Aircraft	13 events	13 events
Tracking Exercise – Submarine	2 events	2 events
Tracking Exercise – Surface Ship	2 events	2 events
Electronic Warfare (EW)		
Counter Targeting Exercise	4 events	4 events
Chaff Exercise	2 events	2 events
EW Exercise	5 events	5 events
Naval Special Warfare		
Special Warfare Operations	10 events	10 events
Strike Warfare[1]		
Air-to-Ground Bombing Exercise	150 sorties	150 sorties
Personnel Recovery	4 events	4 events
Support Operations		
Deck Landing Qualification	6 events	6 events

[1] The GOA Phase III SEIS/OEIS covers the launch and recovery of aircraft from vessels in the GOA Study Area. The training is conducted in the Air Force Special Use Airspace and Army Training Lands that are covered under separate National Environmental Policy Act analysis.

4.3 Classification of Sonar and Explosive Sources into Bins

The Navy developed a series of source classifications, or source bins, in order to better organize and facilitate the analysis of, and implementation of mitigation 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), and explosives. Non-impulsive sources are grouped into bins based on the frequency, source level when warranted, and how the source would be used. Low-frequency (LF) sources operate below 1 kHz; mid-frequency (MF) sources operate at or above 1 kHz, up to and including 10 kHz; high-frequency (HF) sources operate above 10 kHz, up to and including 100 kHz; and very high-frequency (VHF) sources operate above 100 kHz, but below 200 kHz. Impulsive bins are based on the NEW of the munitions or explosive devices.

Sonar source bins are described in Table 11, along with a comparison of the maximum annual activity levels between ongoing activities (GOA Phase II) and the proposed action (GOA Phase III). In addition to the acoustic sources described above, there are other in-water, active acoustic sources from GOA TMAA activities that were not quantitatively analyzed using NAEMO (Table 12).

Table 11. GOA Phase III proposed sonar activity levels compared to the GOA Phase II sonar activity levels analyzed in the 2017 biological opinion (Navy 2021).

For Annual Training Activities					
Source Class Category	**Source Class**	**Description**	**Units**	**Ongoing GOA Phase II Activity Levels**	**Proposed GOA Phase III Activity Levels**
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-60)	H	271	271
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	24	25
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	27	27
	MF5	Active acoustic sonobuoys (e.g., DICASS)	I	126	126
	MF6	Active underwater sound signal devices (e.g., MK 84)	I	11	14
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	39	42
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	0	14

For Annual Training Activities					
Source Class Category	Source Class	Description	Units	Ongoing GOA Phase II Activity Levels	Proposed GOA Phase III Activity Levels
High-Frequency (HF) Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	12	12
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	40	0
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training activities	ASW1	MF systems operating above 200 dB	H	0	14
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	H	40	42
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	273	273
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK3)	I	6	7
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP2	Heavyweight torpedo (e.g., MK 48)	I	0	0

Notes: H = hours; I = count (e.g., number of individual pings or individual sonobuoys).

Table 12. Proposed sonar and transducer sound sources qualitatively analyzed (Navy 2021).

Source Class Category	Bin	Characteristics
Tracking Pingers (P): Devices that send a ping to identify an object location	*P2*	• *low duty cycles (single pings in some cases)* • *short pulse lengths (typically 20 milliseconds)* • *low source levels*

Explosive source bins proposed for GOA Phase III are described in Table 13. This table shows the number of explosive items that could be used in any year for training activities and over a 7-year period. These activity levels are the same as the ongoing GOA Phase II levels.

In addition to the explosives quantitatively analyzed for impacts to ESA-listed species shown in Table 13, the Navy uses some very small impulsive sources (less than 0.1 pounds NEW), categorized in bin E0, that were not quantitatively analyzed by the Navy for potential exposure to marine mammals and sea turtles. These E0 charges are qualitatively analyzed in our effects analysis for these species groups.

Table 13. Description of Navy explosive source bins and comparison of the maximum annual number of explosives by bin between ongoing (GOA Phase II) activities and the proposed action (GOA Phase III) (Navy 2021).

Explosives (Source Class and Net Explosive Weight) (lb.) *	Number of Explosives with the Proposed Action (Annually)	Number of Explosives with the Specified Activity (7-Year Total)
E5 (> 5–10 lb. NEW)	56	392
E9 (> 100–250 lb. NEW)	64	448
E10 (> 250–500 lb. NEW)	6	42
E12 (> 650–1,000 lb. NEW)	2	14

*All of the E5, E9, E10, and E12 explosives would occur in-air, at or above the surface of the water, and would also occur offshore away from the continental shelf and slope beyond the 4,000-meter isobath.

4.4 Activities within the Western Maneuver Area

While the WMA significantly increases the size of the GOA action area the vast majority of the training activities would still occur within the TMAA. The activities conducted in the WMA would be limited to vessel movements and aircraft training, and several events associated with these movements. No activities using sonar or explosives will occur in the WMA, as these activities would still only occur in the TMAA. The WMA allows for a broader geographic region where the activities shown in

Table 14 would occur. The proposed expansion of the action area would not result in an increased level of training events or activities, number of vessels or steaming hours, or number of aircraft, events or flight times. The activities in Table 14 would also continue to occur within the TMAA, in addition to all other activities described above (Section 4.2).

Table 14. Activities Proposed in the GOA Western Maneuver Area.

Activity Name	*Activity Description*
Air Warfare	
Air Combat Maneuver	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercise	Aircrew and ship crews conduct defensive measures agains threat aircraft or simulated missiles.
Surface Warfare	
Maritime Interdiction	Vessels and aircraft conduct a suite of maritime security operations at-sea, including maritime interdiction operations, force protection, and anti-piracy operations.
Sea Surface Control	Airborne assets investigate surface contacts of interest and attempt to identify, via onboard sensors, the type, course, speed, name, and other pertinent data about the ship of interest.
Surface-to-Surface Gunnery Exercise (Non-explosive Practice Munitions)	Surface ship crews fire small-caliber, medium-caliber, or large-caliber guns at surface targets
Electronic Warfare	
Electronic Warfare Exercise	Aircraft and surface ship crews conduct jamming and deploy chaff to disrupt threat targeting and missile guidance radars.
Other Training Activities	
Deck Landing Qualification	Ship's personnel launch and recover fixed-wing and rotary-wing aircraft to achieve qualifications and certifications.

4.5 Standard Operating Procedures

When conducting training activities the Navy implements standard operating procedures to provide for safety and mission success. Navy standard operating procedures are broadcast via numerous naval instructions and manuals to ensure compliance. Standard operating procedures applicable to training have been developed through years of experience, and their primary purpose is to provide for safety (including public health and safety) and mission success. In many cases, there are benefits to environmental resources resulting from standard operating procedures.

4.5.1 Vessel Safety

Ships operated by or for the Navy have personnel assigned to stand watch at all times, day and night, when vessels are moving through the water (underway). Watch personnel undergo training on tasks such as avoiding hazards and ship handling. Training includes on-the-job instruction and a formal qualification program to certify that they have demonstrated all necessary skills. Skills include detection and reporting of floating or partially submerged objects. Watch personnel include officers, enlisted men and women, and civilians operating in similar capacities. Their duties as watchstanders may be performed in conjunction with other job responsibilities, such as navigating the ship or supervising other personnel. While on watch, personnel 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. The standard operating procedures for vessel safety could reduce adverse effects to marine mammals and sea turtles through a reduction in the potential for vessel strike due to the presence of watch personnel at all times.

4.5.2 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. This standard operating procedure benefits marine mammals and sea turtles by increasing the effectiveness of visual observations for mitigation during applicable explosive weapons firing activities.

4.5.3 Target Deployment and Retrieval Safety

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

During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. Recovery of these items helps minimize the amount of materials that remain on the surface or on the seafloor. This standard operating procedure benefits marine mammals, sea turtles, and fish by reducing the potential for physical disturbance and strike, entanglement, or ingestion of applicable targets and any associated decelerators/parachutes.

4.5.4 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. Concentrations of floating vegetation can be indicators of potential marine mammal or sea turtle presence because marine mammals and sea turtles have been known to seek shelter in, feed on, or feed among floating vegetation. This standard operating procedure benefits marine mammals, sea turtles, and vegetation serving as habitat for these animals through a reduction in the potential for physical disturbance and strike by towed in-water device. For more details on proposed use of in-water devices and potential stressors associated with physical disturbance and strike see Section 5.2.2.

4.6 Mitigation Measures[3]

The Navy proposed to implement mitigation measures to avoid or reduce potential impacts from acoustic, explosive, and physical disturbance and strike stressors from training activities on ESA-listed species in the action area (described in Section 4). NMFS considers these measures as reasonably certain to be implemented and thus components of the Navy's proposed action. 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 activity takes place within the GOA TMAA or WMA. Mitigation areas are geographic locations within the action area where the Navy will implement additional measures

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

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

during all or a part of the year. Additional detail on both proposed procedural mitigation and mitigation areas is provided in the sections below.

The following sections summarize the mitigation measures that the Navy proposes to implement in association with the training 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 the Navy's Final SEIS/SOEIS for this action. For each of the mitigation measures described below, the Navy operational community provided input on the practicability of implementation, whether the measure affected personnel safety, the impact on the effectiveness of the military readiness activity, and whether additional mitigation could be implemented to further reduce potential impacts to ESA-listed species.

4.6.1 Procedural Mitigation

Procedural mitigation is mitigation that the Navy will implement whenever and wherever training activities involving applicable acoustic, explosive, and physical disturbance and strike stressors take place within the GOA TMAA or WMA. The Navy customized procedural mitigation for the activity categories and stressors applicable to the proposed action. Procedural mitigation generally involves: (1) the use of one or more trained Lookouts to observe for specific biological resources within a mitigation zone; (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate 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, and incoming aircraft). Lookouts have an additional duty of helping meet the Navy's mitigation requirements by visually observing for marine mammals, sea turtles and other biological resources associated with the presence of ESA-listed species. 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 protection for marine mammals and sea turtles.

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

Depending on the activity, a Lookout may be positioned on a ship (i.e., surface ships and surfaced submarines), on a small boat (e.g., a rigid-hull inflatable boat), or in an aircraft. Certain platforms, such as aircraft and small boats, have manning or space restrictions; therefore, the Lookouts on these platforms are typically existing members of the aircraft or boat crew (e.g., pilot) who are 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. In most cases, the Navy is unable to position Lookouts on unmanned vehicles and unmanned aerial systems, or have Lookouts observe during activities that use systems deployed from or towed by unmanned platforms. Although the Navy is unable to position Lookouts on unmanned vessels, as a standard operating procedure, some vessels that operate autonomously have embedded sensors that aid in avoidance of large objects.

The Navy'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 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 vegetation) in a mitigation zone. First, a Lookout will communicate the sighting to the appropriate watch station. Next, the watch station will implement the prescribed mitigation (e.g., 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 listed below 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 wait period for activities conducted from vessels and activities that involve aircraft that are not typically fuel constrained (e.g., maritime patrol aircraft). Thirty minutes is the maximum amount of time that those activities can be halted without preventing the activity from meeting its intended objective (Navy 2018b; Navy 2021). A 30-minute period covers the average dive times of most marine mammals, and a portion of the dive times of sea turtles and deep-diving marine mammals (i.e., sperm whales, dwarf and pygmy sperm whales [*Kogia* species], and beaked whales). The Navy proposes a shorter wait period of 10 minutes for activities that involve aircraft with fuel constraints (e.g., rotary-wing aircraft [i.e., helicopters], fighter aircraft), since 10 minutes is the maximum amount of time that those activities can be halted without compromising safety due to aircraft fuel restrictions (Navy 2018b; Navy 2021). A 10-minute period covers a portion of the marine mammal and sea turtle dive times, but not the average dive times of most species.

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

4.6.1.1 Environmental Awareness and Education

The Navy provides environmental awareness and education training to aid in visual observation, environmental compliance, and reporting responsibilities. This training helps Navy personnel gain a better understanding of their personal environmental compliance roles and responsibilities and helps to ensure Navy-wide compliance with environmental requirements. The Navy will provide environmental awareness and education training modules to the appropriate personnel as outlined in Table 15.

Table 15. Environmental awareness and education procedural mitigation.

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

4.6.1.2 Active Sonar

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from active sonar, as outlined in Table 16. For all active sonar sources used under the proposed action, bin MF1 has the longest predicted ranges to PTS. For the highest source level in bin MF1, the 1,000 yard and 500 yard power down mitigation zones and 200 yard shut down mitigation zone extend beyond the average ranges to PTS for marine mammals. The ranges to PTS for the 200 yard shut down mitigation zone were calculated based on full power transmissions and do not consider that the impact ranges would be reduced if the 1,000 yard and 500 yard power down mitigation measures are implemented in response to a marine mammal sighting in those mitigation zones. If an animal is first sighted in the 1,000 yard or 500 yard power down mitigation zone, the source level reduction would shorten the ranges to PTS, and the 200 yard shut down mitigation would then extend even further beyond the average ranges to PTS for all marine mammal hearing groups. The active sonar mitigation zones also extend beyond the average ranges to TTS for otariids and into a portion of the average ranges to TTS for all other marine mammal hearing groups; therefore, mitigation will help avoid or reduce the potential for some exposure to higher levels of TTS. Active sonar sources that fall within lower source bins or are used at lower source levels have shorter impact ranges than those discussed above; therefore, the mitigation zones will extend further beyond or into the average ranges to PTS and TTS for these sources.

Due to sea turtle hearing capabilities, the mitigation only applies to sea turtles during the use of sources below two kHz. The range to auditory effects for most active sonar sources in sea turtle hearing range) is zero meters. Impact ranges are longer (i.e., up to tens of meters) for active sonars with higher source levels. The mitigation zones for active sonar extend beyond the ranges to PTS and TTS for sea turtles; therefore, mitigation will help avoid or reduce the potential for exposure to these effects for sea turtles.

Table 16. Procedural mitigation for active sonar.

Procedural Mitigation Description

Stressor or Activity
• Mid-frequency active sonar and high-frequency active sonar
  ○ For vessel-based active sonar activities, mitigation applies only to sources that are positively controlled and deployed from manned surface vessels (e.g., sonar sources towed from manned surface platforms).
  ○ For aircraft-based active sonar activities, mitigation applies only to sources that are positively controlled and deployed from manned aircraft that do not operate at high altitudes (e.g., rotary-wing aircraft). Mitigation does not apply to active sonar sources deployed from unmanned aerial systems 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:
  ○ 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.
  ○ 2 Lookouts: Platforms without space or manning restrictions while underway (at the forward part of the ship)
• Sources that are not hull-mounted:
  ○ 1 Lookout on the ship or aircraft conducting the activity

Mitigation Requirements • Mitigation zones: ○ 1,000 yards (914 meters) power down, 500 yards (457 meters) power down, and 200 yards (183 meters). shut down for hull-mounted mid-frequency active sonar

Procedural Mitigation Description
○ 200 yards (183 meters) shut down for mid-frequency active sonar sources that are not hull-mounted and high-frequency active sonar • Prior to the initial start of the activity (e.g., when maneuvering on station): ○ Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of active sonar transmission. • During the activity: ○ 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 a marine mammal or sea turtle is observed within 1,000 yards (914 meters) of the sonar source; power down an additional 4 dB (10 dB total) if a marine mammal or sea turtle is observed within 500 yards (457 meters); cease transmission if a marine mammal or sea turtle is observed within 200 yards (183 meters). ○ 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 transmission if a marine mammal or sea turtle is observed within 200 yards (183 meters) of the sonar source. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: ○ The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-deployed sonar sources or 30 minutes 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 Lookout 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).

4.6.1.3 Weapons Firing Noise

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from weapons firing noise, as outlined in Table 17. The mitigation zone extends beyond the distance to which marine mammals and sea turtles would likely experience PTS or TTS from weapons firing noise; therefore, mitigation will help avoid or reduce the potential for exposure to these impacts.

Table 17. Procedural mitigation for weapons firing noise.

Procedural Mitigation Description
Stressor or Activity • Weapons firing noise associated with large-caliber gunnery activities
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the ship conducting the firing ○ Depending on the activity, the Lookout could be the same one described in Table 18 for Explosive Large-Caliber Projectiles or Table 22 for Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions.
Mitigation Requirements • Mitigation zone: ○ 30° on either side of the firing line out to 70 yards (64 meters) from the muzzle of the weapon being fired • Prior to the initial start of the activity: ○ Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of weapons firing. • During the activity: ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, cease weapons firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: ○ The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing 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.

4.6.1.4 Explosive Large-Caliber Projectiles

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive gunnery activities, as outlined in Table 18. When developing mitigation during this consultation, the Navy analyzed the potential for increasing the size of this mitigation zones. The Navy identified an opportunity to increase the mitigation zone size by 400 yards (366 meters) for surface-to-surface activities to enhance protections to the maximum extent practicable.

The mitigation zones are now based on the largest areas within which it is practical to implement mitigation for explosive large-caliber gunnery activities. The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of the activity. In accordance with the 2016 GOA Final SEIS/OEIS consultation requirements, the Navy currently conducts post-activity observations for some, but not all explosive activities. When developing mitigation for the proposed action, the Navy determined that it could expand this requirement to other explosive activities for enhanced consistency and to help determine if any resources were injured during explosive events, when practical. The Navy is also adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources.

Large-caliber gunnery activities involve vessels firing projectiles at targets located up to six nautical miles down range. These events are conducted from surface combatants, and Lookouts typically have access to high-powered binoculars mounted on the ship deck. This will enable observation of the distant mitigation zone in combination with hand-held binoculars and naked-eye scanning. Due to their relatively lower vantage point, Lookouts on vessels will be more likely to detect large visual cues (e.g., whale blows, breaching whales) than individual marine mammals, cryptic marine mammal species, and sea turtles when observing around targets located at the furthest firing distances. Observing for floating vegetation will further help avoid or reduce potential impacts on marine mammals and sea turtles within the mitigation zones.

The mitigation applies only to activities using surface targets. Most airborne targets are recoverable aerial drones that are not intended to be hit by ordnance. Given the speed of the projectiles and mobile target, and the long ranges that projectiles typically travel, it is not possible to definitively predict or to effectively observe where the projectile fragments will fall. For gunnery activities using explosive large-caliber projectiles, the potential military expended material (MEM) fall zone can only be predicted within thousands of yards, which can be up to 6 nautical miles from the firing location. These areas are too large to be effectively observed for marine species with the number of personnel and platforms available for this activity.

Explosive bin 5 (E5; e.g., large-caliber projectiles with NEW >5–10 pounds) has the longest predicted impact ranges for explosive projectiles used in the Action Area. The 1,000 yard mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals for bin E5. The mitigation zone extends into a portion of the average ranges to PTS for high frequency cetaceans and beyond the average ranges to PTS for sea turtles and other marine mammal hearing groups for bin E5. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E5.

The mitigation zones are based on the largest areas within which it is practical for the Navy to implement mitigation for marine mammals and sea turtles. It is not practical to increase this mitigation zone because observations within the margin of increase would be unsafe and ineffective.

Table 18. Procedural mitigation for explosive large-caliber projectiles.

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive large-caliber projectiles   ○ 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 conducting the activity
  ○ Depending on the activity, the Lookout could be the same as the one described in
  ○ Table 17 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:
  ○ 1,000 yards (914 meters). (for marine mammals and sea turtles) around the intended impact location
• Prior to the initial start of the activity (e.g., when maneuvering on station):
  ○ Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
  ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing.
• During the activity:
  ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity:
  ○ The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 30 min. or (4) for activities using mobile targets, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.
• After completion of the activity (e.g., prior to maneuvering off station):
  ○ When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead ESA-listed species are observed, follow established incident reporting procedures.
  ○ If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

4.6.1.5 Explosive Bombs

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive bombs, as outlined in Table 19. In the 2017 GOA

TMAA biological opinion (NMFS 2017c), the explosive bombing mitigation zone was based on the NEW and the associated average ranges to PTS. When developing the mitigation during this consultation, the Navy analyzed the potential for increasing the size of this mitigation zone. The Navy determined that the current mitigation zone for explosive bombs is the largest area within which it is practical to implement mitigation for this activity; therefore, it will continue implementing this same mitigation zone under the Proposed Action.

The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of this activity. In accordance with the 2016 GOA Final SEIS/OEIS, the Navy currently conducts post-activity observations for some, but not all explosive activities. When developing mitigation for the proposed action, the Navy determined that it could expand this requirement to other explosive activities for enhanced consistency and to help determine if any resources were injured during explosive events, when practical. The Navy is also adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. Typically, when aircraft are firing explosive munitions there are additional observation aircraft, multiple aircraft firing munitions, or other safety aircraft in the vicinity. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources.

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

Bin E12 (e.g., 2,000-pound bomb) has the longest predicted impact ranges for explosive bombs used in the Action Area. The 2,500 yard mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends beyond the average ranges to PTS for sea turtles and hearing groups of ESA-listed marine mammals for bin E12. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for marine mammals and sea turtles. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest bombs in bin E12. Smaller bombs in bin E12 have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

The mitigation zone is based on the largest area within which it is practical for the Navy to implement mitigation. It is not practical to increase this mitigation zone because observations within the margin of increase would be ineffective unless the Navy allocated additional platforms to the activity to observe for biological resources.

Table 19. Procedural mitigation for explosive bombs.

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in the aircraft conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: o 2,500 yards (2,286-meters) around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): o Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. o Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during 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 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.

4.6.1.6 Vessel Movement

The Navy will implement procedural mitigation to avoid or reduce the potential for vessel strikes of marine mammals and sea turtles, as outlined in Table 20. Although the Navy is unable to position Lookouts on unmanned vessels, as a standard operating procedure, some vessels that operate autonomously have embedded sensors that aid in avoidance of large objects. The embedded sensors may help those unmanned vessels reduce the risk of vessel strikes of marine mammals and sea turtles.

Table 20. Procedural mitigation for vessel movement.

Procedural Mitigation Description
Stressor or Activity • Vessel movement ○ The mitigation will not be applied if: (1) the vessel's safety is threatened, (2) the vessel is restricted in its ability to maneuver (e.g., during launching and recovery of aircraft or landing craft, during towing activities, when mooring, (3) the vessel is submerged or operated autonomously, or (4) when impractical based on mission requirements (e.g., during Vessel Visit, Board, Search, and Seizure activities as military personnel from ships or aircraft board suspect vessels).
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 or more Lookouts on underway vessels[1] • If additional watch personnel are positioned on underway vessels, those personnel (e.g., persons assisting with navigation or safety) will support observing for marine mammals and sea turtles while performing their regular duties.
Mitigation Requirements • Mitigation zones: ○ 500 yards (457 meters) around whales ○ 200 yards (183 meters) (for surface ships) around other marine mammals (except bow-riding dolphins and pinnipeds hauled out man-made navigational structures, port structures, and vessels) ○ Within the vicinity of the vessel for sea turtles • When underway: ○ Observe the direct path of the vessel and waters surrounding the vessel for marine mammals and sea turtles. ○ If a marine mammal or sea turtle is observed in the direct path of the vessel, maneuver the vessel as necessary to maintain the appropriate mitigation zone distance. ○ If a marine mammal or sea turtle is observed in waters surrounding the vessel, maintain situational awareness of that animal's position. Based on the animal's course and speed relative to the vessel's path, maneuver the vessel as necessary to ensure that the appropriate mitigation zone distance from the animal continues to be maintained. • Additional requirements: ○ If a marine mammal or sea turtle vessel strike occurs, the Navy will follow the established incident reporting procedures.
[1] Underway vessels will maintain at least one Lookout. For ship classes required to maintain more than one Lookout, the specific requirement is subject to change over time in accordance with Navy navigation instruction.

4.6.1.7 Towed In-water Devices

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from towed in-water devices, as outlined in Table 21. The small mitigation zone size and proximity to the observation platform will result in a high likelihood that Lookouts will be able to detect marine mammals throughout the mitigation zone when manned vessels or manned aircraft are towing in-water devices.

Table 21. Procedural mitigation for towed in-water devices.

Procedural Mitigation Description

Stressor or Activity
• Towed in-water devices
  ○ Mitigation applies to devices towed from a manned surface platform or manned aircraft, or when a manned support craft is already participating in an activity involving in-water devices being towed by unmanned platforms
  ○ 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 towing platform or support craft

Mitigation Requirements
• Mitigation zones:
  ○ 250 yards (229 meters) around marine mammals (except those intentionally swimming alongside or closing to swim alongside towing vessels, such as for bow-riding or wake-riding).
  ○ Within the vicinity of sea turtles.
• During the activity (i.e., when towing an in-water device)
  ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance.

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

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from small-, medium-, and large-caliber non-explosive practice munitions, as outlined in Table 22. The mitigation zone is designed to be several times larger than the impact footprint for large-caliber non-explosive practice munitions, which are the largest projectiles used for these activities. Small-caliber and medium-caliber non-explosive practice munitions have smaller impact footprints than large-caliber non-explosive practice munitions; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller projectiles.

Large-caliber gunnery activities involve vessels firing projectiles at a target located up to 6 nautical miles down range. Small- and medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets located up to 4,000 yards (3,658 meters) down range, although typically much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets located close to the firing platform. When observing activities that use a target located far from the firing platform, Lookouts will be more likely to detect large visual cues (e.g., whale blows, breaching whales, or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles.

Table 22. Procedural mitigation for small-, medium-, and large-caliber non-explosive practice munitions.

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using small-, medium-, and large-caliber non-explosive practice munitions ○ Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the platform conducting the activity ○ Depending on the activity, the Lookout could be the same as the one described in ○ Table 17 for Weapons Firing Noise.
Mitigation Requirements • Mitigation zone: ○ 200 yards (183 meters) around the intended impact location • Prior to the initial start of the activity (e.g., when maneuvering on station): ○ Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of firing. • During the activity: ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, cease firing. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: ○ The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-based firing or 30 min. for vessel-based firing; or (4) for activities using a mobile target, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

4.6.1.9 Non-Explosive Bombs

The Navy will implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from non-explosive bombs, as outlined in Table 23. The mitigation zone for non-explosive bombs is designed to be several times larger than the impact footprint for the largest non-explosive bomb used for these activities. Smaller non-explosive bombs have smaller impact footprints than the largest non- explosive bomb used for these activities; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller military expended materials.

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

Table 23. Procedural mitigation for non-explosive bombs.

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: ○ 1,000 yards (914 meters) around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): ○ Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during approach of the target location): ○ Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting prior to or during the activity: ○ 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 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.

4.6.2 Mitigation Areas

In addition to the procedural mitigation measures explained in Section 4.6.1, the following subsections present the area and activity specific mitigation measures that the Navy will operate under in the Gulf of Alaska. Should national security present a requirement to conduct training prohibited by the mitigation requirements specified below, naval units will obtain permission from the appropriate designated Command, U.S. Third Fleet authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include relevant information about the event (e.g., sonar hours, use of explosives detonated at or near [within 10 m] the water surface) in its annual activity reports to NMFS.

4.6.2.1 Continental Shelf and Slope Mitigation Area

The Navy has proposed a new mitigation area for GOA Phase III to avoid or reduce potential impacts from explosive training activities on marine species. The Navy will prohibit the use of in-air explosives (sea surface to 10,000 feet altitude) over the continental shelf and slope out to the 4,000 meter depth contour within the TMAA (Figure 17). There are no underwater explosions in the Navy's proposed action and explosives would not be used in the WMA. This new mitigation measure for GOA Phase III expands on previous mitigation for explosives from Phase II, and encompasses the Portlock Bank Mitigation Area and the North Pacific Right Whale Mitigation Area. The Navy expanded its mitigation area for explosives in order to avoid potential impacts within this highly-productive area that supports several marine mammal and fish species, including the humpback whale, gray whale, and ESA-listed salmonids.

4.6.2.2 North Pacific Right Whale Mitigation Area

The Navy will not use surface ship hull mounted mid-frequency sonar or explosives during training within the portion of the NMFS-identified North Pacific right whale feeding area overlapping the TMAA in the June 1 to September 30 timeframe (Figure 17) . The Navy reserves the right to use surface ship hull mounted mid-frequency sonar or explosives in this area in the event of national security needs. Approval from the appropriate designated Command, U.S. Third Fleet Command Authority, is required prior to using surface ship hull mounted mid-frequency sonar or explosives in this area from June through September. Explosives would not be used in this area which is encompassed by the Continental Shelf and Slope Mitigation Area.

4.6.3 Pre-Event Awareness Messages

The Navy will issue pre-event awareness messages to alert ships and aircraft participating in training activities within the TMAA to the possible presence of concentrations of large whales on the continental shelf and slope. Occurrences of large whales may be higher over the continental shelf and slope relative to other areas of the TMAA. To maintain safety of navigation and to avoid interactions with these species, the Navy will instruct vessels to remain vigilant to the presence of large whales that may be vulnerable to vessel strikes or potential impacts from training activities. Additionally, ships and aircraft will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation.

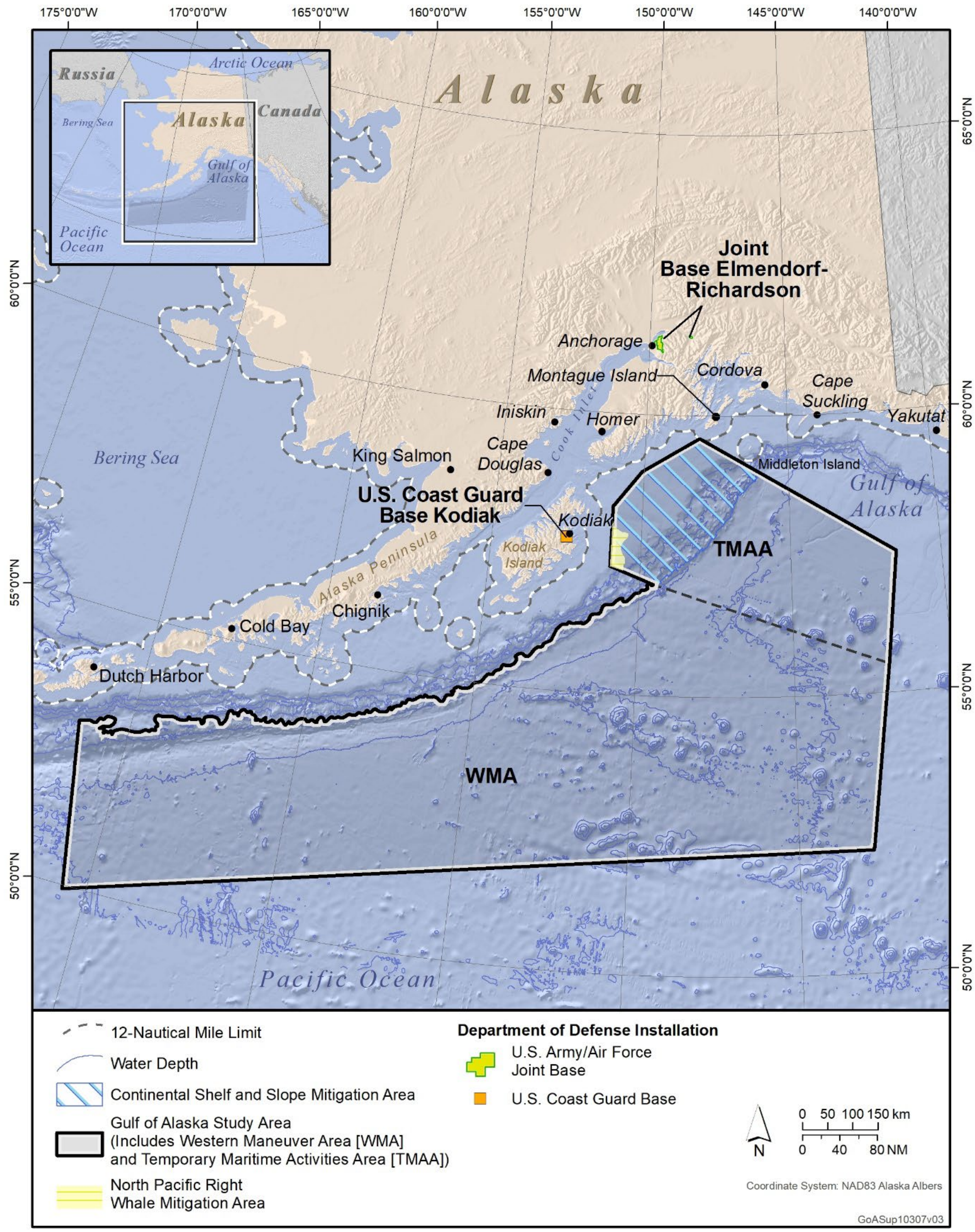


Figure 17. Mitigation Areas in the Gulf of Alaska Temporary Maritime Activities Area.

4.7 MMPA Regulations and Issuance of a Letter of Authorization

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 GOA TMAA/WMA activities from December 2022 through December 2029. The regulations propose to authorize the issuance of a LOA that will allow the Navy to "take" ESA-listed marine mammals incidental to their training activities.

Authorized take would occur by Level A harassment and Level B harassment, as defined by the MMPA and take levels in the LOA are consistent with the take levels analyzed in our effects analysis (Section 8.2.1) and exempted in the ITS (Section 12.1) for this consultation. The eight marine mammal species in the LOA that are also ESA-listed species are: blue whale, fin whale, humpback whale Mexico and Western North Pacific DPSs, North Pacific right whale, sperm whale, sei whale, gray whale Western North Pacific DPS, and Steller sea lion Western DPS. ESA-listed species (and DPSs) and the number of takes by Level A & B harassment that the Permits Division anticipates authorizing over the seven-year period of effectiveness are outlined in Table 2. In some cases, all stocks for a species are ESA-listed, while in other cases only designated stocks are ESA-listed (please refer to table notes). Full details of the exposure estimation process are provided in the Federal Register notice of the proposed rule (87 FR 49656; August 11, 2022).

The Permits Division's proposed regulations are available at the following website: https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities. This consultation considers the proposed MMPA regulations for the Navy to "take" marine mammals incidental to GOA TMAA/WMA activities (NMFS 2020e). The final MMPA regulations, upon publication, will also be available at the website shown above. Note that this biological opinion was completed prior to the publication of the final MMPA regulations in the Federal Register. We anticipate that, upon publication, the MMPA regulations will reflect the mitigation and monitoring measures proposed by the Navy and/or agreed to during ESA consultation (a description of the mitigation measures is in Section 4.6 of this opinion). We will also review mitigation measures imposed by the final regulations to ensure they are consistent with measures to avoid and minimize take prescribed in the ITS included in this opinion. We also anticipate that the levels of take of ESA-listed marine mammals authorized under the final MMPA regulations and LOA will be consistent with those analyzed in this opinion. Upon publication, we will review the MMPA regulations to ensure these conditions are met. If administrative changes are needed following publication of the MMPA regulations, we will update the biological opinion to reflect these changes. If more substantive changes (e.g., those related to the effects analyses, take authorization, and/or avoidance and minimization measures) are needed, the reinitiation triggers described in Section 14 may apply.

Table 24. Maximum annual and seven-year total species-specific take estimates proposed by the NMFS Permits Division for authorization in the LOA from acoustic and explosive sound source effects for all training activities in the GOA Study Area

Species	Stock	Annual		7-Year Total	
		Level B	Level A	Level B	Level A
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Family Balaenidae (right whales)					
North Pacific right whale*	Eastern North Pacific	3	0	21	0
Family Balaenopteridae (rorquals)					
Humpback whale†	California, Oregon, & Washington	10	0	70	0
	Central North Pacific	79	0	553	0
	Western North Pacific	3	0	21	0
Blue whale*	Central North Pacific	3	0	21	0
	Eastern North Pacific	36	0	252	0
Fin whale*	Northeast Pacific	1,242	2	8,694	14
Sei whale*	Eastern North Pacific	37	0	259	0
Suborder Odontoceti (toothed whales)					
Family Physeteridae (sperm whale)					
Sperm whale*	North Pacific	112	0	784	0

* ESA-listed species (all stocks). †Only designated stocks are ESA-listed (under a DPS).

5 POTENTIAL STRESSORS

The potential stressors we expect to result from the proposed action are acoustic stressors, explosive stressors, energy stressors, physical disturbance and strike stressors, entanglement stressors, and ingestion stressors. In addition to the effects of these stressors on ESA-listed species, we consider any effects of stressors through impacts to species' habitat (including water quality or sediments) or prey. Further discussion of each of these stressors is below.

5.1 Acoustic Stressors

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars), as well as incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique energetic characteristics.

5.1.1 Sonar and other Transducers

Active sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. 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 very 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 (Navy 2018c).

The Navy employs a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Under the Navy's proposed action, training activities using sonar and other transducers could occur throughout the action area, although use would generally occur within 200 nautical miles of shore in Navy operating areas, on Navy range complexes, on Navy testing ranges, or around inshore locations (See Section 8.2). Below we describe the use of sonar and other transducers for anti-submarine warfare, mine warfare and small object detection, navigation and safety, and communication as potential stressors on ESA-listed resources.

5.1.1.1 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. Some anti-submarine warfare tracking exercises and ship unit level training activities would also be conducted using simulators in conjunction with other training exercises.

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 feet deep due to safety concerns about running aground at shallower depths. Sonars used for anti-submarine warfare activities would typically be used beyond 12 nautical miles 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.

5.1.1.2 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.

5.1.1.3 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.

5.1.2 Explosives

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

Explosive detonations during training activities associated with high-explosive munitions include, but are not limited to, bombs, missiles, rockets, and naval gun shells. Explosive detonations associated with bombs, missiles, and naval gun shells could occur in the air (see below) or near the water's surface. In-air explosions include detonations of projectiles and missiles during air-to-air missile exercises conducted during air warfare. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Table 25. Many of the in-air explosions typically occur far above the water surface at altitudes greater than 15,000 feet. In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind. The Navy has proposed a new mitigation area for GOA Phase III to avoid or reduce potential impacts from explosive training activities on marine species. Within the Continental Shelf and Slope Mitigation Area (see Section 4.4) the Navy will prohibit the use of in-air explosives (sea surface to 10,000 feet altitude) over the continental shelf and slope out to the 4,000 meter depth contour within the TMAA. There are no underwater explosions in the Navy's proposed action and explosives would not be used in the WMA.

Table 25. Typical air explosive munitions during Navy activities.

Weapon Type[1]	Net Explosive Weight (lb.)	Typical Altitude of Detonation (feet)
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-7 Sea Sparrow	36	> 15,000 (can be used on low targets)
FIM-92 Stinger	7	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-7 Sparrow	36	> 15,000
AIM-120 AMRAAM	17	> 15,000
Projectile - Large Caliber[2]		
5"/54 caliber HE-ET	7	< 100
5"/54 caliber Other	8	< 3,000

[1]Mission Design Series and popular name shown for missiles.
[2]Most medium and large caliber projectiles used during Navy training activities do not contain high explosives.
Notes: AMRAAM = Advanced Medium-Range Air-to-Air Missile; HE-ET = High Explosive-Electronic Time;
lb. = pound(s).

5.1.3 Vessel Noise

Potential impacts of vessel noise on ESA-listed species include masking of other biologically relevant sounds, physiological stress, and changes in behavior. Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and SPLs at a source will vary according to speed, burden, capacity and length (Kipple and Gabriele 2007; McKenna et al. 2012; Richardson et al. 1995c). Because of the number of vessels involved in Navy training activities, the vessel speed, and the use of course changes as a tactical measure with the associated sounds, the available evidence leads us to expect marine mammals and sea turtles to treat Navy vessels as stressors. Further, without considering differences in sound fields associated with any active sonar that is used during these activities, the available evidence suggests that unit- and intermediate-level exercises activities would represent different stress regimes because of differences in the number of vessels involved, vessel maneuvers, and vessel speeds.

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

As described in more detail in Section 5.2.1 below (*Vessel Strike*), Navy vessel traffic makes up an extremely small amount of overall vessel traffic (i.e., much less than one percent) in the action area. Navy vessels may represent an even smaller amount of overall vessel traffic noise in the action area because many Navy ships incorporate quieting technology that other vessels (e.g., commercial ships) do not (Mintz and Filadelfo 2011b). For example, surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection. The Navy implements a "Buy Quiet" policy for equipment aboard ships which requires designers and engineers to obtain noise emission data before purchasing to choose the quietest available. The Navy also researches and implements technology improvements that minimize noise. For example, propellers used on Navy ships have been subject to design improvements to reduce excitation. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz and Filadelfo 2011b). The average acoustic signature for a Navy vessel is 163 dB re 1 μPa, while the average acoustic signature for a commercial vessel is 175 dB re 1 μPa (Mintz and Filadelfo 2011a). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (MacGillivray et al. 2019; Mintz and Filadelfo 2011a; Richardson et al. 1995a; Urick 1983b). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (McKenna et al. 2012). Small craft will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed (MacGillivray et al. 2019; Wladichuk et al. 2019).

5.1.4 Aircraft Noise

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

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training activities throughout the action area, contributing both airborne and underwater sound to the ocean environment. Aircraft used in training 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 26 provides source levels for some typical aircraft used during training in the action area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D aircraft during takeoff. Table 27 shows the number of ongoing events and the number of events proposed that include the use of aircraft.

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

Table 26. Representative aircraft sound characteristics (Navy 2021).

Noise Source	***Sound Pressure Level***
In-Water Noise Level	
F/A-18 Subsonic at 1,000 feet (300 meters) Altitude	152 dB re 1 µPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 feet (3,000 meters) Altitude	128 dB re 1 µPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 feet (25 meters) 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 feet (25 meters) Altitude	113 dBA re 20 µPa at 25 m from source[2]

Sources: [1]Eller and Cavanagh (2000), [2]Bousman and Kufeld (2005), [3]U.S. Naval Research Advisory Committee (2009)
*estimate based on in-air 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)

Table 27. Annual number of aircraft events and sorties including aircraft combat maneuver (Navy 2021).

Activity Area	Aircraft	*Ongoing*	Proposed Action
Anti-Air Warfare	EA-6B, EA-18G, FA-18, F-16, F-15, F-22, E-2	**300 sorties**	**300 sorties**
Air Defense Exercise	FA-18, F-16, F-15, F-22, EA-6B, EA-18G, E-2, P-3C, P-8 MMA,	**4 events**	**4 events**
Air to Surface Missile Exercise	MH-60R/S, FA-18, F-16, F-15, F-22, EA-6B, EA-18G	**2 events**	**2 events**
Air to Surface Bombing Exercise	FA-18, F-16, F-15, F-22	**18 events**	**18 events**
Air to Surface Gunnery Exercise	MH-60R/S	**7 events**	**7 events**
Sea Surface Control	FA-18, EA-6B, EA-18G, E-2, P-3C, P-8	**6 events**	**6 events**
ASW Tracking Exercises	MH-60R	**22 events**	**22 events**
ASW Tracking /Maritime Patrol	P-3C, P-8	**15 events**	**15 events**
Electronic Combat Exercise	EA-6B, EA-18G, E-2, P-3, EP-3,	**11 events**	**11 events**

Special Warfare Operations	C-130, MH-60S	**10 events**	**10 events**
Strike Warfare Air-Ground Bombing	FA-18, F-16, F-15, F-22, EA-6B, EA-18G, E-2	**150 Sorties**	**150 sorties**
Personnel Transport/Recovery	MH-60S	**16 events**	**15 events**
Deck Landing Qualifications	Helicopters	**6 Events**	**6 events**

5.1.4.1 Fixed-wing aircraft

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

5.1.4.2 Helicopters

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 145 dB re 1 μPa at 1 meter below water surface for a UH-60 hovering 82 feet (25 meter) 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 feet. 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.

5.1.4.3 Sonic Booms

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

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves. 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. Atmospheric conditions such as wind speed and direction, and air temperature and pressure can also influence the sound propagation of a sonic boom.

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing the sonic boom intensity that is experienced at the sea or shore level. The width of the boom "carpet" or area exposed to a sonic boom beneath an aircraft is about one mile for each 1,000 feet of altitude. For example, an aircraft flying supersonic, straight, and level at 50,000 feet 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.

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 feet (10 meters) (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 28.

Table 28. Sonic boom underwater sound levels modeled for supersonic flight from a representative aircraft (Navy 2021).

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

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

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

[1] Equivalent to SEL for a plane wave.

5.1.5 Weapons Firing, Launch and Impact Noise

The Navy trains and tests using a variety of weapons. Depending on the weapon, noise may be produced at launch or firing, while in flight, or upon impact. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, were discussed in Section 5.1.2.

Small- to medium-caliber rounds up to but not including the 57 millimeter (mm) non-explosive round could be used 12 nautical miles or more from shore. Large-caliber non-explosive rounds could be used 20 nautical miles or more from shore. Medium- and large-caliber explosive rounds could be used 50 nautical miles or more from shore. Examples of some types of weapons noise resulting from the proposed action are shown in Table 29.

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

Table 29. Examples of some types of weapons noise from GOA TMAA/WMA activities (Navy 2021).

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]

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

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

Supersonic projectiles, such as a fired gun shell or kinetic energy weapon, create a bow shock wave along the line of fire. A bow shock wave is an impulsive sound caused by a projectile exceeding the speed of sound. The bow shock wave itself travels at the speed of sound in air. The projectile bow shock wave created in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65°) behind the projectile in the direction of fire (Pater 1981). Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location. Measurements of a five inch projectile shock wave ranged from 140 to 147 dB re 20 μPa SPL peak taken at the ground surface at 0.59 nautical miles distance from the firing location and 10° off the line of fire for safety (approximately 190 meters from the shell's trajectory) (U.S. Department of the Navy 1981). Hyperkinetic projectiles may travel up to and exceed approximately six times the speed of sound in air, or about 6,500 feet per second (U.S. Department of the Navy 2014). 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. Missiles can be rocket or jet propelled. Examples of launch noise sound levels are shown in Table 29. (U.S. Department of the Navy 2014).

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)(Mclennan 1997)(Mclennan 1997)(Mclennan 1997)(Mclennan 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

5.2 Physical Disturbance and Strike Stressors

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

5.2.1 Vessel Strike

Vessels used by the Navy during training activities include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 15 feet to over 1,000 feet. Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 40 feet in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. There are a few specific events including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the joint high speed vessel (which will operate at an average speed of 35 knots) where vessels would operate at higher speeds.

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 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002; 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. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002; Wursig et al. 1998). 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 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., sperm whales). In addition, some baleen whales seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al. 2004a). 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; Silber et al. 2021; 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. (2010) found when a whale is below the surface (about one to two times the vessel draft), under certain circumstances (vessel speed and location of the whale relative to the ship's centerline), 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.

For the GOA Phase III proposed action, the estimated vessel activity would be up to 126 vessel days per year (i.e., up to six surface combatant vessels for an exercise lasting up to 21 days), or 3,024 steaming hours per year. Navy vessel activity in the GOA is extremely small compared to the large numbers of cargo, fishing, cruise, and other ships transit Alaskan waters each year (see Section 7.5.2 below for details). Navy ships that participate in GOA training events would come from a variety of locations depending on the specifics of each individual exercise. Private fishing vessels that come from existing ports in Alaska are sometimes contracted by the Navy to simulate opposition forces during the GOA exercises. The Coast Guard may also participate in Navy GOA exercises, and those vessels would come from existing Coast Guard bases/homeports in Alaska (e.g., Cordova, Kodiak, or Juneau).

5.2.2 In-Water Devices

In-water devices include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles and unmanned undersea vehicles 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 (Table 30). In-water devices are generally smaller than most Navy vessels, ranging from several inches to about 50 feet, and can operate anywhere from the water surface to the benthic zone.

Table 30. Representative types, sizes, and speeds of Navy in-water devices (Navy 2021).

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

5.2.3 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 target fragments, and (4) expended materials other than munitions, such as expended bathythermographs. Table 31 presents a comparison of military expended material during ongoing activities with the numbers as part of the Navy's proposed action that can potentially affect ESA-listed species such as non-explosive practice munitions (small-, medium-, and large-caliber missiles, rockets, bombs), fragments from explosives, and countermeasures (flares, chaff).

Table 31. Annual Number of Military Expended Materials (Navy 2021).

Military Expended Materials Item	*GOA Phase II Ongoing*	*GOA Phase III Proposed*
Non-Explosive Practice Munitions		
Missiles (Air-to-Air)	3	3
Large-Caliber Projectiles	160	160
Large-Caliber Projectile Casings	218	218
Medium-Caliber Projectiles	1,225	1,225
Medium-Caliber Projectile Casings	1,225	1,225
Small-Caliber Projectile Casings	700	700
Marine Markers	58	58
Sonobuoys	760	760
Explosive Munitions that May Result in Fragments		
Bombs	72	72
Large-Caliber Projectiles	58	58
Missiles (Air-to-Air)	3	3
Missiles (Air-to-Surface)	2	2
Missiles (Surface-to-Air)	6	6
Decelerators/Parachutes		
Small Decelerator/parachutes	758	758
Large Parachutes	3	3
Wires and Cables		
Sonobuoy Wires	760	760
Targets		

Military Expended Materials Item	*GOA Phase II Ongoing*	*GOA Phase III Proposed*
MK-39 Expendable Mobile ASW Training Target	35	35
Countermeasures		
In-Water Acoustic Countermeasures	2	2
Chaff	159	159
Flares	175	175
Endcaps	334	334
Compression pads/pistons	175	175
O-rings	175	175
Other Expended Items		
Illumination Flares	3	3

5.2.4 Seafloor Devices

Seafloor devices include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as "crawlers." 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 species. The only seafloor device used during training activities that has the potential to strike an ESA-listed species 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, therefore the analysis of the potential impacts from those devices are covered in the military expended material strike section.

5.3 Entanglement Stressors

The Navy proposes to utilize a variety of materials that could pose an entanglement risk to ESA-listed species including fiber optic cables, guidance wires, sonobuoys wires, decelerators and parachutes, and biodegradable polymers. Depending on the type of material, entanglement could occur at the sea surface, in the water column, or on the seafloor. Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with certain types of military expended materials could result in negative sub-lethal effects and mortality. For one of these materials to result in entanglement it must be long enough to wrap around the appendages of marine animals. Another critical factor is rigidity; the item must be flexible enough to wrap around appendages or bodies.

5.3.1 Wires and Cables

During some proposed training activities, the Navy may temporarily install and remove or expend different types of wires and cables. Temporary installations could include arrays or mooring lines attached to the seafloor or to surface buoys or vessels.

5.3.1.1 Fiber Optic Cables

Although a portion may be recovered, some fiber optic cables used during Navy training activities would be expended. The length of the expended tactical fiber would vary depending on the activity. Tactical fiber has a silica core and acylate coating, and looks and feels like thin monofilament fishing line. Tensile strength and cable diameter may vary depending on the type of tactical fiber used, however, tactical fibers are generally 242 micrometers (µm; 0.24 mm) in diameter, have a 12 pounds tensile strength, and a 3.4 mm bend radius (Corning Incorporated, 2005 and Raytheon Company, 2015 as cited in 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.). 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 per second) where it would be susceptible to abrasion and burial by sedimentation.

5.3.1.2 Guidance Wires

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 rapidly 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 pounds (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 meters per second (Swope and McDonald 2013).

5.3.1.3 Sonobuoy and Bathythermograph Wires

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 lbs. 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 feet 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.

5.3.2 Decelerators and Parachutes

Decelerators and parachutes used during training activities are classified into four different categories based on size: small, medium, large, and extra-large. Aircraft-launched sonobuoys and lightweight torpedoes use nylon decelerators/parachutes ranging in size from 18 to 48 inches in diameter (small). The numbers of each being currently used and proposed will not change and are presented in Table 31. 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 feet 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.

Aerial targets (drones) use large (between 30 and 50 feet in diameter) and extra-large (80 feet 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 feet in length [with up to 28 lines per decelerator/parachute]; and extra-large: 82 feet in length [with up to 64 lines per decelerator/parachute]). Some aerial targets also use a small drag parachute (6 feet 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.

5.4 Ingestion Stressors

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

5.4.1 Non-Explosive Practice Munitions

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

5.4.2 Fragments from High Explosive Munitions

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

5.4.3 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 feet 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.

5.4.4 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. 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. 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.

Table 31 shows the number and location of chaff cartridges used during training activities, most to be used in special use airspace, not near shore.

5.4.5 Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft. The flare device consists of a cylindrical cartridge approximately 1.4 inches in diameter and 5.8 inches in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic compression pad or piston (0.45 to 4.1 grams depending on flare type). The flare pads and pistons float in sea water for some time and are typically not recovered.

5.5 Secondary Stressors

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

The use of Navy explosives could impact other species in the marine food web, including prey species that the ESA-listed species considered in this opinion feed upon. Underwater explosions may reduce available prey items for ESA-listed species by either directly killing prey or through behavioral responses such as diving, scattering or avoidance of an area. Explosions can also leave explosive byproducts in the water which could have impacts on water quality.

Metals are introduced into seawater and sediments as a result of training activities involving targets, munitions, and other military expended materials (Navy 2021). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Several Navy training activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, missiles, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures may allow propellants and their degradation products to be released into the marine environment.

6 Species and Designated Critical Habitat that May be Affected

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area that may be affected by the proposed action along with their regulatory status (Table 32). Critical habitat denoted with a star (*) in Table 32 indicates that critical habitat for this species does not overlap with the action area and is not considered in this consultation.

Section 6.1 identifies those species and designated critical habitat that may be affected but are not likely to be adversely affected by the proposed action because the effects of the proposed action, evaluated for each stressor, were deemed insignificant, discountable, or wholly beneficial.

In Section 6.2 we provide a summary of the biology, ecology, and population status of those species that are likely to be adversely affected by one or more stressors created by the proposed action and detail information on their life histories in the action area, if known. The species that are likely to be adversely affected by the proposed action are carried forward in our effects analysis (Section 0).

Table 32. ESA-listed species and designated critical habitat that may be affected by the proposed action.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998 10/2018
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) – Western North Pacific DPS	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	84 FR 54354	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Western North Pacific DPS	E – 81 FR 62259	84 FR 54354	11/1991
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000*	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Pinnipeds			
Steller Sea Lion (*Eumetopias jubatus*) – Western DPS	E – 55 FR 49204	58 FR 45269*	73 FR 11872 2008
Marine Reptiles			
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170*	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Fishes			
Chinook salmon (*Oncorhynchus tshawytscha)* – California Coastal ESU	T – 70 FR 37160	70 FR 52488*	81 FR 70666
Chinook salmon (*Oncorhynchus tshawytscha)* – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488*	79 FR 42504
Chinook salmon (*Oncorhynchus tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629*	78 FR 41911
Chinook salmon (*Oncorhynchus tshawytscha)* – Puget Sound ESU	T – 70 FR 37160	70 FR 52629*	72 FR 2493
Chinook salmon (*Oncorhynchus tshawytscha)* – Sacramento River Winter-Run ESU	E – 70 FR 37160	58 FR 33212*	79 FR 42504
Chinook salmon (*Oncorhynchus tshawytscha)* – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543*	80 FR 67386 (Draft)
Chinook salmon (*Oncorhynchus tshawytscha)* – Snake River Spring/Summer Run ESU	T – 70 FR 37160	64 FR 57399*	81 FR 74770 (Draft) 11-2017-Final
Chinook salmon (*Oncorhynchus tshawytscha)* – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629*	72 FR 57303
Chinook salmon (*Oncorhynchus tshawytscha)* – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629*	76 FR 52317

Species	ESA Status	Critical Habitat	Recovery Plan
Chum salmon (*Oncorhynchus keta*) – Columbia River ESU	T – 70 FR 37160	70 FR 52629*	78 FR 41911
Chum salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629*	72 FR 29121
Coho salmon (*Oncorhynchus kisutch*) – Central California Coast ESU	E – 70 FR 37160	64 FR 24049*	77 FR 54565
Coho salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251*	78 FR 41911
Coho salmon (*Oncorhynchus kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816*	81 FR 90780
Coho salmon (*Oncorhynchus kisutch*) – Southern Oregon and Northern California Coasts ESU	T – 70 FR 37160	64 FR 24049*	79 FR 58750
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 71 FR 17757	74 FR 52300*	2010 (Outline) 8/2018- Final
Sockeye salmon (*Oncorhynchus nerka*) – Ozette Lake ESU	T – 70 FR 37160	70 FR 52630*	74 FR 25706
Sockeye salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543*	80 FR 32365
Steelhead (*Oncorhynchus mykiss*) – California Central Valley DPS	T – 71 FR 834	70 FR 52487*	79 FR 42504
Steelhead (*Oncorhynchus mykiss*) – Central California Coast DPS	T – 71 FR 834	70 FR 52487*	81 FR 70666
Steelhead (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629*	78 FR 41911
Steelhead (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629*	74 FR 50165
Steelhead (*Oncorhynchus mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487*	81 FR 70666
Steelhead (*Oncorhynchus mykiss*) – Puget Sound DPS	T – 72 FR 26722	81 FR 9251*	84 FR 71379
Steelhead (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629*	81 FR 74770 (Draft) 11-2017-Final
Steelhead (*Oncorhynchus mykiss*) – South-Central California Coast DPS	T – 71 FR 834	70 FR 52487*	78 FR 77430

Species	ESA Status	Critical Habitat	Recovery Plan
Steelhead (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487*	77 FR 1669
Steelhead (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629*	72 FR 57303
Steelhead (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629*	76 FR 52317

* indicates that critical habitat for this species does not overlap with the action area and is not considered in this consultation.

6.1 Species and Critical Habitat Not Likely to be Adversely Affected

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

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

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

Beneficial effects have an immediate positive effect without any adverse effects to the species or habitat.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect.

Discountable effects are those that are extremely unlikely to occur (NMFS and USFWS 1998).

We applied these criteria to the ESA-listed species in Table 32 above. We summarize our results below for ESA-listed species and critical habitat that are not likely to be adversely affected by any stressor created by the proposed action.

6.1.1 Gray Whale Western North Pacific DPS

Gray whales occur in two genetically distinct populations on the eastern and western sides of the North Pacific Ocean (Brownell Jr. et al. 2009; Burdin et al. 2011; Kanda et al. 2010; Lang et al. 2004; Lang et al. 2005; Lang et al. 2010; Leduc et al. 2002; Swartz et al. 2006; Weller et al. 2007; Weller et al. 2004; Weller et al. 2006). Western North Pacific gray whales migrate annually along Asia during autumn, although migration routes are poorly known. Migration from summer foraging areas off the northeastern coasts of Sakhalin Island and south-eastern Kamchatka along the Japanese coasts to the South China Sea is suspected (Commission 2004; IWC 2003; Omura 1988; Tsidulko et al. 2005; Weller et al. 2008; Weller et al. 2012b). Eastern and western North Pacific gray whales were once considered geographically separated along either side of the ocean basin, but recent photoidentification, genetic, and satellite tracking data refute this. Two western North Pacific gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south to the Washington State and Oregon coasts in one case (Mate et al. 2011), and to the southern tip of Baja California and back to Sakhalin Island in another (IWC 2012). Most gray whales follow the coast during migration and stay within a few miles of the shoreline, except when crossing major bays, straits, and inlets from southeastern Alaska to the eastern Bering Sea (NMFS 2019e).

The winter breeding grounds for the Western North Pacific DPS may be areas in the South China Sea, although a total of 23 Western North Pacific gray whales have been photo-identified when on the eastern side of the Pacific Coast during winter and spring (Weller et al. 2013). Additionally, long-term studies of radio-tracked whales and genetic studies have detected western population whales along the North American coast from British Columbia, Canada, and as far south as Baja California, Mexico (Brüniche-Olsen et al. 2018; Mate et al. 2015a; Muir et al. 2016; Weller et al. 2013; Weller and Brownell 2012; Weller et al. 2002; Weller et al. 2012a). In a review of tagging data from Oregon State University, a total of 73 gray whales were tagged in the North Pacific from 1994 to 2013, providing tracks for 69 whales (Palacios et al. 2021). Tag deployments took place in Oregon and California in 1994, 2009, 2012, and 2013 (37 tags), in Mexico in 1996 and 2005 (29 tags), and in Russia in 2010 and 2011 (7 tags). No whales tagged in Oregon and California were tracked within the TMAA. Two whales tagged in Mexico had locations within the TMAA, and the track of one additional individual crossed the TMAA. Finally, one whale tagged in Russia had locations within the TMAA during its southbound migration and one other individual crossed the TMAA during its northbound track (Palacios et al. 2021). Therefore, while most gray whales migrating through the action area are likely from the eastern population, individuals from the Western North Pacific DPS may also be present (Carretta et al. 2020c). It is assumed that a very small percentage of gray whales migrating through the action area could be individuals from the endangered Western North Pacific DPS.

There is limited information on the presence or abundance of Western North Pacific gray whales in the WMA. NMFS (2019e) determined that Western North Pacific gray whales would be considered rare within the action area for the NMFS Biological Opinion for Alaska Fisheries Science Center Surveys in the Gulf of Alaska, Bering Sea/Aleutian Islands, and Chukchi Sea/Beaufort Sea Research Areas, which partially overlaps with the WMA.

While Western North Pacific gray whales could potentially be exposed to sonar and other acoustic sources associated with training activities in the TMAA, the estimated density of this species in the action area is so low that it is extremely unlikely that any stressors from Navy activities would overlap (in time and space) with this DPS. The Navy's quantitative analysis using NAEMO estimates no impacts to Western North Pacific gray whales as a result of the proposed action. In addition to procedural mitigation (Section 3.5.1), the Navy will implement mitigation within mitigation areas, which will further help avoid the already low potential for impacts from active sonar and explosives on gray whales. Given the extremely low numbers of the western North Pacific gray whale stock in the North Pacific Ocean and their rare occurrence in the Gulf of Alaska, exposure to other potential stressors in the TMAA/WMA, including vessel strike, would be extremely unlikely.

The Navy will issue annual seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of gray whales in their migration habitat from April 1 to August 31. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation during activities using active sonar. This mitigation area overlaps habitat within the northernmost corner and southwestern edge of the action area that has been identified by Ferguson et al. (2015a) as biologically important gray whale migration habitat.

In summary, due to the very rare occurrence of Western North Pacific DPS gray whales in Alaska, anticipated extremely low density in the TMAA, and extremely unlikely overlap of Navy activities in the GOA and this species, the effects of the proposed action on Western North Pacific gray whales are discountable. For these reasons, we determine that the proposed action may affect, but is not likely to adversely affect Western North Pacific DPS gray whales.

6.1.2 Humpback Whale – Western North Pacific DPS

The humpback whale is a widely distributed baleen whale found in all major oceans. Humpback whales 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 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico) (Figure 39).

Information available from the recovery plan (NMFS 1991), the recent SAR (Carretta 2019), the status review (Bettridge et al. 2015b), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

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

In Alaska waters, humpback whales feed in association with high densities of zooplankton and fish near the Kodiak Archipelago (Witteveen et al. 2014; Witteveen et al. 2011; Witteveen and Wynne 2017) and in association with seasonal runs of herring in Prince William Sound (Burrows et al. 2016; Moran et al. 2018; Moran et al. 2015). Witteveen et al. (Witteveen et al. 2011) determined that in the biologically important area (BIA) humpback whales fed heavily on euphausiids, but also ate herring, eulachon, juvenile walleye pollock, capelin, and sand lance, with annual differences in diet due to either individual prey preferences or prey availability. Moran et al. (2018) estimated that humpback whales in Prince William Sound consumed approximately the biomass lost to natural mortality over winter and that the herring predation in Prince William Sound can exert top-down controlling pressure but not overall in the Gulf of Alaska at this time. In 2019, commercial fishermen landed over 40 million pounds of herring in Alaska for that year (Alaska Department of Fish and Game 2020).

While humpback whales are present in Prince William Sound year round (Moran et al. 2018; Rice et al. 2015b), off Kodiak Island the greatest densities are present July–September, and in the Prince William Sound feeding area the greatest densities are present September–December (Ferguson et al. 2015a). Humpback whales in the offshore waters adjacent to Prince William Sound (including Lower Cook Inlet, Kenai Fjords, and the Barren Islands) tended to have a diet higher in fish than zooplankton, whereas the animals located in Prince William Sound fed almost exclusively on fish (Witteveen et al. 2011). Line transect surveys overlapping the Action Area in 2009, 2013, and 2015 determined that the main humpback whale aggregations in all survey years were located on the eastside of Kodiak Island (Rone et al. 2009; Rone et al. 2014; Rone et al. 2017).

Western North Pacific DPS humpback whales mainly feed in Russian waters and have been suggested to potentially feed in the Gulf of Alaska (Muto et al. 2020) . This DPS winters in waters described as Okinawa/Osagawara/Philippines or Western North Pacific (Bettridge et al. 2015a) which now also includes the Mariana Islands (Hill et al. 2017; Hill et al. 2016; Hill et al. 2020; National Marine Fisheries Service 2016; National Oceanic and Atmospheric Administration 2015; National Oceanic and Atmospheric Administration 2018; Titova et al. 2017).

In Wade (2021), a multi-strata mark recapture model was fit to the photo-identification data using a six-month time-step, with the four winter areas and the six summer areas defined to be the sample strata. The four winter areas corresponded to the four North Pacific DPSs: Western North Pacific, Hawaii, Mexico, and Central America. The analysis was used to estimate abundance within all sampled winter and summer areas in the North Pacific, as well as to estimate migration rates between these areas. The migration rates were used to estimate the probability that whales from each winter/breeding area were found in each of the six summer/feeding areas. Results of the Wade (2021) analysis indicated a less than one percent probability that a humpback whale encountered in the Gulf of Alaska summer feeding area was from the endangered Western North Pacific DPS, compared to an 89 percent probability from the Hawaii DPS and 11 percent probability from the Mexico DPS.

The Navy's quantitative analysis (NAEMO), using the maximum number of sonar hours and explosions per year, estimates no impacts to Western North Pacific DPS humpback whales under the proposed action from sonar or explosives.

In summary, the probability of encountering humpback whales from the Western North Pacific DPS in the Gulf of Alaska extremely small. Therefore, the likelihood Navy training activities in the Gulf of Alaska TMAA/WMA affecting Western North Pacific DPS of humpback whales is extremely unlikely and thus discountable. Thus, we determine that the proposed action may affect, but is not likely to adversely affect the Western North Pacific DPS of humpback.

6.1.3 Steller Sea Lion Western DPS

Steller sea lions are distributed mainly around the coasts to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaiddo, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California. Based on the results of genetic studies, the Steller sea lion population was reclassified into two distinct population segments: western and eastern. The data which came out of these studies indicated that the two populations had been separate since the last ice age (Bickham et al. 1998). Further examination of the Steller sea lions from the Gulf of Alaska (i.e., the Western DPS) revealed a high level of haplotypic diversity, indicating that genetic diversity had been retained despite the decline in abundance (Bickham et al. 1998).

The endangered Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia). The Western DPS also includes Steller sea lions that have been born at and west of Cape Suckling, Alaska (144° West) but members of the Eastern (ESA-delisted) and Western DPS are known to cross this boundary (Muto et al. 2018). Based on (Muto et al. 2021)2019 modeled data, the best estimate of abundance of the Western Steller sea lion DPS in Alaska is 12,581 pups and 40,351 non-pups (total N_{min} = 52,932) (Muto et al. 2021). This represents a large decline from counts in the 1950s (N = 140,000) and 1970s (N = 110,000).

Steller sea lions from the Western DPS are likely to occur year round in the nearshore portion of the TMAA. Only Steller sea lions from the Eastern Gulf of Alaska and Central Gulf of Alaska are expected to occur within the TMAA, based on proximity of haulout and breeding sites located along the coastline. Unpublished data from the Alaska Department of Fish and Game show tagged female Steller sea lions repeatedly traveling from haulout sites to the shelf break (approximated as the 500 meter isobath) to forage but not venturing off the shelf. Very little data exist on the offshore movements of male Steller sea lions. The pooled juvenile home range of Steller sea lions tagged between 2000 and 2014 in Prince William Sound were concentrated within their home range, which extended from Kayak Island in the east (59.90 N, 144.40 W) to Kodiak Island in the west (58.20 N, 154.30 W). These animals were generally coastal, with some evidence of excursions offshore onto the shelf, or to adjacent regions, as well as movement between the two DPSs (Bishop et al. 2018; Jemison et al. 2018; Kuhn et al. 2017).

The Navy's quantitative analysis (NAEMO), using the maximum number of sonar hours and explosions per year, estimates no impacts to Western DPS Steller sea lions under the proposed action from sonar or explosives. The occurrence of a Western DPS Steller sea lion within the offshore portions (i.e., beyond the shelf break) of either the TMAA or the WMA is unlikely as this species is more associated with the inland portion of the action area. The large majority of Navy GOA activities, including vessel movement, sonar and explosives would occur in the offshore portion of the action area where Steller sea lions are only rarely encountered. Noise from aircraft covered under the proposed action would be limited to within the action area and would not affect Steller sea lion nearshore breeding and haulout sites. Aircraft transits into and out of the action area are covered under the U.S. Air Force Joint Pacific Alaska Range Complex in Alaska (JPARC) EIS.

As such, it is extremely unlikely that Steller sea lions would be exposed to stressors from Navy activities. Implementation of Navy mitigation measures (Section 4.6.1) will further reduce the likelihood of impacts on Steller sea lions. In addition, the proposed action will avoid Steller sea lion haulouts and nursing areas and the TMAA boundaries will continue to be located outside of the 1993 NMFS-designated Steller sea lion critical habitat. For the reasons above, the likelihood of Navy training activities in the Gulf of Alaska TMAA/WMA affecting Western DPS Steller sea lions is extremely unlikely, and thus discountable. Thus, we determine that the proposed action may affect, but is not likely to adversely affect Western DPS Steller sea lion.

6.1.4 Leatherback Sea Turtle

The leatherback sea turtle ranges worldwide from tropical to subpolar latitudes. Because only leatherbacks originating from the Western Pacific nesting beaches may be found in the action area, this biological opinion will focus on the effects of the proposed action on the West Pacific population. In contrast with other sea turtles, leatherback sea turtles have physiological traits that allow for the conservation of body heat which enable them to maintain body core temperatures well above the ambient water temperatures (Eckert 1993; Greer et al. 1973; Pritchard 1971). Leatherback sea turtles have been documented in Alaska waters as far north as approximately 60° latitude and as far west in the Gulf of Alaska as the Aleutian Islands (Eckert 1993). There are no known nesting habitats for the leatherback sea turtle in the action area.

Within the GOA leatherback sea turtles are considered very rare. The likelihood of an individual leatherback sea turtle occurring in the GOA action area is extremely low. Approximately 20 sightings of leatherbacks have been recorded in Alaskan waters over the past six decades, with the most recent occurring in 2013 (Cushing et al. 2021; Hodge and Wing 2000). Cushing et al. (2021) collected observations of species generally associated with warmer waters over the course of 15 years of vessel-based seabird surveys within the Gulf of Alaska. One observation of a leatherback sea turtle was reported in the summer of 2013, to the east of the TMAA over the continental shelf. Prior to 2013, the last confirmed sighting of a leatherback in Alaskan waters was in 1993. No tagged leatherbacks have been tracked to Alaska in recent telemetry studies, with tags ending at approximately 50°N (Navy 2021). The rare occurrence of leatherback sea turtles in Alaska suggests that they are ranging into marginal habitat (Hodge and Wing 2000). In a study analyzing the movements of 135 leatherbacks fitted with satellite tracking tags, the turtles were found to inhabit waters with sea surface temperatures ranging from 11.3 to 31.7°C (mean of 24.7°C) (Bailey et al. 2012). Sea surface temperature (SST) in the GOA is frequently colder. An average of three years of SST data in the Gulf of Alaska for the month of May indicated that temperatures in the TMAA ranged from 6.7 to 8.7°C (Navy 2021), several degrees below the minimum temperature reported by Bailey et al. (2012). Analyzing several years of SST data for the month of August, when temperatures are warmest, showed the average temperature in the TMAA was still below 15°C, which is at the lower end of the temperature range characteristic of leatherback habitat, and nearly 10°C below the mean temperature where Bailey et al. (2012) reported leatherbacks occurred (Navy 2021).

Based on the extremely rare occurrence of leatherback sea turtles in the action area, we anticipate that the likelihood of individual sea turtles co-occurring with stressors from the Navy's proposed GOA activities is extremely unlikely and thus discountable. For these reasons, we determine that the proposed action may affect, but is not likely to adversely affect leatherback sea turtles.

6.1.5 Green Sturgeon – Southern DPS

Southern DPS green sturgeon are confirmed to occur from Graves Harbor, Alaska, to Monterey Bay, California (Figure 18) (Moyle 2002). While green sturgeon have been observed in coastal, nearshore, and estuarine habitats from southeast Alaska through the Gulf of Alaska to the northwest side of Unalaska Island in the Aleutian Chain (Environmental Protection Information Center et al. 2001), this species is only infrequently encountered at these extreme boundaries of their range (Colway and Stevenson 2007). Cold temperatures, perhaps in combination with other factors related to the danger and energy expenditure associated with dispersing far from their spawning grounds in California, likely explain why Southern DPS green sturgeon are rare visitors north of 54°N latitude (Huff et al. 2012).

Studies support the notion that green sturgeon are rare in Alaskan waters (NMFS 2015c). Lindley et al. (2008) tagged 213 sub-adult and adult Northern DPS (not ESA-listed) and Southern DPS green sturgeon from Oregon, Washington, and California and observed only one tagged (Southern DPS) green sturgeon taken in a commercial gillnet fishery in southeast Alaska, further supporting the assumption that green sturgeon only rarely enter Alaskan waters.

The North Pacific Groundfish Observer Program, which observes federal groundfish fisheries off Alaska within the action area, has recorded rare encounters with green sturgeon in trawl fisheries in the Bering Sea for over three decades (1982:1 fish; 1984:2 fish; 2005:1 fish; 2006:3 fish; 2009:1 fish; 2012:1 fish; 2013:1 fish; and 2015:1 fish; reported in (NMFS 2015c). It is unknown whether these green sturgeon belonged to the Northern DPS or the Southern DPS. During the same three decade period there have been no takes of green sturgeon reported from any of the fishery surveys conducted in the Alaska region by the Alaska Fisheries Science Center.

In 2006, Colway and Stevenson (2007) noted the presence of two green sturgeon specimens (unidentified DPS) in the Bering Sea and the western Gulf of Alaska. Since then, fishery observers in the Bering Sea have encountered only four additional green sturgeon specimens (DPS unknown). Since green sturgeon have been documented as far north as Graves Harbor (in eastern Gulf of Alaska) (73 FR 52300), it is possible that Southern DPS fish could be present in the Gulf of Alaska and the on-shelf portion of the TMAA. However, it is more likely that any green sturgeon in the Gulf of Alaska are non-listed Northern DPS fish. The Alaska Department of Fish and Game indicates that information about green sturgeon presence is limited to a few anecdotal reports of sightings and captures in State of Alaska waters, occurring mostly in southeastern Alaska (encompassing the mouths of the Stikine and Taku rivers).

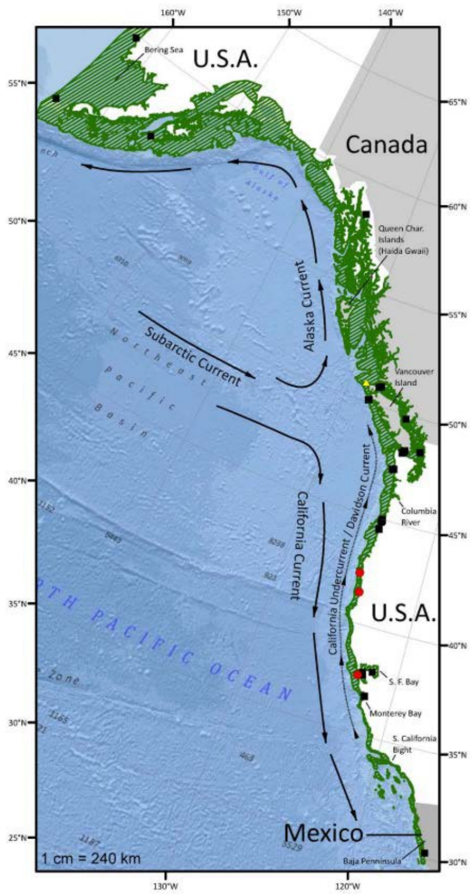


Figure 18. Distribution of green sturgeon along the West Coast of North America (from Huff et al. 2012).

Green sturgeon typically inhabit estuaries on the northern California, Oregon, and Washington coasts during the summer, and move to coastal marine waters along the central California coast and waters off of Vancouver Island and southeast Alaska over the winter (Lindley et al. 2008). Although there is a chance that green sturgeon may be seasonally present (late fall/winter) in shallower, more rugose portions of the Gulf of Alaska continental shelf (less than 200 meters deep), these areas represent a very small portion of the TMAA (Huff et al. 2020). Thus, the probability that ESA-listed Southern DPS green sturgeon would be present in the action area is very low, particularly during the seven month window (April through October) when training activities could occur. Green sturgeon would not be expected to occur in the offshore WMA portion of the action area.

As documented further in Section 0 of this biological opinion, the only stressor we determined would likely adversely affect ESA-listed fish species is the use of in-air explosive ordnances. Because green sturgeon are benthic-associated fish, typically found on or near the seafloor, the impact of explosives occurring in-air would be lessened by both the air-water interface and the distance from detonation point (at or near surface) and green sturgeon on the seafloor.

In addition, the Navy has proposed to not detonate any explosives on the continental shelf or a portion of the slope extending out to 4,000 meters. Off the U.S. West Coast, green sturgeon have been detected on the outer continental shelf at depths up to 200 m, but are typically found at shallower depths of 20–60 meters, and from 9.5–16.0°C when in the marine environment (Huff et al. 2011). While generally considered rare throughout Alaska, the occurrence of green sturgeon in the action area where explosives would be used (i.e., off the shelf or on the slope in water depths exceeding 4,000 meters) would be extremely rare.

In summary, due to the generally rare occurrence of green sturgeon in Alaska, anticipated very low density of Southern DPS fish in the TMAA, and extremely unlikely overlap (in both time and space) of Navy explosive activities in the GOA with this species, the effects of the proposed action on Southern DPS green sturgeon are discountable. As discussed in Section 8.1.2, effects of all other stressors on ESA-listed fish were found to be either insignificant or discountable. For these reasons, we determine that the proposed action may affect, but is not likely to adversely affect Southern DPS green sturgeon.

6.1.6 Chinook salmon from Oregon, Washington, and Idaho

Chinook salmon are widely distributed in offshore waters of the North Pacific Ocean, however, little is known about their oceanic ecology (Courtney et al. 2019). The oceanic range of Chinook salmon throughout the North Pacific Ocean encompasses Washington, Oregon, California, and extends north into Alaska and as far south as the U.S./Mexico border. Significant variability in Chinook salmon ocean distribution across populations has been documented (Celewycz et al. 2014; Shelton et al. 2019; Weitkamp 2010). ESA-listed Chinook salmon from Washington, Oregon and Idaho have been recovered as far north as Bristol Bay and the Gulf of Alaska, and as far south as northern California.

Two general life history strategies have been described for Chinook outmigrating from their natal rivers: subyearling life history types that enter marine waters during their first year of life and tend to remain in shallow coastal waters, and yearling types, which spend more time in freshwater before migrating to the ocean, and migrate further offshore and north faster than subyearlings (Burke et al. 2013). In general, once Chinook leave their natal rivers, they use the cool, upwelled waters of the continental shelf for migration and feeding (Bellinger et al. 2015). The spawning migration of Chinook salmon is variable with most northern populations (e.g., populations migrating to Alaska) returning in the spring (i.e., spring-run), whereas southern migrating populations may return in the spring, summer (i.e., summer-run), or fall (i.e., fall-run) months (Courtney et al. 2019).

Migratory patterns of Chinook salmon can vary greatly within and among populations (PFMC 2014), but some general patterns have been described. Weitkamp (2010) used coded-wire-tags to estimate the distribution of Chinook salmon from various recovery areas along the west coast of North America. She found that Chinook salmon originating from a particular freshwater region generally share a common marine distribution. Chinook salmon originating from north of Cape

Blanco in Oregon tend to migrate towards the Gulf of Alaska, whereas those originating south of Cape Blanco tend to migrate west and south to forage in waters off Oregon and California (PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014)(PFMC 2014) . Chinook salmon originating from Washington, Oregon, and Idaho were recovered within an area from their respective state coasts to Alaska (Figure 19). A fairly large proportion of Chinook from ESA-listed ESUs originating from Washington and Oregon were recovered in the Southeast Alaska recovery area (indicated by dotted yellow [southern Southeast Alaska] and solid yellow [northern Southeast Alaska] bars). Compared to the number recovered in Southeast Alaska, much smaller numbers of ESA-listed Chinook originating from Washington and Oregon were recovered in the three recovery areas in closest proximity to the action area: Yakutat Coast, Cook Inlet West, and Prince William Sound. Of these three areas, the Yakutat Coast recovery area had the largest proportion of Chinook originating from Washington and Oregon recovered, with much smaller proportions recovered in Cook Inlet or Prince William Sound. Thus, information on the proportion recovered in each recovery area suggests higher abundances and densities of ESA-listed Chinook ESUs in Southeast Alaska relative to portions of the GOA closer to the action area (i.e., to the north and west). Trudel et al. (2009) used coded-wire tag recoveries to derive distribution and migration patterns of juvenile Chinook salmon along the continental shelf of North America. Similar to Weitkamp (2010), they found that the vast majority of juvenile Chinook from the Columbia River did not migrate further north than southeast Alaska.

Guthrie III et al. (2021) conducted a genetic analysis of Chinook salmon bycatch of the 2019 GOA trawl fisheries for walleye pollock (*Gadus chalcogrammus*) and rockfish (*Sebastes spp.*) to determine stock composition. Based on analysis of 2,883 Chinook salmon samples from the GOA pollock fishery, fish originating from British Columbia (39 percent) had the largest contribution followed by the U.S. West Coast (33 percent). Based on the genotyping of 686 Chinook salmon bycatch samples collected from the GOA rockfish fishery the West Coast region accounted for the majority of the bycatch (69 percent).

Based on information presented above (Weitkamp 2010) and other available information (e.g., Crane et al. 2000; Templin and Seeb 2004; Wahle and Pearson 1981; Wahle and Vreeland 1978), we would expect the following six ESA-listed Chinook salmon ESUs to occur in the GOA: Upper Columbia River spring-run, Snake River spring/summer-run, Snake River fall-run, Puget Sound, Lower Columbia River, and Upper Willamette River. However, available information for estimating abundance and density of these ESUs within the GOA TMAA, or more specifically in the offshore portion of the TMAA where explosives would be used (i.e., off the continental shelf and beyond 4,000 meter depths), is relatively sparse.

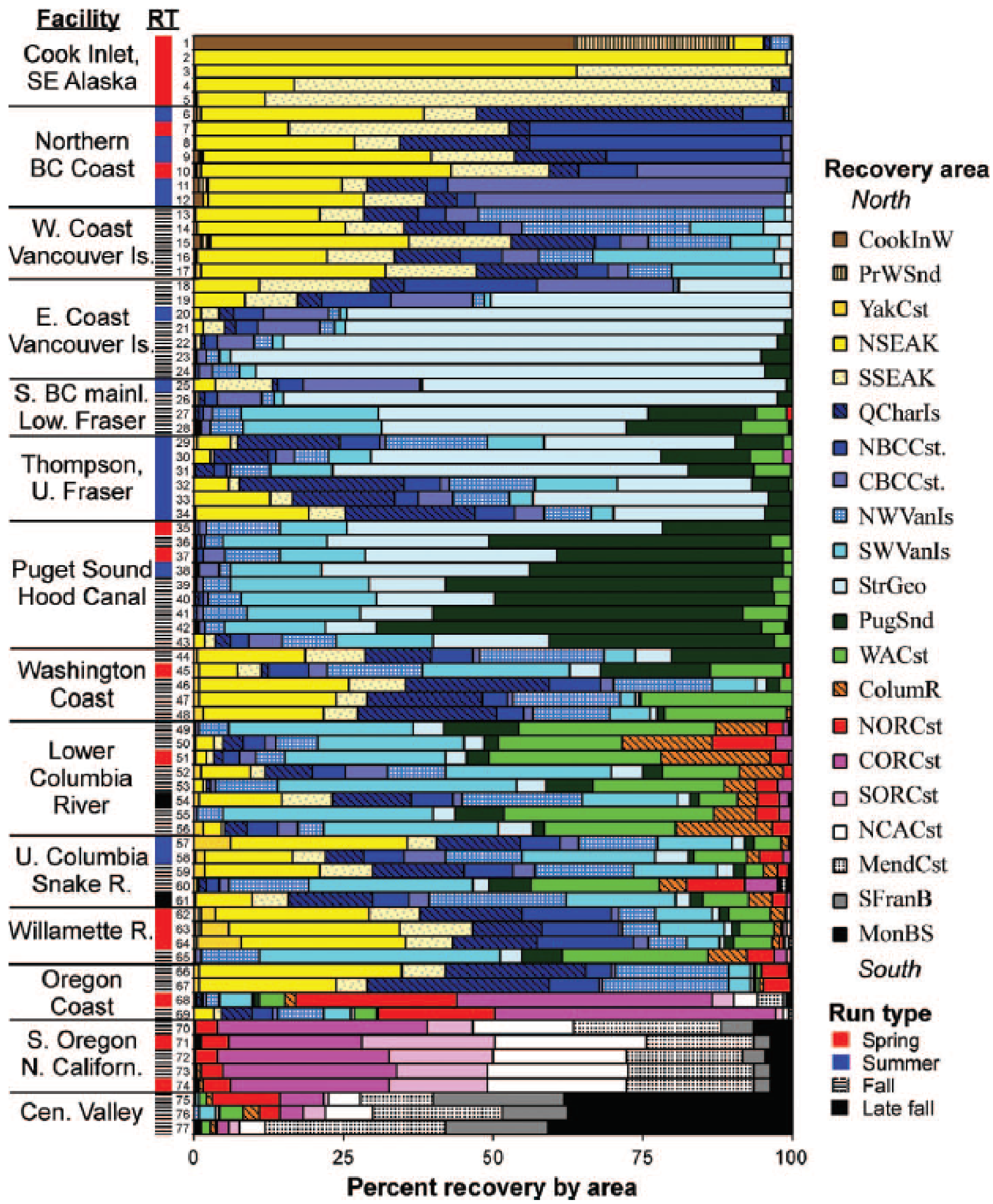


Figure 19. Recovery patterns for coded-wire-tagged Chinook salmon. Each horizontal bar represents the percentages of recoveries in the 21 marine recovery areas for a single hatchery run type group (Weitkamp 2010). Abbreviations of marine recovery areas: CookInW=Cook Inlet west; PrWSound=Prince William Sound; YakCst=Yakutat Coast; NSEAK=northern Southeast Alaska; SSEAK=southern Southeast Alaska; QCharls=Queen Charlotte Islands; NBCCst=northern British Columbia coast; CBCCst=central British Columbia coast; NWVanIs=northwest Vancouver Island; SWVanIs=southwest Vancouver Island; StrGeo=Strait of Georgia; PugSnd=Puget Sound; WACst= Washington coast; ColumR=Columbia River; NORCst=north Oregon coast; CORCst: central Oregon coast; SORCst= southern Oregon coast; NCACst=northern California coast; MendCst=Mendocino coast; SFranB=San Francisco Bay; MonBS=Monterey Bay south.

Based on data from surface trawl and purse seine fisheries in the Alaska Exclusive Economic Zone (EEZ) from 1964 to 2009, Echave et al. (2012) reported that the vast majority of juvenile Chinook salmon in the Gulf of Alaska occur on the continental shelf, mostly in the inside waters of the Alexander Archipelago. While the majority of the distribution of juvenile Chinook salmon in Alaska is within Southeast Alaska waters, the entire coastal belt of the GOA, from the coast extending beyond the shelf break, is considered to contain "ideal" habitat conditions for juvenile Chinook salmon (Echave et al. 2012). They also found that while immature Chinook salmon were distributed farther offshore than juveniles in the Gulf of Alaska (Hartt and Dell 1986), they were still predominantly found on the continental shelf, with offshore areas having low relative abundance for this species (Echave et al. 2012). In comparison to juvenile and immature fish, mature Chinook are found in deeper waters (66 – 2755 m) and at colder temperatures (4.2° – 13.9°C). Echave et al. (2012) observed a relatively high abundance of mature Chinook salmon within Southeast Alaska waters (outside of the action area), but very low abundances of mature Chinook off the continental shelf within the TMAA. Thus, based on Echave et al. (2012), both immature and mature adult Chinook are expected to occur in low abundance within the offshore portion of the action area where Navy explosives would be used (Figure 21).

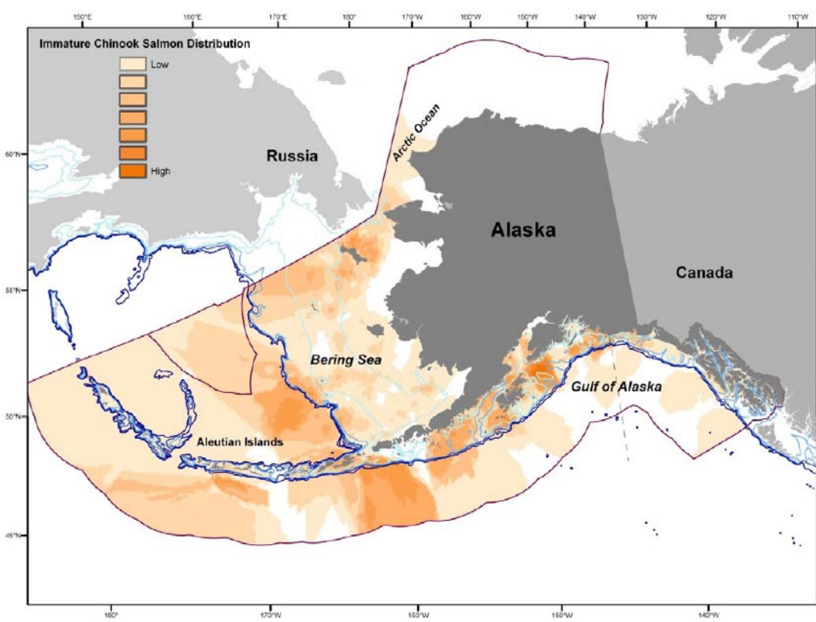


Figure 20. Ninety-five percent of the spatial distribution of marine immature Chinook salmon range. Smooth line represents the EEZ boundary. Depth contours are 50, 100, 200, 400, and 600 meters (Echave et al. 2012).

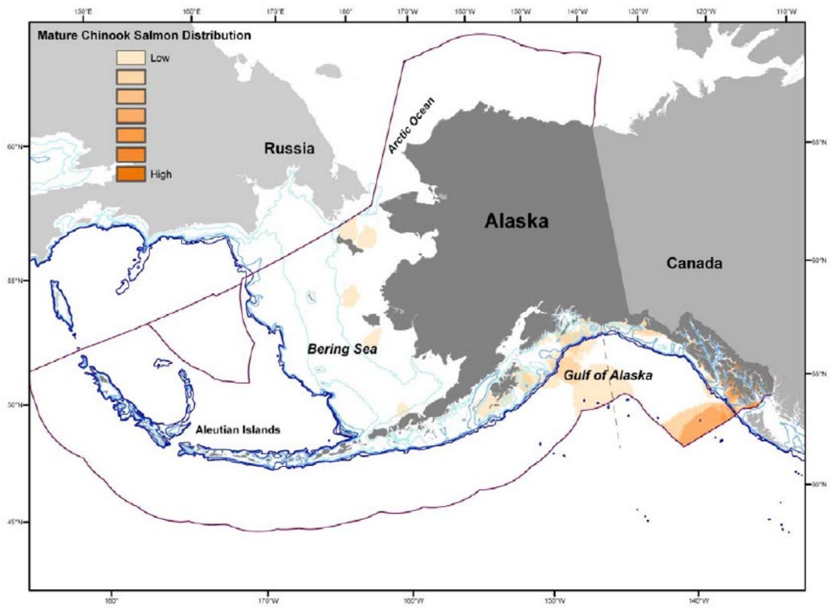


Figure 21. Ninety-five percent of the spatial distribution of marine mature Chinook salmon range. Smooth line represents the EEZ boundary. Depth contours are 50, 100, 200, 400, and 600 meters (Echave et al. 2012).

Masuda (2021) presented the ocean distribution of Chinook salmon recoveries in the GOA for each of the six ESA-listed ESUs found in Alaska. Coded-wire tagged Chinook salmon recovered in groundfish fisheries, rockfish trawl fishery, and U.S. research surveys in the GOA from 1981-2020 were combined for this analysis. The maps below highlight the diversity among Chinook populations in terms of spatial distribution and migratory patterns. For the Lower Columbia River (Figure 22), Upper Willamette River (Figure 23), and Snake River Fall (Figure 24) ESUs, Chinook captures are widely dispersed with a relatively large proportion of Alaska captures occurring either within the TMAA or in areas in close proximity to the west of the TMAA. For the Snake River Spring/Summer (Figure 25) and Upper Columbia River (Figure 26) ESUs, Chinook captures within Alaska are predominantly from Southeast Alaska. Puget Sound ESU (Figure 27) captures in Alaska are extremely rare, with only two recorded from 1981-2020 for the fisheries and research data sources included in this study. For all ESUs, Chinook captures from these two fisheries and research surveys are almost entirely on the continental shelf (Masuda 2021).

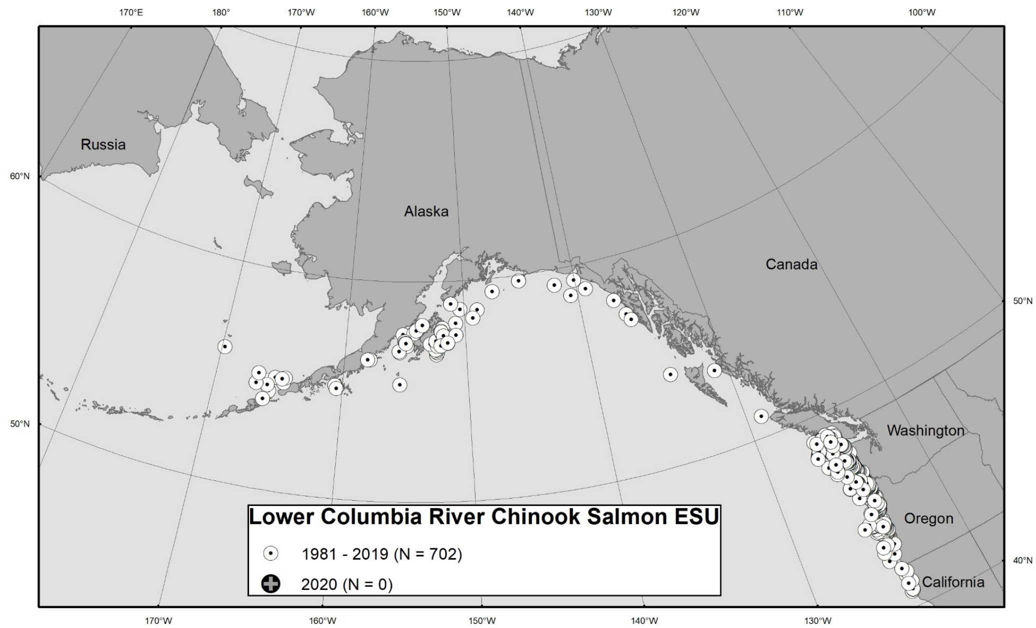


Figure 22. Ocean distribution of coded-wire tagged Chinook salmon recoveries from the Lower Columbia River ESU, 1981-2018 (Masuda 2021).

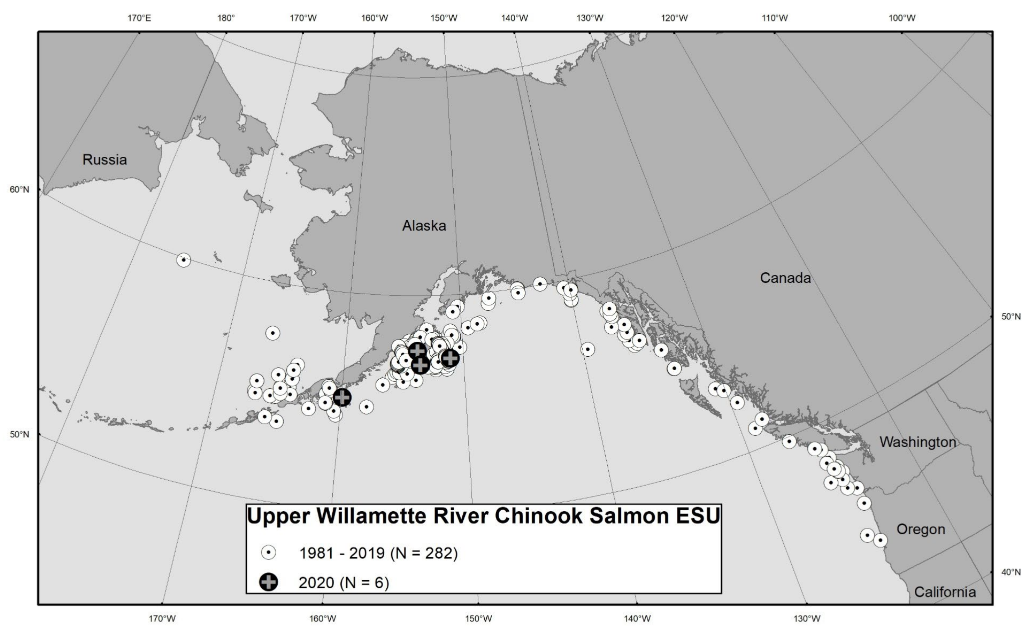


Figure 23. Ocean distribution of coded-wire tagged Chinook salmon recoveries from the Upper Willamette River ESU, 1981-2018 (Masuda 2021).

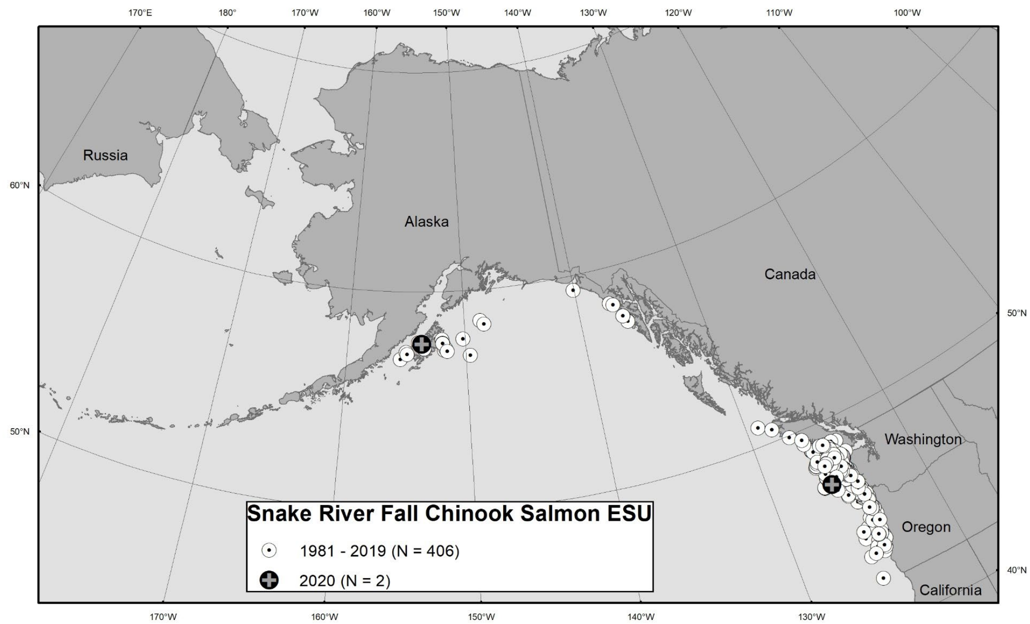


Figure 24. Ocean distribution of coded-wire tagged Chinook salmon recoveries from the Snake River Fall ESU, 1981-2018 (Masuda 2021).

Figure 25. Ocean distribution of coded-wire tagged Chinook salmon recoveries from the Snake River Spring/Summer ESU, 1981-2018 (Masuda 2021).

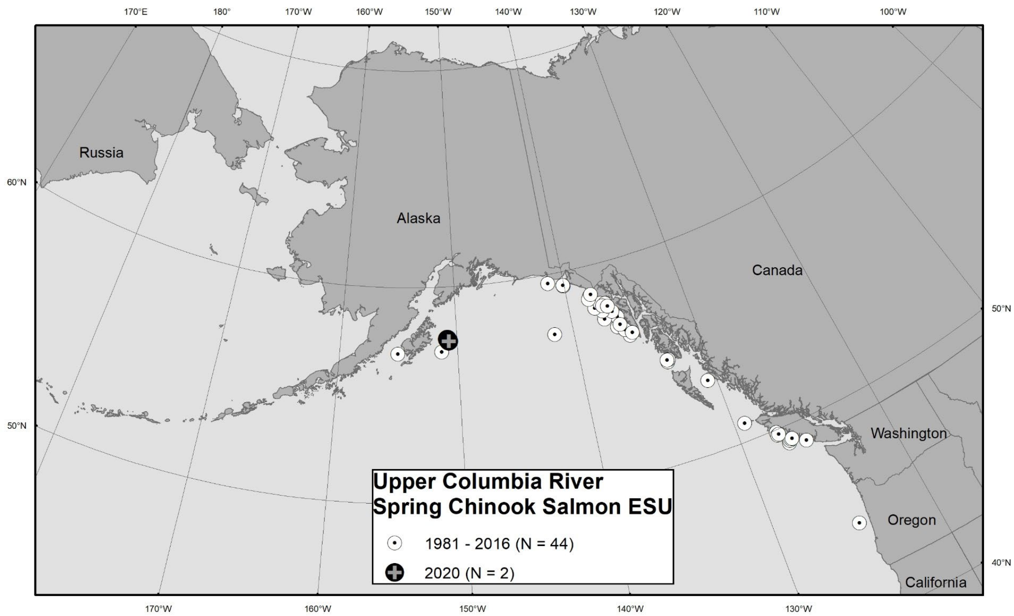


Figure 26. Ocean distribution of coded-wire tagged Chinook salmon recoveries from the Upper Columbia River Spring ESU, 1981-2018 (Masuda 2021).

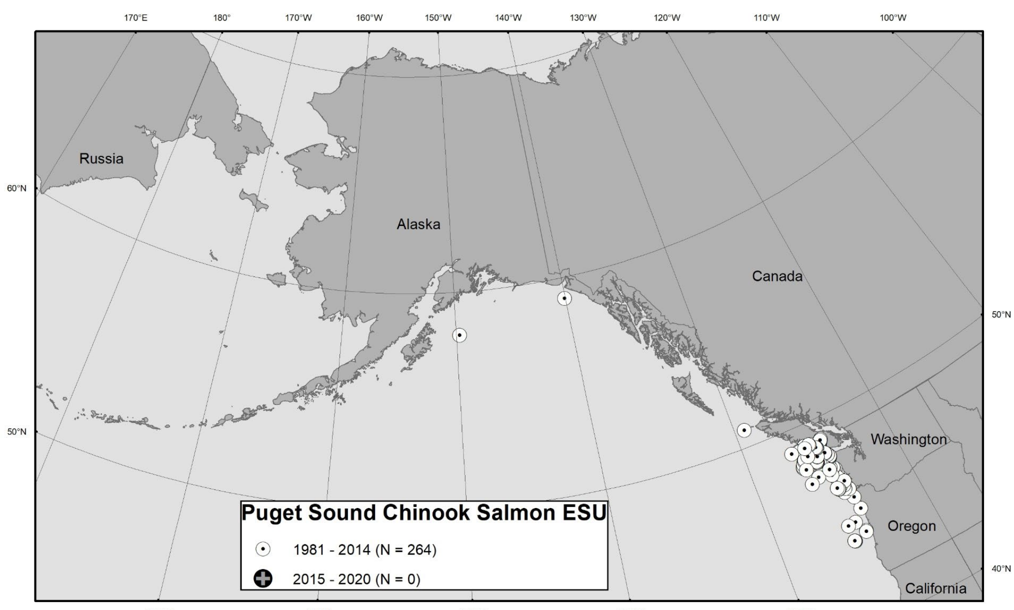


Figure 27. Ocean distribution of coded-wire tagged Chinook salmon recoveries from the Puget Sound ESU, 1981-2018 (Masuda 2021).

The tag recovery distribution maps above are consistent with findings from Echave et al. (2012), and suggest very low abundances of Chinook off the shelf as compared to on the shelf. However, we recognize the limitations of using data from fisheries for distribution and abundance information, because sampling locations and times of year are opportunistically determined based on where and when the fishing effort occurs, rather than based on a statistical design.

Pakhomov et al. (2019) conducted a winter (February and March) trawl survey for overwintering Pacific salmon in an area of the GOA covering nearly 700 km^2, including northern sampling stations within a small area of overlap with the action area. Only three Chinook salmon were caught out of 423 salmon from all species (chum were the most common followed by coho). Genetic analysis was not conducted so the natal origin on these fish is unknown. The authors did note that the small number of Chinook relative to other species was likely because Chinook salmon have the deepest distribution in the water column of any salmon and may not be effectively caught by the near-surface (0-30 m) midwater trawl used for sampling.

Seitz and Courtney (2022) used pop-up satellite archival tags (PSATs) on Chinook salmon captured in three Alaska locations (Yakutat, Kodiak, and Chignik) to study the occupancy and relative use of onshore versus offshore areas by large, immature Chinook salmon in the GOA, and specifically within the Navy TMAA. For fish at liberty greater than 21 days (n = 57 tagged fish), they reconstructed movement tracks using the Hidden Markov Model (Figure 28, Figure 29, and Figure 30). Based on end locations and estimated daily locations, 15 fish occupied the TMAA for an aggregated total of 252 days, representing about seven percent of all aggregated fish days (3,720 days) (Seitz and Courtney 2022). While occupying waters of the TMAA, Chinook salmon mostly occupied the northern portion of the TMAA while over the continental shelf. Within the TMAA, Chinook spent 58 percent of their time over the continental shelf, 22 percent over the continental slope, and 20 percent over basin. Overall, Chinook were found over the basin within the TMAA on less than 1.5 percent of all aggregated fish days. Mean individual occupied depths in the TMAA ranged from 19 to 110 meters (70 ± 27 m; grand mean ± SD). While inferably occupying basin waters of the TMAA, where Navy in-air explosives could be used, fish occupied waters ranging from 0 to 293 m, with individual mean depths ranging from 20 to 82 meters (53 ± 23 m; grand mean ± SD). While the data on the timing and duration of occupation of the TMAA are biased by the timing and locations of tag deployment, tagged Chinook salmon were documented to occupy waters of the TMAA across the calendar year. During the months the U.S. Navy conducts at-sea training in the GOA TMAA (April to October), 10 tagged Chinook salmon occupied the TMAA for an aggregated total of 92 days. Of these 92 days, 35 were inferred to occur over the basin, whereas 57 days were inferred to occur over the Continental Shelf and Slope Mitigation Area (see 4.6.2.1) where in-air explosives would be prohibited from the sea surface to 10,000 feet altitude (Seitz and Courtney 2022).

Seitz and Courtney (2022) were able to determine stock origin for 47 of the 60 fish tagged: 11 originated from Southeast Alaska; 23 from western Vancouver Island; two from the Thompson River, British Columbia; two from east Vancouver Island, British Columbia; four from the Columbia River in Washington; one from the Oregon coast; and four from the Willamette River, Oregon. Of these, only the Willamette River fish (n=4) were identified by the authors as part of an ESA-listed Chinook ESU. Stock-origin was determined for 13 of the tagged Chinook that occupied the TMAA. Only one out of these 13 fish were from the ESA-listed Upper Willamette River ESU (Seitz and Courtney 2022).

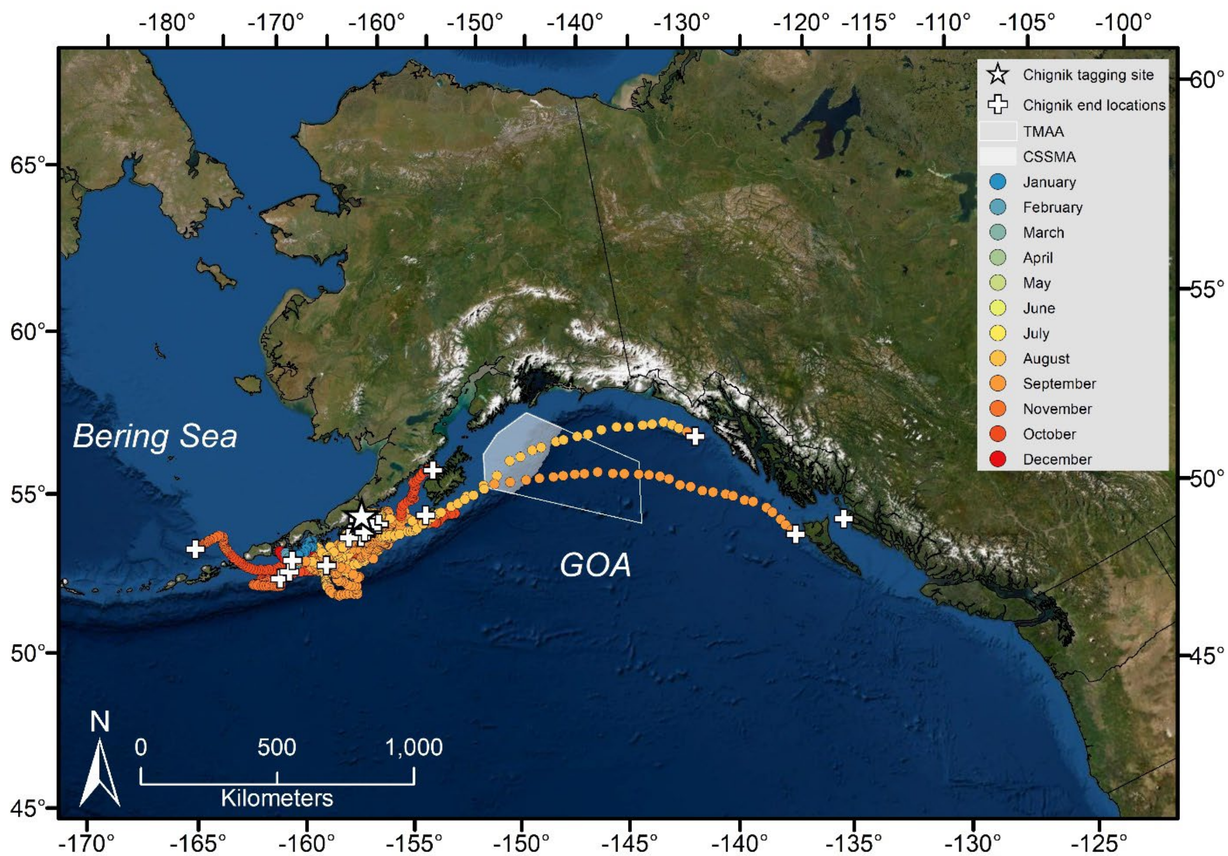


Figure 28. End locations denoted by crosses color coded by release location (n = 19) and most likely movement paths of Chinook salmon (n = 18) tagged near Chignik, AK (star). Estimated daily locations (circles) are color coded by month (Seitz and Courtney 2022).

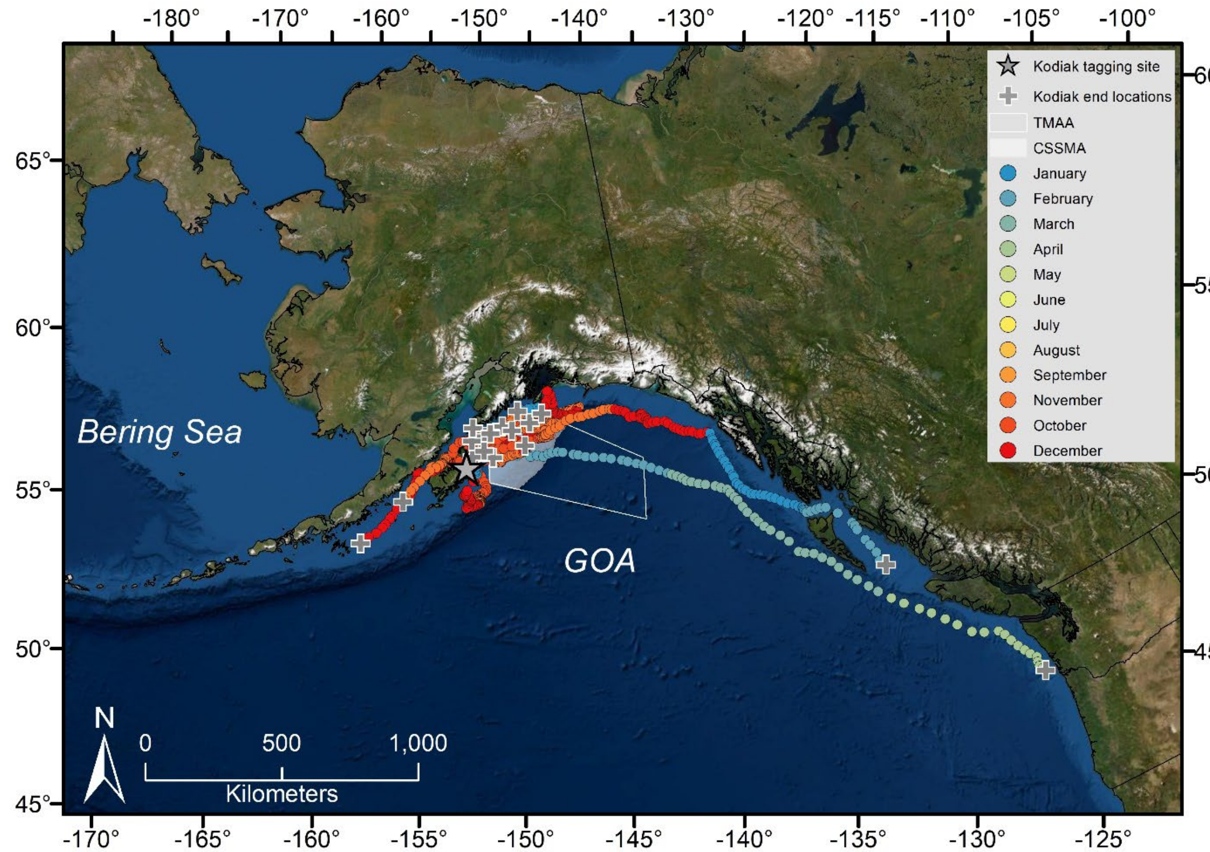


Figure 29. End locations denoted by crosses color coded by release location (n = 19) and most likely movement paths of Chinook salmon (n = 19) tagged near Kodiak, AK (star). Estimated daily locations (circles) are color coded by month (Seitz and Courtney 2022).

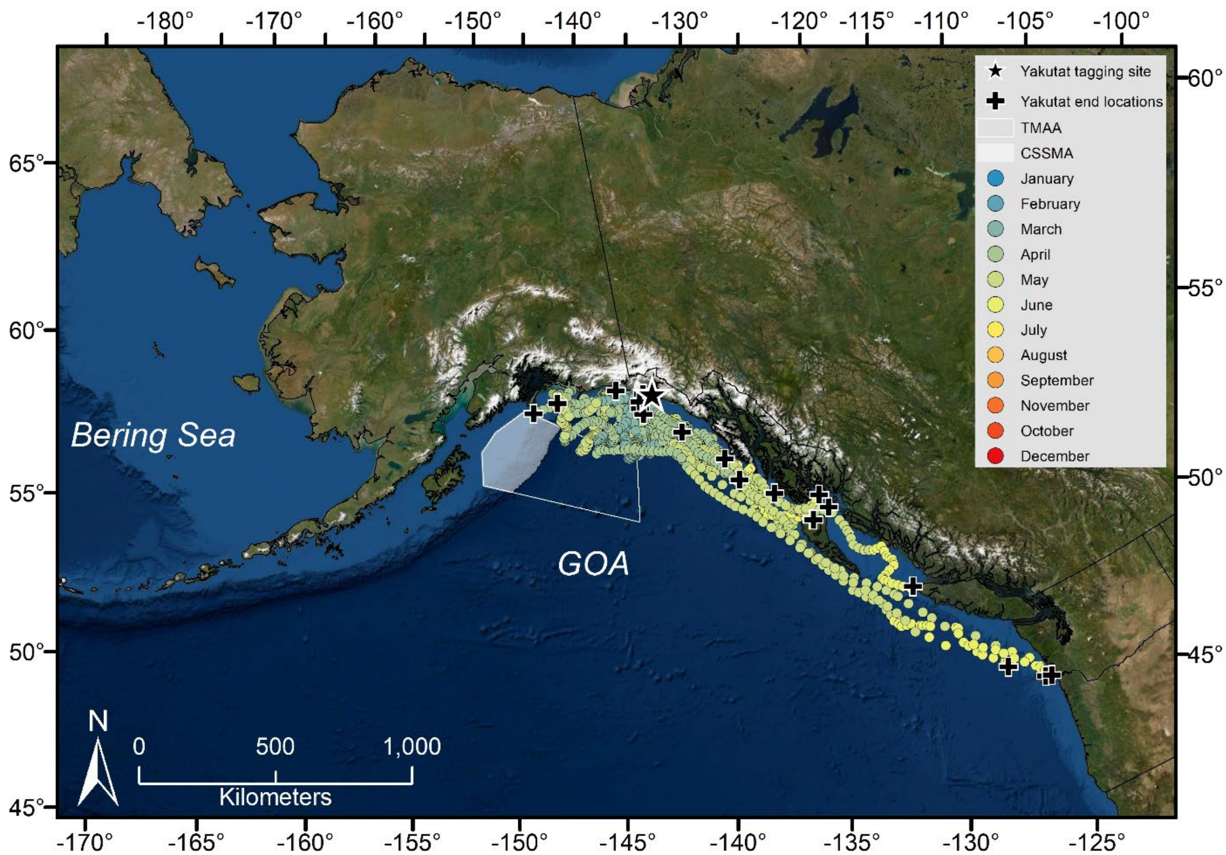


Figure 30. End locations denoted by crosses color coded by release location (n = 19) and most likely movement paths of Chinook salmon (n = 19) tagged near Yakutat, AK (star). Estimated daily locations (circles) are color coded by month (Seitz and Courtney 2022).

Based on the information presented above, we summarize our findings regarding the distribution and relative abundance of Chinook salmon ESUs and life stages in portions of the action area where explosives would be used (i.e., off the continental shelf and beyond the 4,000 meter depth contour) as follows:

- Juvenile Chinook (from any ESA-listed ESU) are not expected to occur in the offshore portion of the GOA action area where they could be exposed to stressors from Navy explosives.
- Immature and mature adult Chinook (from all ESA-listed ESUs) primarily occupy the nearshore shelf portion of the GOA, but occasionally will move farther offshore, either to feed over the continental slope or to transit from west to east across the GOA basin.
- In general, abundances of both immature and mature adult Chinook are expected to be very low within the offshore portion of the TMAA where Navy explosives would be used.

- Puget Sound ESU Chinook (any life stage) have only rarely been documented in Alaska waters; therefore, fish from this ESU are not expected to occur in the offshore portion of the GOA action area where they could be exposed to stressors from Navy explosives.
- Within the GOA, Upper Columbia River ESU and Snake River Spring/Summer ESU Chinook abundances are likely concentrated in Southeast Alaska, with relatively low abundances expected in the action area.
- Chinook from the Lower Columbia River, Snake River Fall, and Upper Willamette River ESUs are more widely dispersed throughout the GOA, with a relatively large proportion likely occurring either within the TMAA or in areas in close proximity to the west of the TMAA.

As documented further in Section 0 of this opinion, the only stressor we determined would likely adversely affect some of the ESA-listed fish species in the action area was the use of in-air explosive ordnances (see Section 8.1.2 for discussion of stressors not likely to adversely affect salmonids). While six different ESA-listed Chinook ESUs could potentially occur within the action area, based on the best available information (summarized above) we anticipated very low densities of all Chinook ESUs within portions of the TMAA where Navy explosives would be used (i.e., off the continental shelf and beyond the 4,000 meter depth contour). In addition, compared to smaller fish, mature adult Chinook (which are more likely to be found offshore) typically occupy deeper portions of the water column (66 – 2755 m), which further reduces the likelihood of exposure to sound from in-air explosions occurring at or near the surface.

NMFS (2017c) determined that no ESA-listed Chinook salmon from Oregon, Washington, or Idaho would be adversely affected by Navy explosives use during Phase II in the Gulf of Alaska TMAA. The additional mitigation measure proposed for Phase III, to move all explosives off of the TMAA shelf and beyond the 4,000 meter depth contour on the slope, further reduces that likelihood of any adverse effects to ESA-listed Chinook from the proposed action. There are no activities involving the use of explosives proposed for the WMA.

In summary, based on the anticipated very low densities of ESA-listed Chinook where Navy explosives would be used (i.e., within the TMAA off the continental shelf and beyond the 4,000 meter isobath), use of only in-air explosives (i.e. no in-water explosives proposed), and short time window (i.e., three weeks) for Navy training activities in the GOA, we find it extremely unlikely that Chinook salmon would be exposed to stressors from Navy explosives. Therefore, we consider the effects from explosive stressors on the following Chinook salmon ESUs to be discountable: Upper Columbia River spring-run, Snake River spring/summer-run, Snake River fall-run, Puget Sound, Lower Columbia River, and Upper Willamette River. We conclude that the proposed action may affect, but is not likely to adversely affect, these six Chinook salmon ESUs.

6.1.7 ESA-listed Salmonids from California

Juveniles and adults from many of the ESA-listed West Coast salmonid ESUs and DPSs are known to migrate into the Gulf of Alaska, and may use portions of the action area for rearing or migration during the marine portion of their life cycle. However, virtually all of the ESA-listed salmonids recovered in Alaska originate from rivers in Washington and Oregon. Documented reports of salmon migrations to Alaska from rivers in California (or even Southern Oregon) are rare.

Weitkamp (2010) examined coded wire-tag recovery data and found that Chinook salmon originating from north of Cape Blanco in Oregon tend to migrate towards the Gulf of Alaska, whereas those originating south of Cape Blanco tend to migrate west and south to forage in waters off Oregon and California (PFMC 2014). Weitkamp (2010) found that Chinook originating from southern Oregon and California were generally only recovered off the coast of Oregon and California (see Figure 19 above). Similarly, Shelton et al. (2019) reported that Chinook originating between California and southern Oregon remained in U.S. waters south of the British Columbia border and were observed rarely in Canadian and Alaskan waters.

Masuda (2021) reported the stock origins of coded-wire tagged Chinook salmon recovered in the GOA groundfish fisheries, rockfish trawl fishery, and U.S. research surveys in the GOA from 1981-2020. Sample sizes of observed coded-wire tagged Chinook from GOA groundfish fisheries analyzed for stock origin averaged 19.4 per year from 2001-2011, and 101 per year from 2012-2020. Supplemental sampling from the rockfish trawl fishery from 2013-2020 averaged 42 observed coded-wire tagged Chinook per year, and another 114 coded-wire tagged Chinook were sampled and analyzed from research surveys from 1996-2017. Over the entire time series (from 1981-2020) none of the Chinook salmon recovered in the GOA groundfish fisheries, rockfish trawl fishery, or research surveys originated from California (Masuda 2021).

We do not have information (e.g., coded-wire tag data) to suggest that coho salmon or steelhead from California or southern Oregon (south of Cape Blanco) regularly migrate north to Gulf of Alaskan waters in close proximity to the action area. Myers et al. (1996b) did not report any steelhead or coho salmon from California in northern Gulf of Alaska waters in close proximity to the action area. Weitkamp and Neely (2002) reported a similar pattern for coho salmon from southern Oregon and California as Weitkamp (2010) reported for Chinook. They did not document any coho from these more southern waters in the western Gulf of Alaska in close proximity to the action area.

As documented further in Section 0 of this opinion, the only stressor associated with the proposed action that we determined would likely adversely affect some of the ESA-listed fish species in the action area is the use of explosive ordnances. The salmonid ESUs and DPSs from California (inclusive of Southern Oregon/Northern California coho ESU) are only rarely expected to occur in the action area. Though the rare individual from these more southern ESUs/DPSs could migrate to the northern Gulf of Alaska in close proximity to the action area, the vast majority will not.

In summary, due to the rarity of such a migratory pattern resulting in an extremely low abundance of individuals from California origin salmonid ESUs/DPSs occurring within the action area, and the infrequent nature of Navy explosive training activities in the Gulf of Alaska TMAA, the likelihood of Navy training activities in the Gulf of Alaska TMAA affecting individuals from these ESUs/DPSs is extremely low. In addition, the Navy has proposed to not detonate explosives on the continental shelf or portion of the slope out to 4,000 meters, thus further reducing the likelihood of spatial overlap between ESA-listed salmonids and acoustic stressors. Thus, based on our understanding of the migratory patterns of fish from these California origin ESUs and DPSs, effects to the following salmonid populations from Navy GOA in-air explosives are discountable: Chinook (Central Valley spring-run ESU, California Coastal ESU, Sacramento River winter-run ESU), coho (Southern Oregon Northern California Coast ESU, Central California Coast ESU), and steelhead (Northern California DPS, Central California Coast DPS, California Central Valley DPS, South-Central California Coast DPS, Southern California DPS). We conclude that the proposed action may affect, but is not likely to adversely affect, these salmonid ESUs and DPSs.

6.1.8 Coho Salmon

Coho salmon distribution in the marine environment varies considerably among seasons, years, life stages, and populations. Weitkamp and Neely (2002) provided evidence that coho salmon exhibit high diversity in ocean migration patterns, rivaling the variability that has been well demonstrated in the species' freshwater life history. Coho salmon from different freshwater regions are generally recovered, presumably while returning to spawn in their natal rivers, from different areas of the coastal ocean, identifying 12 distinct ocean distribution patterns from California to Alaska. In marine waters, coho are generally found within the upper portion of the water column (PFMC 2014). Walker et al. (2007) found that the average depth of coho salmon in the North Pacific Ocean was 11 meters.

In Section 6.1.7 we analyzed the effects of the proposed action on ESA-listed salmonid populations originating from California, including two coho salmon ESUs: Southern Oregon-Northern California Coast ESU and Central California Coast ESU. We determined that the proposed action was not likely to adversely affect these two coho ESUs. In this section, we consider the effects of the proposed action on the Oregon Coast and Lower Columbia River coho salmon ESUs.

Morris et al. (2007) used coded wire tag recoveries from 1995-2004 to develop a conceptual model of juvenile coho salmon migration from Oregon, Washington, the Columbia–Snake River system, British Columbia, and southeast Alaska. Consistent with previous studies, they found that juvenile coho salmon generally undertake a northward migration and utilize the continental shelf as a migration highway. They also found that both regional and specific river stocks of coho salmon from all parts of the North American coast are composed of fast moving components that take a rapid and direct migration in the summer to as far west as Kodiak Island, Alaska. Columbia–Snake River system, coastal Oregon, and coastal Washington had the highest proportion of juvenile coho fast migrants among regions. In the Gulf of Alaska, juvenile coho salmon predominantly occur in coastal waters, throughout the continental shelf and slope (Echave et al. 2012; Quinn 2005). Thus, while juvenile coho salmon from the Oregon Coast and Lower Columbia River ESUs could overlap with the GOA TMAA, they are not likely to be found off the continental shelf or beyond 4,000 meter depths where Navy explosives would be used.

Coho salmon in the Gulf of Alaska occur along the continental shelf, but are more widely distributed into offshore oceanic waters beyond the shelf break as well (Figure 31) (Echave et al. 2012). Within the GOA, few catches of mature coho salmon are seen within the Alexander Archipelago, and overall abundance levels are low. Areas of highest coho abundance over the GOA basin are off of southeast Alaska, well east of the TMAA.

Weitkamp and Neely (2002) investigated geographic variation in the ocean migration of coho salmon by examining recovery locations of nearly 1.8 million coded-wire tagged fish captured in commercial fisheries from 90 hatcheries and 36 wild populations along the west coast of North America. Recovery patterns for 36 wild populations closely matched those for hatchery fish, suggesting that patterns derived from recoveries of millions of hatchery fish are a reasonable surrogate for wild populations. Results showed that coho salmon originating from Oregon and Washington are rarely recovered as far north as Alaska (Figure 32). From Weitkamp and Neely (2002), it appears as if Vancouver Island represents the northern extent for the vast majority of coho salmon originating from the Columbia River or the Oregon Coast.

Masuda et al. (2015) presented data analyzing coho salmon distribution in the eastern North Pacific Ocean from coded wire tag recoveries in fisheries and research surveys from 1981-2013. The ocean distribution of Oregon and Washington coho populations are shown in Figure 33 and Figure 34, respectively. Whereas Weitkamp and Neely (2002) suggest Vancouver Island as the northern extent of migration for most coho salmon originating from the Columbia River and Oregon Coast (Figure 32), the coho recovery distribution maps from Masuda et al. (2015) show at least some recoveries within the GOA. This suggests that fish from the Oregon Coast and Lower Columbia River ESUs occasionally migrate through the GOA as far west as Kodiak Island, and could, therefore, occur within the TMAA portion of the action area. This is consistent with findings reported by Morris et al. (2007) for the migration pattern of juvenile coho from Oregon and Washington.

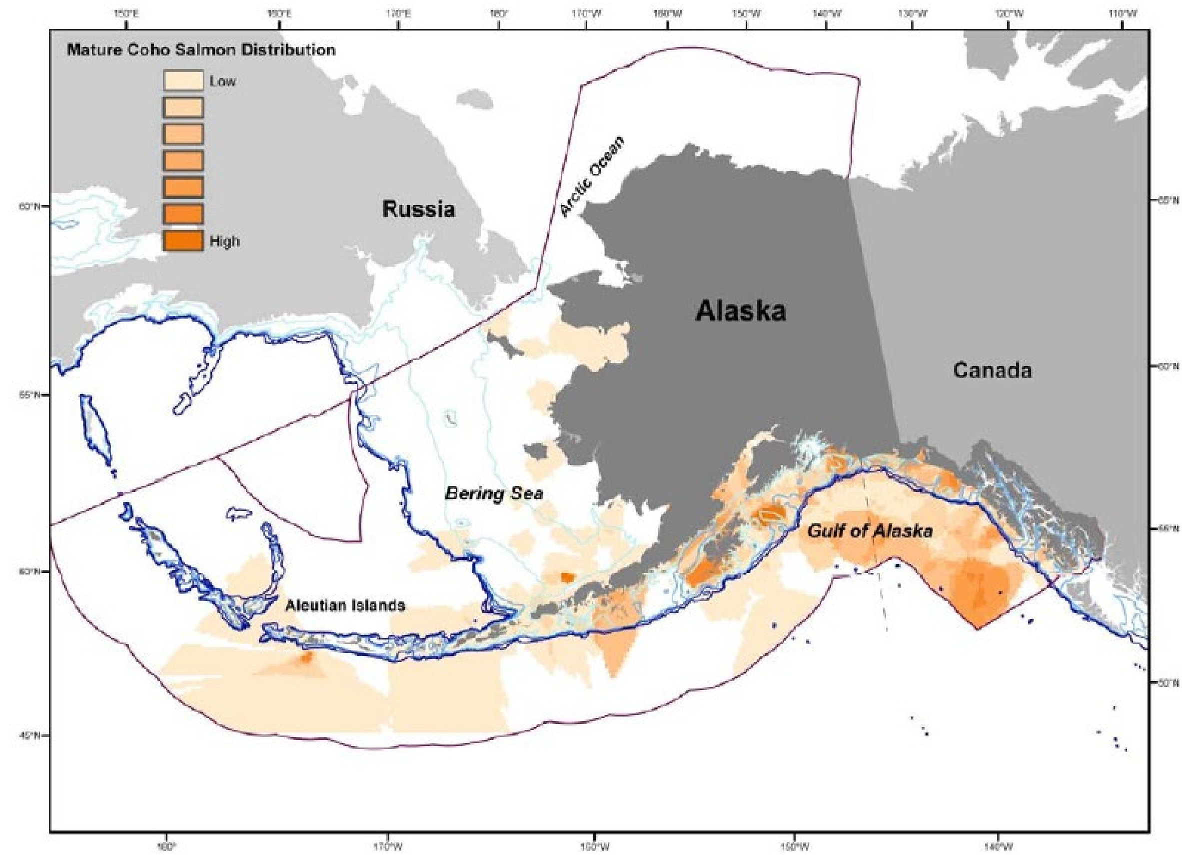


Figure 31. Ninety-five percent of the spatial distribution of marine mature coho salmon range. Smooth line represents the EEZ boundary. Depth contours are 50, 100, 200, 400, and 600 meters (Echave et al. 2012).

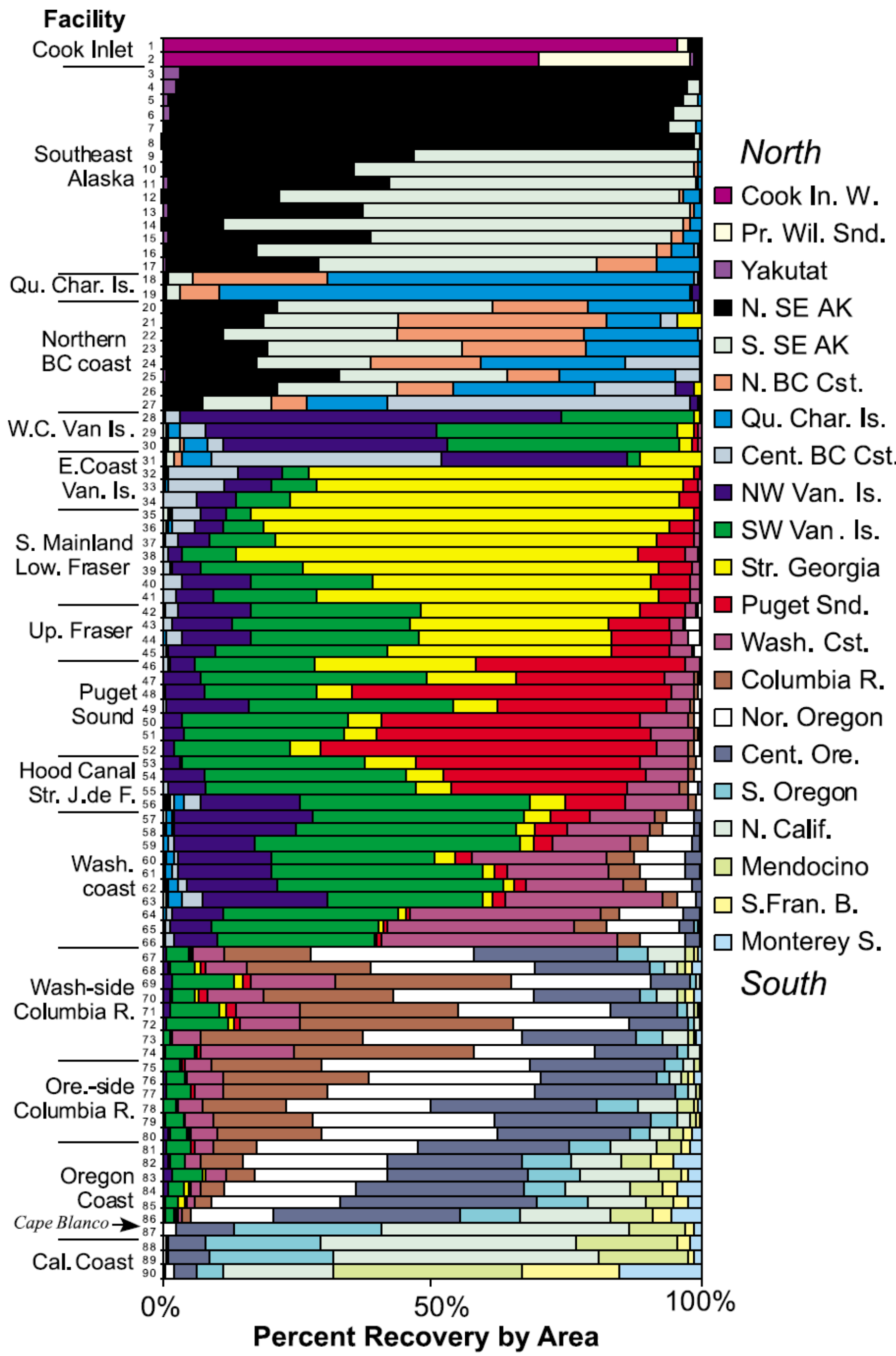


Figure 32. Recovery patterns of coded-wire tagged coho salmon by hatchery. Each bar provides the percent of recoveries in the 21 recovery areas for a single hatchery (Weitkamp and Neely 2002). See Figure 19 for abbreviations of marine recovery areas.

Pakhomov et al. (2019) conducted a winter (February-March) trawl survey for overwintering Pacific salmon in an area of the GOA covering nearly 700 km^2, including northern sampling stations within a small area of overlap with the action area. Ninety-three coho salmon were caught out of 423 salmon from all species (chum were the most common followed by coho). The highest estimated densities of coho from this study were in the southeast portion of the study area, the farthest removed from the TMAA. The vast majority of coho captures were at stations well to the south (i.e., south of 54° latitude) of the TMAA. Pakhomov et al. (2019) conducted at-sea genetic analyses on captured coho salmon to identify stock origins. Preliminary results show that the majority of coho were from populations in Northern British Columbia (Pakhomov et al. 2020), while Washington and the Columbia River fish each made up less than two percent of the coho captured. This suggests that while adult coho salmon utilize the upper pelagic layer of the GOA basin, the proportion of coho salmon from ESA-listed ESUs is very low. However, we recognize the limitations of this study for our purposes including: 1) the relatively small area of spatial overlap between the study area and the TMAA, 2) the lack of temporal overlap between this study (February-March) and Navy training months in the GOA (April – October), 3) that this study only represents a single year and may not account for significant annual variability, and 4) the relatively small sample size of fish captured and analyzed for genetics.

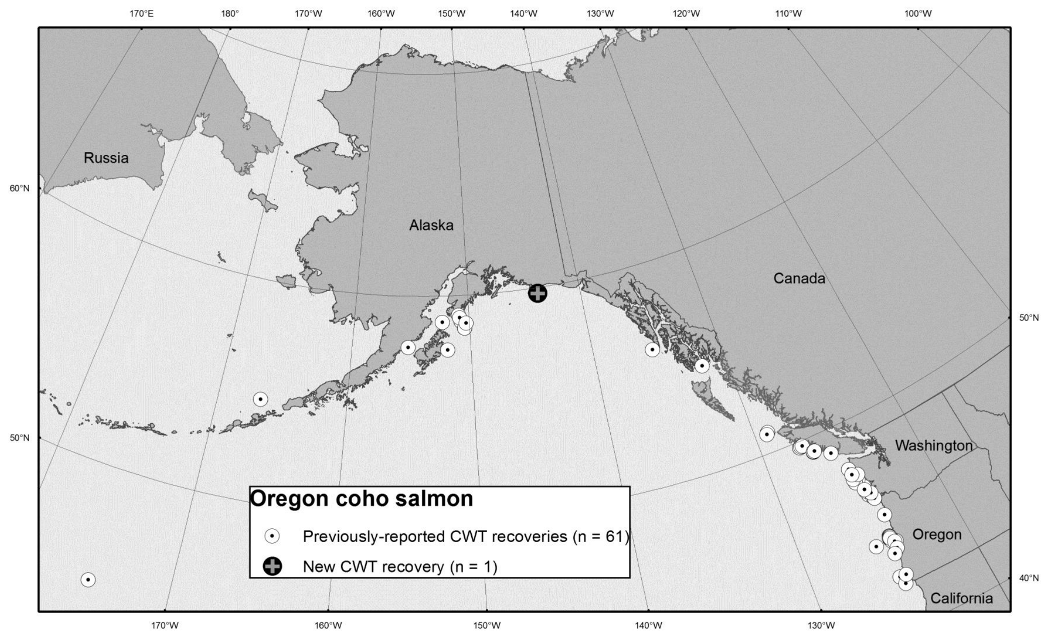


Figure 33. Ocean distribution of Oregon coho salmon as indicated by code-wire tag recoveries, 1981-2013 (Masuda et al. 2015b).

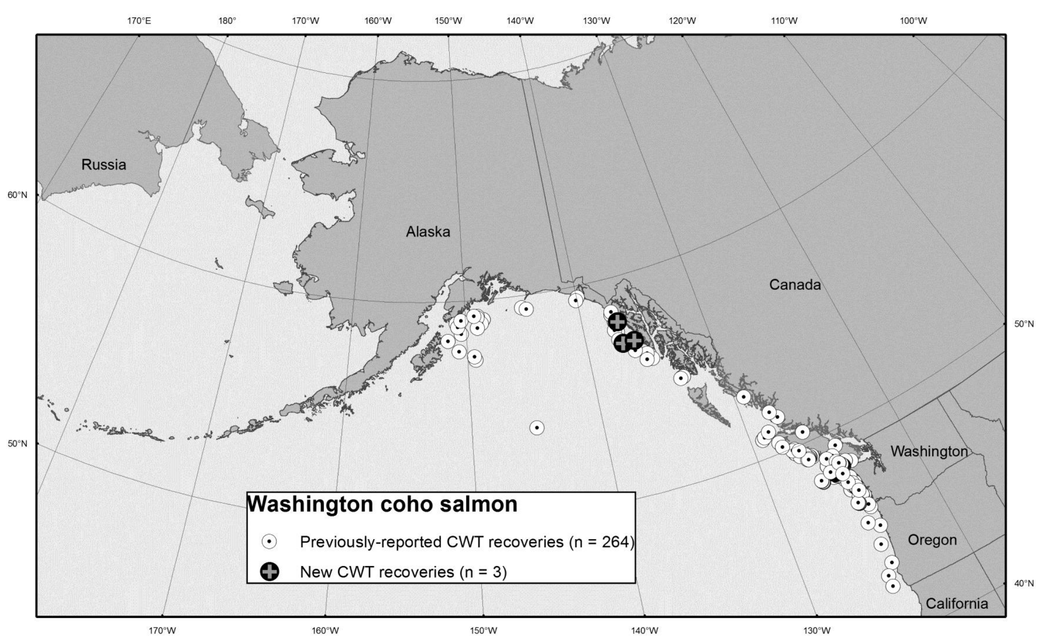


Figure 34. Ocean distribution of Washington coho salmon as indicated by code-wire tag recoveries, 1981-2013 (Masuda et al. 2015b).

Based on the information presented above, we summarize our findings regarding the distribution and relative abundance of Oregon Coast and Lower Columbia River ESUs of coho salmon in portions of the action area where explosives would be used (i.e., off the continental shelf and beyond the 4,000 meter depth contour) as follows:

- In general, Oregon Coast ESU and Lower Columbia River ESU coho abundances in the action area are likely very low, as many fish from these populations are not expected to migrate north of Vancouver Island.
- Juvenile coho salmon are primarily found on the continental shelf and are not expected to occur in the offshore portion of the GOA action area where they could be exposed to stressors from Navy explosives.
- While immature and mature coho salmon are also expected to have higher abundances on the continental shelf, these life stages are more widely dispersed throughout the entire GOA, including the slope and basin.
- Limited genetic information suggests that coho salmon from the Oregon Coast and Lower Columbia River ESUs represent an extremely small proportion of the coho salmon occurring in the offshore portion of the action area where explosives would be used.

As documented further in Section 0 of this opinion, the only stressor we determined would likely adversely affect some of the ESA-listed fish species in the action area was the use of in-air explosive ordnances (see Section 8.1.2 for discussion of stressors not likely to adversely affect salmonids). While Oregon Coast and Lower Columbia River coho salmon ESUs could potentially occur within the action area, based on the best available information (summarized above) we anticipated very low densities of these ESUs within portions of the TMAA where Navy explosives would be used (i.e., off the continental shelf and beyond the 4,000 meter depth contour).

In summary, based on the anticipated very low densities of ESA-listed coho salmon where Navy explosives would be used, use of only in-air explosives (i.e. no in-water explosives proposed), and short time window (i.e., three weeks) for Navy training activities in the GOA, we find it extremely unlikely that ESA-listed coho salmon would be exposed to acoustic stressors from Navy explosives. Therefore, we consider the effects from explosive stressors on Oregon Coast and Lower Columbia River coho salmon ESUs to be discountable, and conclude the proposed action may affect, but is not likely to adversely affect these ESUs.

6.1.9 Humpback Whale Designated Critical Habitat

On April 21, 2021, NMFS designated critical habitat for the Central America, Mexico, and Western North Pacific DPSs of humpback whale effective as of May 21, 2021. Specific areas designated as critical habitat for the Western North Pacific DPS contain approximately 59,411 square nautical miles of marine habitat in the North Pacific Ocean, including areas within the eastern Bering Sea and Gulf of Alaska. Critical habitat for the Mexico DPS include 175,812 square nautical miles of marine habitat off the coasts of Alaska, Washington, Oregon, and

California (Figure 35). Critical habitat for the Central America DPS is outside of the action area and, therefore, is not included in our analysis.

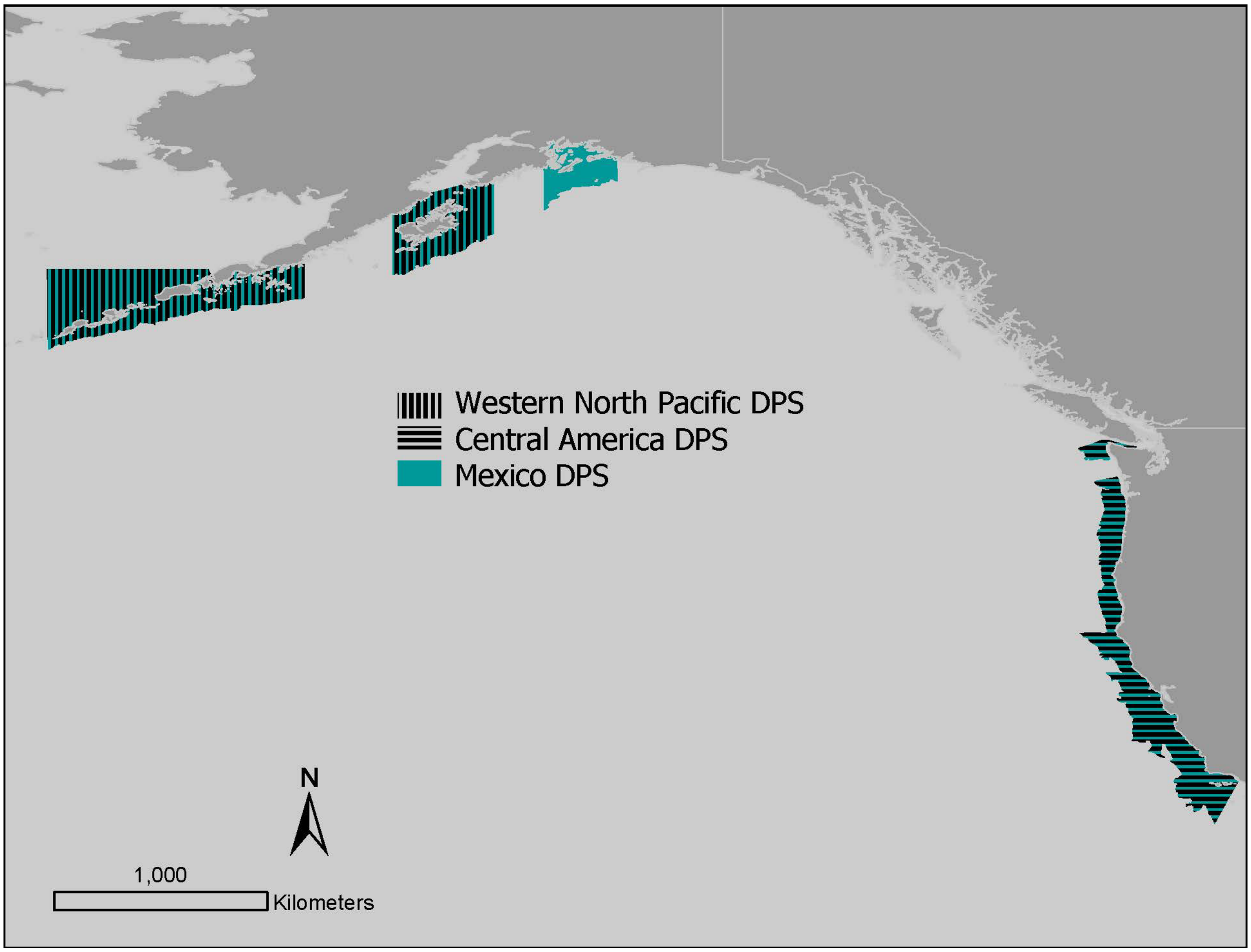


Figure 35. Critical habitat for the humpback whale Western North Pacific, Central America, and Mexico Distinct Population Segments.

The designation of critical habitat includes identification of the physical or biological features (PBFs) associated with that habitat. The essential PBF of recently designated critical habitat for the Mexico and Western North Pacific DPSs of humpback whale are as follows:

Mexico DPS: Prey species, primarily euphausiids (*Thysanoessa, Euphausia, Nyctiphanes,* and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

Western North Pacific DPS: Prey species, primarily euphausiids (*Thysanoessa and Euphausia*) and small pelagic schooling fishes, such as Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus)* and Pacific sand lance (*Ammodytes* *personatus*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

The GOA TMAA overlaps with a portion of the designated critical habitats for the humpback whale Mexico and Western North Pacific DPSs (Figure 36). Unit 5 (named the "Kodiak Island Area" by NMFS) overlaps the TMAA at its western boundary and is defined by the line drawn at 154°54′ West longitude as opposed to any oceanographic or biological feature. This unit is "occupied critical habitat" for the Mexico and Western North Pacific DPSs and characterized as having a high conservation value (National Marine Fisheries Service 2019a; National Marine Fisheries Service 2019b). Unit 8 (the "Prince William Sound Area") was also determined to have a low conservation value and "limited conservation benefit" for the Western North Pacific DPS. The Unit 8 area was excluded for that Western North Pacific DPS because, "… whales from the Western North Pacific DPS have not been directly observed …" in Unit 8 (National Marine Fisheries Service 2019a; National Marine Fisheries Service 2019b). Unit 8 has been determined to have a high conservation value as critical habitat for the threatened Mexico DPS humpback whales (84 FR 54378). There is no overlap between the WMA and humpback whale designated critical habitat.

Here we evaluate the effects of the proposed action on the one identified PBF of humpback critical habitat described above. As discussed below in Section 8.1.2, energy, physical disturbance and strike, entanglement, ingestion, and non-impulsive acoustic stressors are not likely to adversely affect ESA-listed fishes. For these reasons, it is extremely unlikely that humpback whale prey items (i.e., euphausiids and schooling fishes) would be adversely affected by these stressors. In addition, the abundance of prey items in critical habitat for the Western North Pacific and Mexico DPSs is likely several orders of magnitude higher than those of ESA-listed fishes in the region.

Proposed training activities in the portion of the action area overlapping critical habitat, and that may have the potential to impact quality, abundance, or accessibility to prey species for humpback whales, would be those involving in-air explosives. Humpback whale prey items may be adversely affected by impulsive acoustic stressors from in-air explosives if they happen to be near the surface during in-air detonations, as discussed in Section 8.2.2 for ESA-listed fishes. Adverse effects may include injury, TTS, physiological stress, behavioral reactions, and mortality. Those euphausiids and schooling fishes that are killed would no longer be available to humpback whales as prey items. Adverse effects other than mortality would not be anticipated to remove individuals (prey) from their respective populations, nor would any non-mortal temporary or isolated impacts to prey items be expected to reduce the quality of prey in terms of nutritional content.

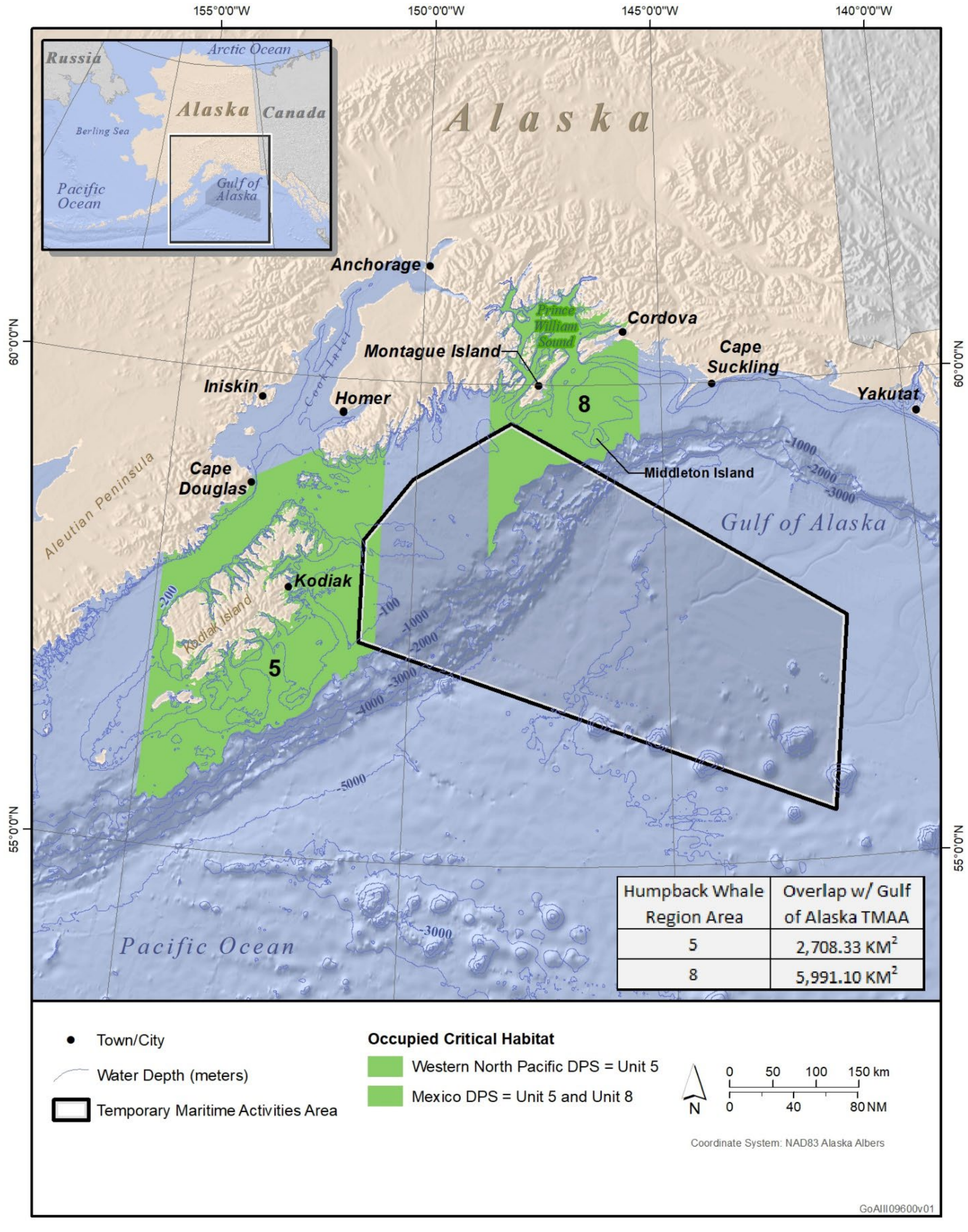


Figure 36. Overlap of humpback whale critical habitat (Units 5 through 8) with the GOA TMAA.

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

With the Navy's proposed Continental Shelf Mitigation Area (see Section 4.6.2.1), no explosive training activities would occur within the designated humpback whale critical habitat off Kodiak or Monague Islands (Units 5 and 8; see Figure 36). The likelihood that prey items are killed within designated humpback whale critical habitat is extremely low due to the fact that there will be no explosions. Although some prey items could be killed outside of the Continental Shelf Mitigation Area during an explosive activity, other prey items would likely be available to humpback whales in the immediate area surrounding the activity or would return to the area after the activity is complete. This would result in a minimal change in the overall quantity or availability of prey items as a whole. Although some individual prey items may be killed outside of humpback critical habitat, long-term consequences for fish and invertebrate populations and the effect on overall quantity, quality and availability of prey items would be insignificant.

Given the small amount of overlap among the designated critical habitats and the GOA TMAA, the fact that no explosives will be detonated within either unit, the frequency of these events, the short duration of these events, the various mitigation measures (including halting of activities until marine mammals are out of the area and are not observed feeding, see Section 4.6.1), and the relatively large number of prey items available throughout designated critical habitat, we conclude that any impacts of explosives resulting from GOA TMAA activities on prey availability for the humpback whale Mexico and Western North Pacific DPSs would be insignificant. In summary, although explosives would likely result in injury and mortality to humpback whale prey species within designated critical habitat areas, we have no information to indicate that this stressor would have a measureable impact on the occurrence of prey species of sufficient condition, distribution, diversity, abundance and density necessary to support individual, as well as population growth, reproduction, and development of the Western North Pacific and Mexico DPSs. The effects of all stressors analyzed on the essential PBF were found to be insignificant and not likely to reduce the conservation value of proposed critical habitat. Therefore, for the reasons provided above, we determine that the proposed action may affect, but is not likely to adversely affect designated critical habitat for the Mexico and Western North Pacific DPSs of humpback whales.

6.2 Status of Species Likely to be Adversely Affected

This opinion examines the status of the following species that are likely to be adversely affected by the proposed action: blue whales, fin whales, Mexico DPS humpback whales, North Pacific right whales, sei whales, sperm whales, chum salmon - two ESUs, coho salmon - two ESUs, sockeye salmon - two ESUs, and steelhead - six DPSs.

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

6.2.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 37). The blue whale is a globally listed species that was originally listed as endangered throughout its range under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained on the list of threatened and endangered species after the passage of the ESA in 1973.

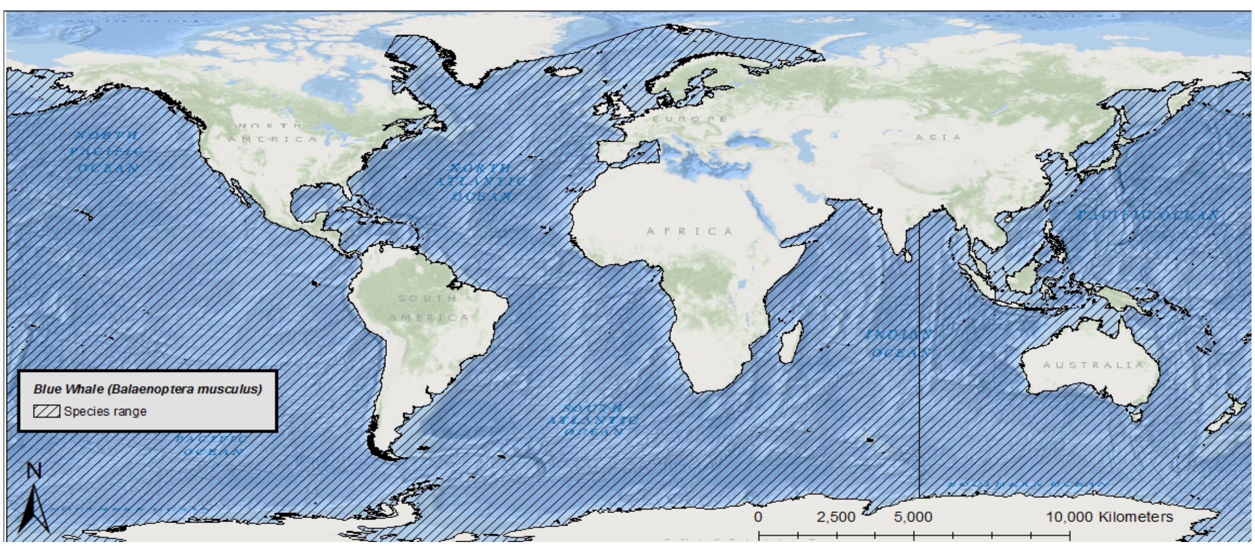


Figure 37. Map identifying the range of the endangered blue whale.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of 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.

Distribution

In general, blue whale distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters off eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. 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.

<u>Occurrence in the GOA Action Area</u>

The number of blue whales in the population that inhabits the TMAA/WMA is complicated by there being uncertainty regarding the number of populations in the Pacific (one to possibly three populations) (Carretta et al. 2020a; International Whaling Commission 2019; Monnahan et al. 2015; National Marine Fisheries Service 2018; National Marine Fisheries Service 2020).

There have not been a sufficient number of surveys in Alaskan waters to support the type of habitat models that have been used to predict the species distribution elsewhere (Abrahms et al. 2019; Becker et al. 2018a; Becker et al. 2017; Forney et al. 2015; Redfern et al. 2017). The Eastern North Pacific stock of blue whales range from the Gulf of Alaska to as far south as the waters off Costa Rica (Carretta et al. 2020c). Blue whales in the Central North Pacific Stock have been observed in the limited surveys of the U.S. EEZ around Hawaii (Carretta et al. 2020c; National Marine Fisheries Service 2018) and acoustically detected at Saipan and Tinian in the Mariana Islands (Oleson et al. 2015), but this reflects very limited survey coverage of the Central Pacific. Previous line transect surveys in the GOA reported blue whale sightings near sea mounts and in pelagic waters (Rone et al. 2017), but passive acoustic data found that blue whales were also present on the continental shelf and slope, for at least a proportion of the year (Rice et al. 2021). Rice et al. (2021) indicate that acoustic data indicates a clear separation of blue whale calls, with B-calls, which are attributed to the Eastern North Pacific stock being more prevalent at the slope and shelf, whereas CenPac calls, attributed to the Central North Pacific stock, being most prevalent farther offshore, at the Quinn and Pratt Seamounts, consistent with temporal differences that have previously been reported (Stafford 2003a). There are no data suggesting or reason to believe that the two stocks do not overlap in their distribution when in Alaskan waters.

Blue whales from the Central North Pacific stock feed in summer off Kamchatka, the Aleutians, and in the Gulf of Alaska, and migrate to lower latitudes in the winter, including the Western Pacific and to a lesser degree the Central Pacific, including Hawaii (Stafford 2003a; Stafford et al. 2001a). Based on a photo-identification match of a blue whale observed during the 2013 Gulf of Alaska Line-Transect Survey II survey in the TMAA, Rone et al. (2014) determined the whale had been previously identified off Baja California, Mexico, in 2005. In a review of blue whale tagging done by Oregon State University, of the 241 tags deployed on blue whales, no whales were tracked within the TMAA and only one whale, tagged in California in 2007, came within 260 kilometers of the southeastern corner of the TMAA (Palacios et al. 2021).

Acoustic monitoring from May to September 2015, April to September 2017, September 2017 to June 2018, and April to September 2019 recorded blue whales in the GOA TMAA from May to January across various years (Debich et al. 2013a; Debich et al. 2014; Rice et al. 2015b; Rice et al. 2018; Rice et al. 2020). Northeast Pacific blue whale B calls started being detected in June and July and peaked in August and September to January (Rice et al. 2020). Central Pacific blue whale tonal calls occurred mainly in August and September at all sites monitored (Rice et al. 2020) although in relatively low numbers overall compared to other blue whale call types (Rice et al. 2018; Rice et al. 2020).

Based on this acoustic data, it is likely that the blue whale's occurrence in the TMAA is year round, with the highest numbers present from June to December (Debich et al. 2013a; Debich et al. 2014; Rice et al. 2015b; Rice et al. 2018; Rice et al. 2020). Both male and female blue whales of all life stages are expected to occur within the GOA TMAA during the proposed action.

Population Structure

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

The blue whale consists of five currently recognized subspecies (NMFS 2020d): B. m. musculus is the northern blue whale (North Atlantic and North Pacific Oceans); B. m. intermedia is the Antarctic blue whale; B. m. brevicauda colloquially known as the "pygmy" blue whale; and B. m. indica is the northern Indian Ocean blue whale. The 2020 blue whale recovery plan identified the following nine management units: North Atlantic; Eastern North Pacific; Western/Central North Pacific; Northern Indian Ocean; Madagascar; Western Australia/Indonesia; New Zealand; Chilean; and Antarctic (NMFS 2020d).

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

Blue whales from both the eastern and western North Pacific have been heard, tracked, or harvested in waters off Kodiak Island; acoustic detections are made in the Gulf of Alaska from mid-July to mid-December and a peak from August through November (COSEWIC 2002; Ivashin and Rovnin. 1967; Moore et al. 2006; Stafford 2003b; Stafford et al. 2007; Yochem and Leatherwood 1985). Although acoustic detections in the Gulf of Alaska were absent since the late 1960s, recordings have increased during 1999 to 2002 and a few sightings have been made in the northern Gulf of Alaska (Calambokidis et al. 2009a; Moore et al. 2006; NOAA 2004; Stafford 2003b; Stafford et al. 2007; Stafford and Moore 2005). However, surveys in the western Gulf of Alaska and east of Kodiak Island have not found blue whales (Rone et al. 2010; Zerbini et al. 2006b). Blue whales are rarely observed in nearshore Alaskan waters, but seem to prefer continental shelf edge waters; such areas in the Gulf of Alaska were formerly feeding grounds for blue whales prior to severe depletion (Rice and Wolman. 1982). Call detections of blue whales from the western North Pacific indicate a greater likelihood of these individual occurring southwest of Kodiak Island (Stafford 2003b). A population of blue whales that has distinct vocalizations inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America (Gregr et al. 2000a; Mate et al. 1998; Stafford 2003b). We assume that this population is the one affected by the activities considered in this biological opinion.

Abundance Estimate and Population Growth Rate

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 United States waters: the Eastern North Pacific Ocean, Central North Pacific Ocean, and Western North Atlantic Ocean. The Eastern North Pacific stock includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2020b).

There is no best estimate of blue whale abundance in the Gulf of Alaska. Due to the location of the action, either the Eastern North Pacific stock and/or Central North Pacific stock of blue whales could be in the action area (Carretta et al. 2020b). Calambokidis and Barlow (2020) reported the best estimate of current blue whale abundance for the Eastern North Pacific feeding stock in CA/OR/WA waters, based the most-recent 4 years (2015-2018) of capture-recapture data, is 1,898 whales. This represents the best estimate of the abundance of blue whales that may occur in the GOA action area. The minimum population estimate of Eastern North Pacific blue whales, calculated as the lower 20th percentile of the 2018 mark-recapture estimate, is 1,767 whales (Carretta et al. 2022). Based on mark-recapture estimates, there may be evidence of a population size increase since the 1990s, but a formal trend analysis is lacking and the current population trend is unknown (Carretta et al. 2022). Results from a population dynamics model suggest that density dependence, and not vessel strike impacts, explains the observed lack of a population size increase of the Eastern North Pacific Ocean feeding stock (Monnahan et al. 2014b).

There is no best estimate for the Central North Pacific stock outside of the Hawaiian Islands EEZ (133 animals)(Bradford et al. 2017) applicable to the GOA action area.

There is no evidence of a population size increase in this blue whale population since the early 1990s (Carretta et al. 2021). Results from a population dynamics model suggest that density dependence, and not vessel strike impacts, explains the observed lack of a population size increase of the Eastern North Pacific Ocean feeding stock (Monnahan et al. 2014b). Current estimates indicate a growth rate of around three to four percent per year for the eastern North Pacific stock (Calambokidis et al. 2009b; Carretta et al. 2021). 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.

Natural Threats

Natural causes of mortality in blue whales are largely unknown, but probably include predation and disease (not necessarily in their order of importance). Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1928), which are believed to have caused fin whales to die as a result of renal failure (Lambertsen 1986); see additional discussion under Fin whales). Killer whales and sharks are also known to attack, injure, and kill very young or sick fin and humpback whales and likely hunt blue whales as well (Ford and Reeves 2008; Perry et al. 1999).

Anthropogenic Threats

Two human activities are known to threaten blue whales; whaling and shipping. Historically, whaling represented the greatest threat to every population of blue whales and was ultimately responsible for listing blue whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (Tonnessen and Johnsen 1982). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species.

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

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

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

Increasing oceanic noise may impair blue whale behavior. Although available data do not presently support traumatic injury from sonar, the general trend in increasing ambient low-frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006). Blue whales off California altered call levels and rates in association with changes in local vessel traffic (McKenna 2011). There is a paucity of contaminant data regarding blue whales. Available information indicates that organochlorines, including dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCB), benzene hexachloride (HCH), hexachlorobenzene (HCB), chlordane, dieldrin, methoxychlor, and mirex have been isolated from blue whale blubber and liver samples (Gauthier et al. 1997; Metcalfe et al. 2004). Contaminant transfer between mother and calf occurs, meaning that young often start life with concentrations of contaminants equal to their mothers, before accumulating additional contaminant loads during life and passing higher loads to the next generation (Gauthier et al. 1997; Metcalfe et al. 2004). This is supported by ear plug data showing maternal transfer of pesticides and flame retardants in the first year of life (Trumble et al. 2013). These data also support pulses of mercury in body tissues of the male studied (Trumble et al. 2013).

Status and Trends

Blue whale populations declined, due largely from commercial whaling during the 20th century, with over 380,000 blue whales taken between 1868 and 1978, predominantly from Antarctic waters (NMFS 2020d). The global mature population size in 1926 was around 140,000. The current global mature population size is uncertain, but estimated to be in the range of 5,000-15,000 mature individuals (NMFS 2020d). This corresponds to a reduction of 89-97% compared to the 1926 global population estimate (Cooke 2018).

It is difficult to assess the current status of blue whales globally because (1) there is no general agreement on the size of the blue whale population prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population in the North Pacific prior to whaling, although some authors have concluded that their population numbers about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain.

The information available on the status and trend of blue whales do not allow us to reach any conclusions about the extinction risks facing blue whales as a species, or particular populations of blue whales. The possible exception is the eastern North Pacific blue whale population which may not have been subject to as much commercial whaling as other blue whale populations and which may be recovering to a stable population level since the cessation of commercial whaling in 1971 (Campbell et al. 2015b; Monnahan et al. 2014a; Monnahan et al. 2014b). With the limited data available on blue whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats due to anthropogenic activities or natural phenomena (e.g., disease, predation, or changes in the distribution and abundance of their prey in response to changing climate). Commercial whaling no longer occurs, but blue whales are still threatened by vessel strikes, entanglement in marine debris and fishing gear, pollution, harassment due to whale watching, anthropogenic noise, and reduced prey abundance and habitat degradation due to climate and ecosystem change. Although still depleted compared to historical abundance, blue whale populations around the world show signs of growth (NMFS 2020). This suggest that the species appears to be somewhat resilient to current threats.

Diving and Social Behavior

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

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

Life History

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

Vocalizations and Hearing

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

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

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

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971b; McDonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Mellinger and Clark 2003; Payne and McVay 1971). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to approximately 22.5 Hz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Indian, Pacific, and Southern Oceans. Many possible explanations for the shifts exist but none has emerged as the probable cause.

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

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

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

The two main recovery objectives from the 1998 recovery plan for blue whales are to: 1) increase blue whale resiliency and ensure geographic and ecological representation by achieving sufficient and viable populations in all ocean basins and in each recognized subspecies, and 2) increase blue whale resiliency by managing or eliminating significant anthropogenic threats. As stated in the recovery plan, recovery of all nine management units is important for achieving geographic and ecological representation of blue whales in the world's oceans, and to ensure conservation of the breadth of genetic variability. In 2020, NMFS published the first revision to the 1998 plan (NMFS 2020d). Key elements of the recovery strategy laid out in the revised plan include: 1) maintaining the international ban on commercial hunting, 2) improving our understanding of how potential threats may be limiting blue whale recovery and implementing actions where populations may be vulnerable, and 3) outlining a research strategy to obtain data necessary to inform estimation of population abundance and trends. Once the populations and their threats are more fully understood, the blue whale recovery plan will be modified to include actions to minimize any threats that are determined to be limiting recovery.

See the 2020 Recovery Plan for the Blue Whale (NMFS 2020d) for complete down listing/delisting criteria.

6.2.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachonica* (a pygmy form) in the Southern Hemisphere (Figure 38). 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 on December 2, 1970 as endangered throughout its range under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained on the list of threatened and endangered species after the passage of the ESA in 1973.

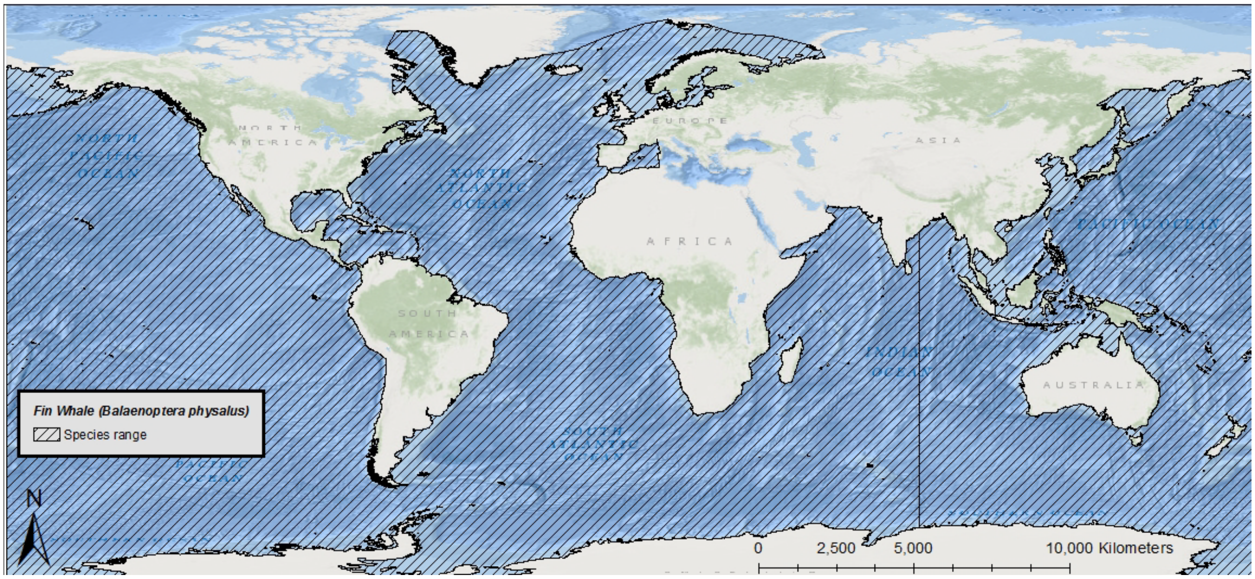


Figure 38. Map identifying the range of the endangered fin whale.

Distribution

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

Occurrence in the GOA Action Area

Fin whales have been documented from 60° N in Alaskan waters, to tropical waters off Hawaii, and in Canadian waters both offshore and inland, including some fjords; and they have frequently been recorded in waters within the Southern California Bight (Barlow and Forney 2007; Campbell et al. 2015a; Jefferson et al. 2014; Mate et al. 2016; Mate et al. 2017; Mizroch et al. 2009; Širović et al. 2016; Širović et al. 2004; Širović et al. 2015b; Smultea 2014). As demonstrated by satellite tags and discovery tags, fin whales make long-range movements along the entire U.S. West Coast (Falcone et al. 2011; Mate et al. 2016; Mate et al. 2017; Mate et al. 2015b; Mizroch et al. 2009). In a review of tagging data collected by Oregon State University on 46 fin whales from 1993 to 2018, only one fin whale tagged in California in 2006 had locations within the TMAA in January and February 2007 (Palacios et al. 2021). Locations of breeding and calving grounds are largely unknown. The species is highly adaptable to changing foraging conditions, following prey, typically off the continental shelf (Azzellino et al. 2008; Panigada et al. 2008). Fin whales have been found to feed in association with high density of zooplankton near the Kodiak Archipelago (Witteveen et al. 2014). Passive acoustic monitoring has detected fin whale vocalizations in the TMAA throughout the year (Archer et al. 2019b; Rice et al. 2018; Rice et al. 2020; Wiggins and Hildebrand 2018). Passive acoustic data have recorded high level of fin whale calls on the slope and shelf, which is consistent with fin whale sighting records, which have typically occurred along the continental shelf and slope (Rice et al. 2021; Rone et al. 2017; Zerbini et al. 2006a).

Fin whale's occurrence in the TMAA/WMA would likely be year round with a greatest numbers between June and August and expected to include males and females of all life stages.

Population Structure

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

Abundance Estimate

There are no reliable estimates of current and historical abundances for the entire Northeast Pacific fin whale stock (Muto et al. 2021). Several studies provide information on the distribution and occurrence of fin whales in the Northeast Pacific, as well as estimates of abundance in certain areas within the range of the stock, however, many of these are over a decade or more old. Visual shipboard surveys for cetaceans were conducted on the eastern Bering Sea shelf during summer in 1997, 1999, 2000, 2002, 2004, 2008, and 2010 ((Friday et al. 2012; Friday et al. 2013; Moore et al. 2002; Moore et al. 2000)). These surveys were conducted in conjunction with the Alaska Fisheries Science Center echo-integrated trawl surveys for walleye pollock. The surveys covered 789 to 3,752 kilometers of tracklines and observation effort for marine mammals varied according to the availability of observers during each cruise. Results of the surveys in 2002, 2008, and 2010, years when the entire Alaska Fisheries Science Center pollock survey sampling area was surveyed, provided estimates of 419 (CV = 0.33), 1,368 (CV = 0.34), and 1,061 (CV = 0.38) fin whales (Friday et al. 2013).

Dedicated line-transect cruises were conducted in coastal waters (as far as 85 offshore) of western Alaska and the eastern and central Aleutian Islands in July and August from 2001 to

2003 (Zerbini et al. 2006c). Over 9,053 kilometers of tracklines were surveyed between the Kenai Peninsula (150°W) and Amchitka Pass (178°W). Fin whales (n = 276) were observed from east of Kodiak Island to Samalga Pass, with high aggregations recorded near the Semidi Islands. Zerbini et al. (2006) estimated that 1,652 fin whales (95% CI: 1,142-2,389) occurred in these areas between 2001 and 2003.

In 2013 and 2015, dedicated line-transect surveys of the offshore waters of the Gulf of Alaska recorded, respectively, 171 and 38 sightings of fin whales (Rone et al. 2017). These surveys provided fin whale abundance estimates of 3,168 fin whales (CV = 0.26) in 2013 and 916 (CV = 0.39) in 2015. The marked differences in these estimates can be partially explained by differences in sampling coverage across the two cruises (Rone et al. 2017).

Estimates of fin whale abundance in the eastern Bering Sea and in the Gulf of Alaska in any given year cannot be considered representative of the entire Northeast Pacific stock because the geographic coverage of surveys was limited relative to the range of the stock. In addition, these estimates have not been corrected for animals missed on the trackline, animals submerged when the ship passed, and responsive movement away from or towards the survey vessel.

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 (Nadeem et al. 2016). The current minimum abundance estimate for fin whales belonging to the Northeast Pacific stock within the GOA is 3,168 (CV=0.36) (Carretta et al. 2020b; Muto et al. 2021; Nadeem et al. 2016) and best represents the potential abundance of fin whales that may occur in the GOA action area.

Natural Threats

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

Anthropogenic Threats

Fin whales have undergone significant exploitation, but are currently protected under the International Whaling Commission (IWC). Fin whales are still hunted in subsistence fisheries off West Greenland. In 2004, five males and six females were killed, and two other fin whales were struck and lost. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005).

Fin whales experience significant injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Carretta et al. 2017b; Douglas et al. 2008; Lien 1994; NMFS 2018a; Perkins and Beamish 1979; Saez 2018; Waring et al. 2007). Based on reports from 2007 to 2014 for waters off the U.S. West Coast, a total of four fin whales were seriously injured by entanglement in fishing gear (Carretta et al. 2018). The minimum estimated mean annual level of human-caused mortality and serious injury for Northeast Pacific fin whales between 2014 and 2018 is 0.6 whales due to ship strikes (Muto et al. 2021). Between 1969 and 1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). In 1999, one fin whale was reported killed in the Gulf of Alaska pollock trawl fishery and one was killed the same year in the offshore drift gillnet fishery (Angliss and Outlaw 2005; Carretta and Chivers. 2004). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004.

Available data from NMFS indicate that, in waters off the U.S. West Coast between 1991 and 2010, there were 11 reported ship strikes involving fin whales (National Marine Fisheries Service 2011b), and from 2010 to 2014 along the U.S. West Coast there were nine reported ship strikes to fin whales (Carretta et al. 2016b). Since 2002, 10 out of the 12 stranded fin whales in Washington have showed evidence attributed to a large ship strike (Cascadia Research 2017). Jensen and Silber (2004) review of the NMFS's ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawai′i. Between 1999 to 2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005; Nelson et al. 2007). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008). Similarly, 2.4 percent of living fin whales from the Mediterranean show ship strike injury and 16 percent of stranded individuals were killed by vessel collision (Panigada et al. 2006). There are also numerous reports of ship strikes off the Atlantic coasts of France and England (Jensen and Silber 2004). Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to be capable of reducing ship strike mortality by 27 percent in the Bay of Fundy region.

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

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

Status and Trends

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000. The North Pacific population of fin whales was reduced to 13,620 to 18,680 by 1973 (Ohsumi and Wada 1974). There are three stocks in United States Pacific Ocean waters: Northeast Pacific [minimum 2,554 individuals], Hawaii (approximately 154 individuals [N_{min}=75]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Carretta et al. 2020b; Muto et al. 2020; Muto et al. 2021; Nadeem et al. 2016). According to whaling records from Canadian Pacific waters, at least 7,605 fin whales were killed between 1908 to 1967 (Gregr et al. 2000a). The best abundance estimate for the ESA-listed fin whales that occur in the GOA action area is 2,554 individuals (Northeast Pacific stock).

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

Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Nevertheless, based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

Diving and Social Behavior

The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5 to 20 shallow dives, each of 13 to 20 s duration, followed by a deep dive of 1.5 to 15 min (Gambell 1985a; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2 to 6 min (Hain et al. 1992; Watkins 1981b). The most recent data support average dives of 98 meters and 6.3 min for foraging fin whales, while non-foraging dives are 59 meters and 4.2 min (Croll et al. 2001a). However, Lafortuna et al. (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 meters are known (Panigada et al. 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75 percent of sightings during the Cetacean and Turtle Assessment Program (Hain et al. 1992).

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

Life History

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

Washington, based on rates of fin whale calls in the area from fall through February (Muto et al. 2019; Soule and Wilcock 2013).

Vocalization and Hearing

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

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

Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing. In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 kHz to 2 kHz range. This study also hypothesized that baleen whales also use bone conduction to hear.

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

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

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

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

Critical Habitat

NMFS has not designated critical habitat for fin whales.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. See the 2010 Final Recovery Plan for the Fin Whale for complete downlisting/delisting criteria for both of the following recovery goals (National Marine Fisheries Service 2010a):

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

6.2.3 Humpback Whale – Mexico DPS

The humpback whale is a widely distributed baleen whale found in all major oceans. Humpback whales 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 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico) (Figure 39).

Distribution

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

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

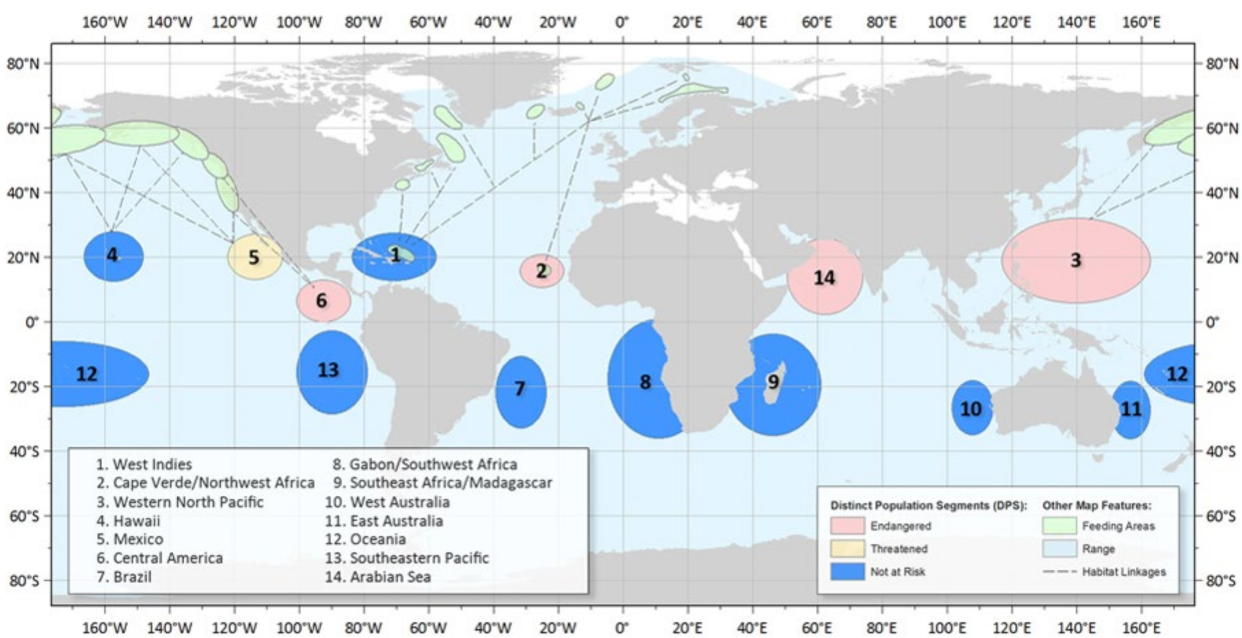


Figure 39. Map showing the distribution of the 14 humpback whale Distinct Population Segments (modified from Bettridge et al. 2015).

Occurrence in the GOA Action Area

Humpback whales belonging to the threatened Mexico DPS feed seasonally in the action area. Both sexes and all life stages of humpback whales would be expected to occur within the action area. Mother/calf pairs are also likely with young calves (recent birth) being highly likely.

In Alaska waters, humpback whales feed in association with high densities of zooplankton and fish near the Kodiak Archipelago (Witteveen et al. 2014; Witteveen et al. 2011; Witteveen and Wynne 2017) and in association with seasonal runs of herring in Prince William Sound (Burrows et al. 2016; Moran et al. 2018; Moran et al. 2015). Witteveen et al. (Witteveen et al. 2011) determined that in the biologically important area (BIA) humpback whales fed heavily on euphausiids, but also ate herring, eulachon, juvenile walleye pollock, capelin, and sand lance, with annual differences in diet due to either individual prey preferences or prey availability. Moran et al. (2018) estimated that humpback whales in Prince William Sound consumed approximately the biomass lost to natural mortality over winter and that the herring predation in Prince William Sound can exert top-down controlling pressure but not overall in the Gulf of Alaska at this time. In 2019, commercial fishermen landed over 40 million pounds of herring in Alaska for that year (Alaska Department of Fish and Game 2020).

While humpback whales are present in Prince William Sound year round (Moran et al. 2018; Rice et al. 2015b), off Kodiak Island the greatest densities are present July–September, and in the Prince William Sound feeding area the greatest densities are present September–December (Ferguson et al. 2015a). Humpback whales in the offshore waters adjacent to Prince William Sound (including Lower Cook Inlet, Kenai Fjords, and the Barren Islands) tended to have a diet higher in fish than zooplankton, whereas the animals located in Prince William Sound fed almost exclusively on fish (Witteveen et al. 2011). Line transect surveys overlapping the Action Area in 2009, 2013, and 2015 determined that the main humpback whale aggregations in all survey years were located on the eastside of Kodiak Island (Rone et al. 2009; Rone et al. 2014; Rone et al. 2017).

Population Structure

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

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

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska, and Bering Sea feeding grounds (81 FR 62259). Wade (2021) has recently reevaluated the Wade et al. (2016) humpback whale guidance to indicate that the probability of encountering the Mexico DPS in the GOA study area is approximately 11 percent. The non-listed Hawaiian DPS has a probability of 89 percent of the humpback whales with occurrence in the summer feeding areas.

Abundance Estimate

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

Based on photoidentification analysis of images collected for three years (2004–2006) in winter areas and for two years (2005–2006) in summer areas, the Mexico DPS was previously estimated to number 3,264 individuals (Wade et al. 2016). Given the age of that data, and there having been no more recent data specifically for the Mexico DPS, a population growth rate was not provided in the SAR for the Mexico population (Bettridge et al. 2015a; Carretta et al. 2020c). There is currently no abundance estimate for the Mexico DPS, although an estimated 3,477 (CV=0.101) whales from the Mexico DPS feed off the U.S. West Coast (Calambokidis and Barlow 2020; Curtis and et al. 2022). Based on the recent guidance from Wade (2021), an estimated 11 percent of all humpbacks in the GOA belong to the Mexico DPS.

Natural Threats

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

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

Anthropogenic Threats

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

Entanglement in pot/trap fisheries has been the most common source of injury to humpback whales along the U.S. Pacific coast (Carretta et al. 2016a; Carretta et al. 2017b; NOAA 2017; Saez et al. 2012). There were 54 separate entanglement cases reported for humpback whales along the U.S. West Coast in 2016 (National Oceanic and Atmospheric Administration 2017). For the five-year period between 2011 and 2015 there were 34 cases of entanglement involving pot/trap fisheries and an additional 26 cases of reported interactions with other fisheries (Carretta et al. 2017c). Humpback whales from Mexico have been identified feeding in Alaska (Bettridge et al. 2015a; Calambokidis et al. 2008). Humpback whales have also been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Helker et al. 2017); some proportion of these entanglements could be to whales from the Mexico DPS. The minimum estimated mean annual level of human-caused mortality and serious injury for Central North Pacific humpback whales between 2014 and 2018 is 26 whales (Muto et al. 2021). This includes impacts from fisheries, ship strike, entanglement and marine debris.

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997). Along the U.S. Pacific coast between 2011 and 2015, there were nine ship strikes involving humpback whales; none were Navy vessels (Carretta et al. 2017a; Carretta et al. 2016b). The mean vessel collision mortality and serious injury rate in Alaska is 4.3 humpback whales (all DPSs) annually (Muto et al. 2017).

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

Status and Trends

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). Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century. Humpback whales in the North Pacific were theoretically fully protected from whaling in 1965, but illegal catches by the U.S.S.R. continued until 1972 (Ivashchenko et al. 2013). From 1948 to 1971, 7,334 humpback whales were killed by the U.S.S.R., and 2,654 of these were illegally taken and not reported to the IWC (Ivashchenko et al. 2013). Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); additional illegal catches were made across the North Pacific, from the Kuril Islands to Haida Gwaii, and other takes may have gone unrecorded. We have no way of knowing the degree to which a specific DPS of humpback whale was affected by historical whaling. However, it is likely that individuals from the Mexico DPS was taken, based on known distributions of humpback whales from this DPS.

Humpback whales may be killed under “aboriginal subsistence whaling” and “scientific permit whaling” provisions of the International Whaling Commission outside of U.S. waters. Subsistence hunters in Alaska are not authorized to take from the stocks of humpback whales which may occur in the GOA. Current threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. Due to on-going threats the Mexico DPS still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

Diving and Social Behavior

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

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

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

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age. Every one to five years, females five birth to a single calf, with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. In British Columbia, the highest numbers of humpback whales are found between May and October, however, individuals are observed throughout the year (Ford 2009). Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015b).

Vocalization and Hearing

Humpback whale vocalization is much better understood than hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144 to 174 dB (Au et al. 2006a; Frazer and Mercado Iii 2000; McCauley et al. 2000; Richardson et al. 1995c; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz to 10 kHz with most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 kilometers (4.9 nm) away (Tyack 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995c; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 μPa at 1 meter) (Edds-Walton 1997; Oleson et al. 2007b; Payne and Webb 1971; Thompson et al. 1992a). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

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

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

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

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

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

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 (National Marine Fisheries Service 1991):

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

6.2.4 North Pacific Right Whale

The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals. Several lines of evidence indicate a total population size of less than 100. Based on photo-identification from 1998 to 2013 (Wade et al. 2011b) estimated 31 individuals, with a minimum population estimate of 25.7 individuals. Genetic data have identified 23 individuals based on samples collected between 1997 and 2011 (Leduc et al. 2012). There is currently no information on the population trend of North Pacific right whales.

Distribution

As a result of past commercial whaling, the remnant population of North Pacific right whales has been left vulnerable to genetic drift and inbreeding due to low genetic variability. This low diversity potentially affects individuals by depressing fitness, lowering resistance to disease and parasites, and diminishing the whales' ability to adapt to environmental changes. At the population level, low genetic diversity can lead to slower growth rates, lower resilience, and poorer long-term fitness (Lacy 1997). Marine mammals with an effective population size of a few dozen individuals likely can resist most of the deleterious consequences of inbreeding (Lande 1991). It has also been suggested that if the number of reproductive animals is fewer than fifty, the potential for impacts associated with inbreeding increases substantially. Rosenbaum et al. (2000) found that historic genetic diversity of North Pacific right whales was relatively high compared to North Atlantic right whales (*E. glacialis*), but samples from extant individuals showed very low genetic diversity, with only two matrilineal haplotypes among the five samples in their dataset.

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20° and 60° latitude (Figure 40). Prior to exploitation by commercial whalers, concentrations of right whales in the North Pacific where found in the Gulf of Alaska, Aleutian Islands, south central Bering Sea, Sea of Okhotsk, and Sea of Japan. There has been little recent sighting data of right whales occurring in the central North Pacific and Bering Sea. However, since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months. Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell Jr. et al. 2001; Shelden et al. 2005b; Wade et al. 2006; Zerbini et al. 2010a). There are far fewer sightings of North Pacific right whales in the Gulf of Alaska than the Bering Sea (Brownell Jr. et al. 2001; Wade et al. 2011b; Zerbini et al. 2010a). In addition to sighting data (Matsuoka et al. 2013; Wade et al. 2011b; Wade et al. 2011c), passive acoustic data have indicated the presence of North Pacific right whales in the Gulf of Alaska (Mellinger et al. 2004b; Sirovic et al. 2015). No right whales were detected from more than 5,324 hours of passive acoustic data obtained from Navy-funded monitoring devices in the north-central Gulf of Alaska (Baumann-Pickering et al. 2012b; Debich et al. 2013b), but calls were detected in 2013 during two days (21 June and 3 August) from a device located at Quinn Seamount (Sirovic et al. 2015).

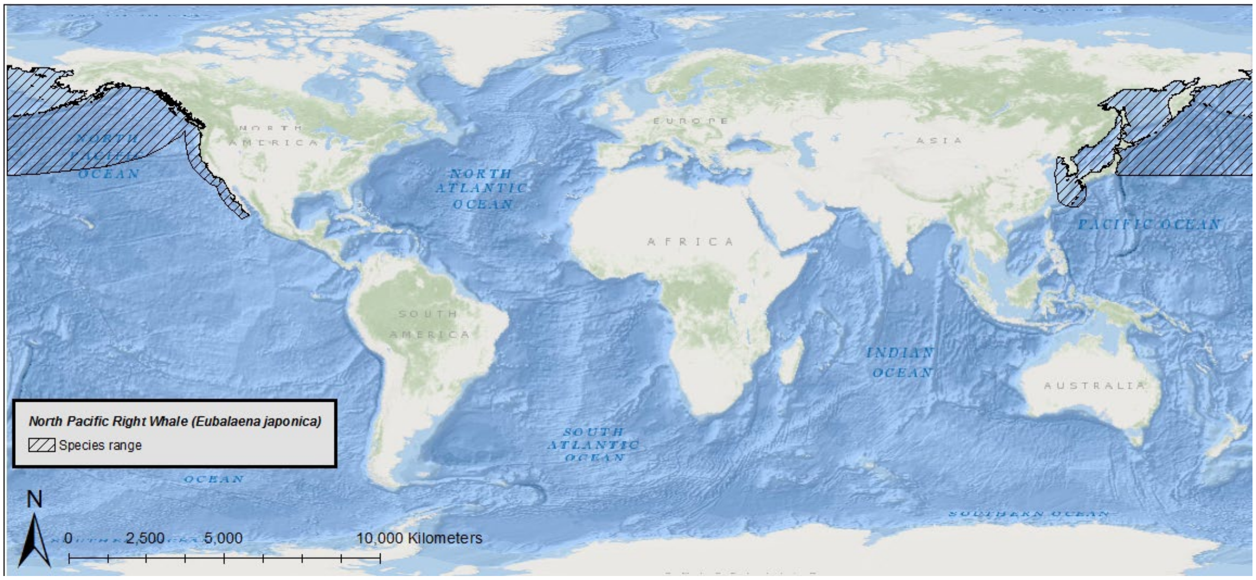


Figure 40. Map identifying the range of the endangered North Pacific right whale.

Occurrence in the GOA Action Area

Until recently, historical whaling records provided virtually the only information on North Pacific right whale distribution (Gregr et al. 2000b; National Marine Fisheries Service 2013; Wright et al. 2019; Wright et al. 2018). This species historically occurred across the Pacific Ocean north of 35°N, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Sea of Okhotsk, and the Sea of Japan (Gregr et al. 2000b; Ivashchenko and Chapham 2012; Scarff 1991; Scarff 2001a; Shelden et al. 2005a). They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (National Marine Fisheries Service 2013; National Marine Fisheries Service 2017). In recent years, this species has generally only been observed or acoustically detected in the Bering Sea/Bristol Bay Alaska area (Brownell et al. 2001; Crance et al. 2017; Ford et al. 2016; Shelden et al. 2005a; U.S. Department of the Navy 2017b; Wade et al. 2011a; Wade et al. 2010; Wright et al. 2019; Zerbini et al. 2015; Zerbini et al. 2010b), with occasional sightings in the western Gulf of Alaska area (Matsuoka et al. 2014; Širović et al. 2015a; U.S. Department of the Navy 2017b; Wade et al. 2011a).

A line transect survey was conducted in 2015 that had a primary focus and design to locate North Pacific right whales in the nearshore waters of the Gulf of Alaska, including the designated critical habitat located off Kodiak Island, the BIA for feeding, right whale habitat based on historical whale catch data, and the nearshore margins of the TMAA (Rone et al. 2017). This survey, which occurred from August 10 to September 8, 2015, sighted no right whales (Rone et al. 2017). More recently, the Pacific Marine Assessment Program for Protected Species survey was conducted in the GOA during August 2021 (Crance et al. 2022). Four unique North Pacific right whales were sighted, two of which were confirmed as new individuals (Figure 41).

Abundance Estimate

For the critically endangered North Pacific right whale, the current minimum population estimate is only 26 individuals (Wade et al. 2011b). Due to their low population size, sightings of North Pacific right whales are very rare in the GOA, with only six sightings from 1966 to 2006, all occurring south of Kodiak Island (Wade et al. 2011c; Zerbini et al. 2006c). Acoustic detections of this species, while also rare, have occurred in areas farther offshore where there have not been visual sightings (Mellinger et al. 2004b; Sirovic et al. 2015).

North Pacific right whales occur in subpolar to temperate waters. They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (Clapham et al. 2004). The rarity of reports for right whales in more southern coastal areas in winter in either historical or recent times suggests that their breeding grounds may have been offshore (Clapham et al. 2004).

Since the 2020 GOA Draft SEIS/OEIS, there have been a few new sightings or acoustic detections of North Pacific right whales in the Arctic and locations farther south off the U.S. West Coast; off Hokkaido, Japan; and in the North Pacific Ocean to the southeast of Kamchatka Peninsula (Filatova et al. 2019; Ford et al. 2016; Hakamada and Matsuoka 2016; Matsuoka et al. 2018a; Matsuoka et al. 2018b; Rice et al. 2018; Rice et al. 2020; Širović et al. 2015a; U.S. Department of the Navy 2017b; WorldNow 2017; Wright et al. 2019; Wright et al. 2018). Based on sightings of whales in association with dense zooplankton layers in Barnabas Tough made by Wade et al. (2011a) and acoustic detections since 1998 and 2011 there and at the Albatross bank area south of Kodiak Island, in 2015 NMFS defined a BIA for feeding from June through September (Ferguson et al. 2015b). This area overlaps with the TMAA by approximately 2,051 square kilometers, which is approximately 1.4 percent of the TMAA. As noted previously, a line transect survey was conducted in 2015 to locate North Pacific right whales in the nearshore waters of the Gulf of Alaska. This includes the designated critical habitat located off Kodiak Island, the BIA feeding area, and right whale habitat based on historical whale catch data, but no right whales were sighted in the areas surveyed (Rone et al. 2017).

Right whales were acoustically detected in Barnabus Trough outside the GOA TMAA but were not visually observed during the 2013 Gulf of Alaska Line-Transect Surveys for marine mammals within the TMAA; six of the possible detections from Rone et al. (2014) occurred within the GOA TMAA. As noted in the 2020 GOA Draft SEIS/OEIS, this species has generally been described as routinely observed or acoustically detected in the Bering Sea/Bristol Bay Alaska area (Matsuoka et al. 2018a; Muto et al. 2020). Acoustic monitoring occurring at five sites in the GOA TMAA between July 2011 and September 2019 did not detect any North Pacific right whale calls (Rice et al. 2018; Rice et al. 2020; Wiggins et al. 2017), and they have not been sighted in the action area during any of the three most recent line transect surveys

(Rone et al. 2017), as noted previously. Based on acoustic monitoring, surveys, and historical information, the Navy has determined the North Pacific right whale's occurrence in the GOA action area would be year round but rare, with a potentially higher density between June and September.

The only recent estimate of abundance comes from mark-recapture analyses of photo-identification and genetic data. Photographic (18 identified individuals) and genotype (21 identified individuals) data through 2008 were used to calculate the first mark-recapture estimates of abundance for right whales in the Bering Sea and Aleutian Islands, resulting in separate estimates of 31 (95% CL: 23-54; CV = 0.22) and 28 (95% CL: 24-42), respectively (Wade et al. 2011). The abundance estimates are for the last year of each study, corresponding to 2008 for the photo-identification estimate and 2004 for the genetic identification estimate.

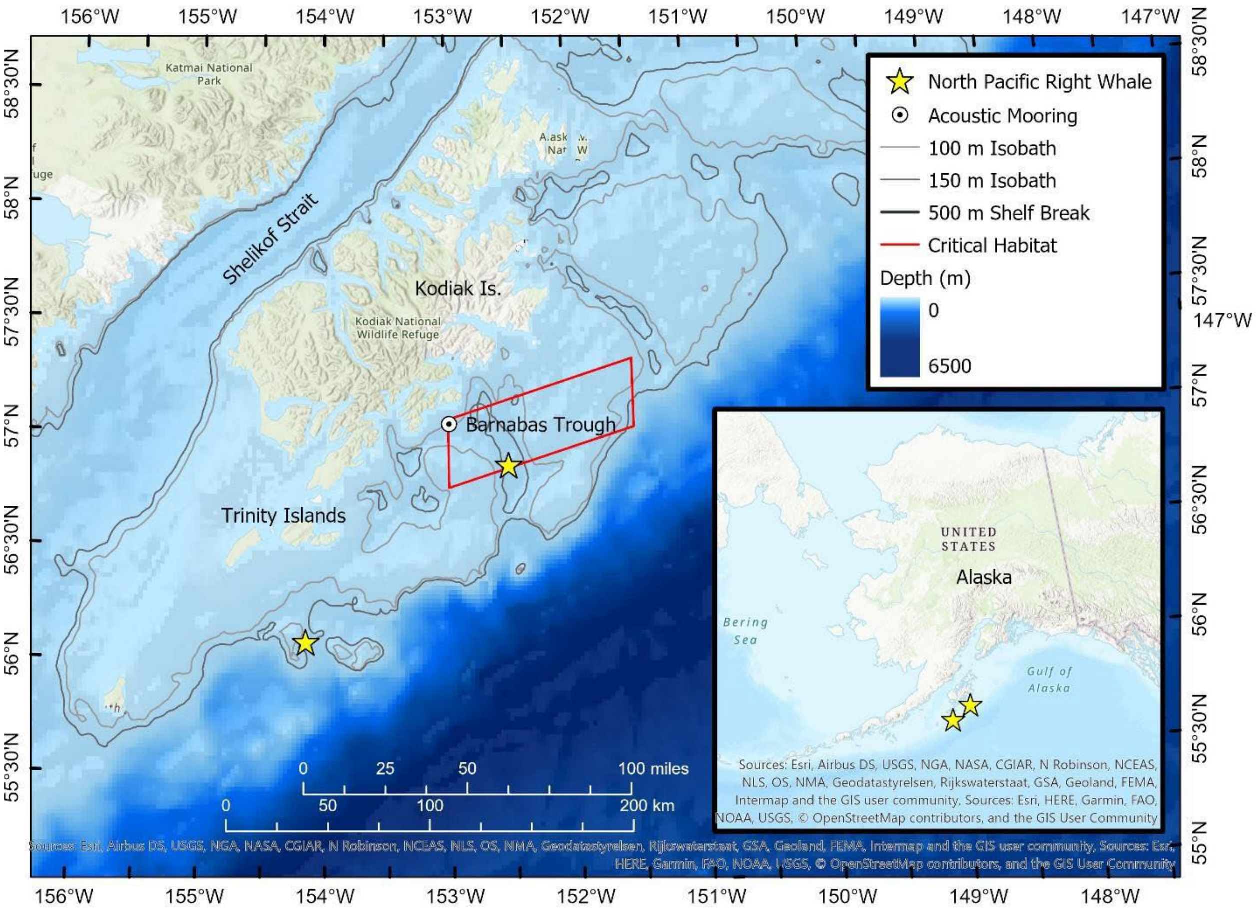


Figure 41. North Pacific right whale sightings during the 2021 Pacific Marine Assessment Program for Protected Species survey (Crance et al. 2022).

The minimum estimate of abundance of Eastern North Pacific right whales is 26 whales based on the 20th percentile of the photo-identification estimate of 31 whales (CV = 0.226: Wade et al. 2011).

Based on the available sighting and acoustic data, the total number of right whales still using the GOA feeding ground is likely 10 or fewer animals. The minimum estimate based on visual sightings is four whales in the northern GOA (Wade et al. 2011c). Given their current extremely low population numbers, to acknowledge their potential presence in the GOA action area, and based on the data summarized above, the Navy has made an assumption that five North Pacific right whales could be present within the TMAA at any one time (DON 2020). Both sexes and all life stages of North Pacific right whales are expected to be present in the action area.

Vocalization and Hearing

Given their extremely small population size and remote location, little is known about North Pacific right whale vocalizations (Marques et al. 2011). However, data from other right whales is informative. Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey path presence

(Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002; Parks and Tyack 2005). A large majority of vocalizations occur in the 300 to 600 Hz range with up and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hz and above 900 Hz were rare And calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Gunshots appear to be largely or exclusively male vocalization (Parks et al. 2005b). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100 to 400 Hz (Gillespie and Leaper 2001).

Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001). Moans are usually produced within 10 meters (33 feet) of the surface (Matthews et al. 2001). Up calls were detected almost year-round in Massachusetts Bay, except July and August, and peaked in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated source levels of gunshots in non-surface active groups are 201 dB re 1 μPa peak-to-peak (Hotchkin et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar to their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). Source levels for these calls in surface active groups range from 137 to 162 dB re 1 μPa at 1 m (rms), except for gunshots, which are 174 to 192 dB re 1 μPa at 1 m (rms) (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves. North Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short-term periods due to exposure to vessel noise (Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2005a; Parks et al. 2011; Parks et al. 2010; Parks et al. 2012b; Parks et al. 2006), particularly the peak frequency (Parks 2009). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004b).

There is no direct data on the hearing range of North Pacific right whales. However, based on anatomical modeling, the hearing range for North Atlantic right whales is predicted to be from 10 Hz to 35 kHz (NOAA, 2018) with functional ranges probably between 15 Hz to 18 kHz (Parks et al. 2007c).

Critical Habitat

In April 2008 (73 FR 19000), NMFS clarified that two areas previously designated as critical habitat for right whales in the North Pacific (71 FR 38277) also applied to the listed North Pacific right whale. The areas encompass about 36,750 square miles of marine habitat, which include feeding areas within the Gulf of Alaska and the Bering Sea that support the species.

Recovery Goals

See the 2013 Final Recovery Plan for the North Pacific Right Whale for complete down listing/delisting criteria for each of the following recovery goals (National Marine Fisheries Service 2013):

- Reduce or eliminate injury or mortality caused by ship collision
- Reduce or eliminate injury and mortality caused by fisheries and fishing gear
- Protect habitats essential to the survival and recovery of the species
- Minimize effects of vessel disturbance
- Continue international ban on hunting and other directed take
- Monitor the population size and trends in abundance of the species
- Maximize efforts to free entangled or stranded individuals and acquire scientific information from dead specimens.

6.2.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 42). 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 throughout its range on December 2, 1970 under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained on the list of threatened and endangered species after the passage of the ESA in 1973.

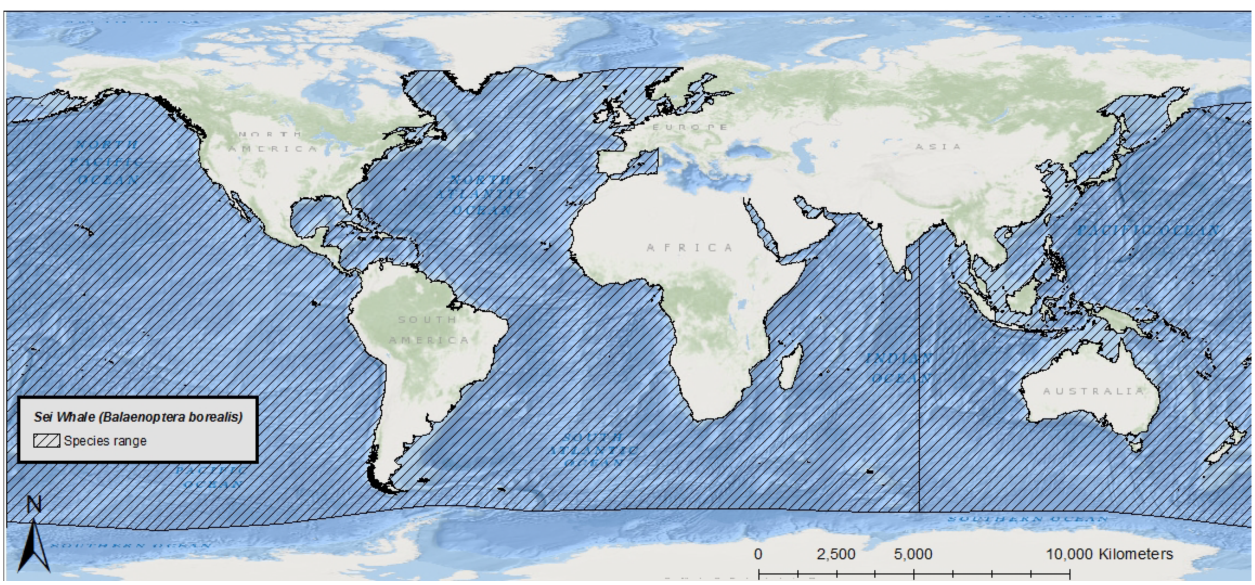


Figure 42. Map identifying the range of the endangered sei whale.

Distribution

The sei whale occurs in all oceans of the world except the Arctic. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

In the western Atlantic Ocean, sei whales occur from Nova Scotia and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985b). In the eastern Atlantic Ocean, sei whales occur in the Norwegian Sea (as far north as Finnmark in northeastern Norway), occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b).

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

Sei whales occur throughout the Southern Ocean during the summer months, although they do not migrate as far south to feed as blue or fin whales. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of Southern Africa and Australia. During the winter, sei whales are found from 20° to 23°N (Gambell 1985b; Masaki 1977). Sasaki et al. (2013) demonstrated that sei whale in the North Pacific are strongly correlated with sea surface temperatures between 13.1 and 16.8°C.

<u>Occurrence in the GOA Action Area</u>

The sei whale's occurrence in the TMAA/WMA could be year round but rare. Whaling records documented high densities of sei whales in the northwestern and northeastern portions of the Gulf of Alaska (e.g., near Portlock Bank). The only confirmed sightings of sei whales in the Gulf of Alaska (and outside the TMAA) in modern times were in 2011 to the west of Kodiak Island (Davis et al. 2011) and two sightings in 2015: a sei whale within the aggregation of fin and humpback whales at Albatross Bank off Kodiak Island and a second observed approximately 300 kilometers south of Kodiak Island (Rone et al. 2017). Although recent surveys (2009, 2013, 2015) have not produced confirmed sei whale sightings in the TMAA and passive acoustic monitoring at fixed sites has not detected their vocalizations (Rice et al. 2020), sei whale calls were acoustically detected in the TMAA during the 2013 survey (Rone et al. 2014). During the more recent Pacific Marine Assessment Program for Protected Species survey, conducted in the GOA during August 2021, 43 whale sightings were reported as fin/sei whale (Crance et al.

2022). Another 125 sightings were confirmed to the species level as fin whales, and none were confirmed as sei whales, suggesting the large majority of the fin/sei whale reported sightings were fin whales. Based on the above considerations, sei whale occurrence in the TMAA/WMA during the summer time period is considered rare but if present, both sexes and all life stages may occur in the action area.

Population Structure

The sei whale occurs in all oceans of the world except the Arctic. In the western Atlantic Ocean, sei whales occur from Nova Scotia and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985b). In the eastern Atlantic Ocean, sei whales occur in the Norwegian Sea (as far north as Finnmark in northeastern Norway), occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b). In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20° to 23° N (Gambell 1985b; Masaki 1977). Sei whales occur throughout the Southern Ocean during the summer months, although they do not migrate as far south to feed as blue or fin whales. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of Southern Africa and Australia. During the winter, sei whales are found from 20° to 23°N (Gambell 1985b; Masaki 1977). Sasaki et al. (2013) demonstrated that sei whale in the North Pacific are strongly correlated with sea surface temperatures between 13.1 and 16.8°C.

Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific sei whales (Wada and Numachi 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker and Clapham 2004; Huijser et al. 2018). Taguchi et al. (2021) conducted the first population genetic study of sei whales worldwide using microsatellite DNA (msDNA). He found that sei whales appear to be significantly differentiated among oceanic regions hierarchically, and sei whales in the Southern Hemisphere are more closely related to sei whales in the North Pacific than sei whales in the North Atlantic (Taguchi et al. 2021).

Genetic studies have found that there is high haplotype diversity in the North Pacific sei whale population and moderate haplotype diversity in the North Atlantic population, indicating greater diversity in the Pacific Ocean (Huijser et al. 2018; Pastene et al. 2016). These studies indicate that the sei whale has moderate to high genetic diversity, providing the raw genetic material required to adapt to changes in its environment, and thus some resilience to such perturbations (NMFS 2021).

Sei whales appear to prefer to forage in regions of steep bathymetric relief, such as continental shelf breaks, canyons, or basins situated between banks and ledges (Best and Lockyer 2002; Gregr and Trites 2001; Kenney and Winn 1987), where local hydrographic features appear to help concentrate zooplankton, especially copepods. In their foraging areas, sei whales appear to associate with oceanic frontal systems (Horwood 1987). In the north Pacific, sei whales are found feeding particularly along the cold eastern currents (Perry et al. 1999).

Abundance Estimate

Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. The central and eastern North Pacific Ocean sei whale population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (Hakamada et al. 2017; IWC 2016; Thomas et al. 2016). To this can be added an estimate of 5,086 from survey in the western North Pacific (Hakamada and Matsuoka 2016), giving a total estimate of about 35,000 sei whales in the North Pacific Ocean (NMFS 2021). There are no estimates of the growth rate of sei whale populations in the North Pacific. The best abundance estimate for sei whales for the waters of the U.S. West Coast is 519 (CV=0.40) (Barlow 2016); the current minimum population estimate is 374 (Carretta et al. 2021) (Carretta et al. 2020b) (Carretta et al. 2020b). Encounter data from a 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ was evaluated using Beaufort sea-state-specific trackline detection probabilities for sei whales, resulting in an abundance estimate of 391 (CV = 0.9) sei whales (Bradford et al. 2017) in the Hawaii stock; the current minimum population estimate is 204 (Carretta et al. 2021) (Carretta et al. 2020b) (Carretta et al. 2020b). No data are available on the current population trend for the Hawaii stock of sei whales. Scientifically reliable abundance estimates are not available for the North Atlantic and Southern Hemisphere, due to inherent uncertainties in sampling design, data collection methodologies, and use of outdated abundance estimates (NMFS 2021).

There are no best abundance estimates for sei whales in the GOA, however, sei whales were acoustically detected during the 2013 GOALS II survey with no confirmed visual sightings and the limited acoustic data prohibited the derivation of line-transect density estimates (Rone et al. (2014). There were two sei whale sightings during a 2015 survey; one sighting within the WMA and the other on Albatross Bank, outside of the action area (Rone et al. 2017). The first sei whale abundance estimates for the central and eastern North Pacific were derived based on 2010–2012 line-transect datacollected during the International Whaling Commission-Pacific Ocean Whale and Ecosystem Research cruises (Hakamada et al. 2017). Over the three-year period, the summer (July and August) surveys covered a broad area north of 40°N, south of the Aleutian Islands, and between 170°E and 135°W. Data from these surveys were used to derive an estimated abundance of 29,632 (CV=0.242; 95 percent confidence interval, 18,576-47,267) sei whales in this region (Gulf of Alaska) for the months of July through August Hakamada et al. (2017). The 2012 northern stratum, with an approximate area of 488,511 km^2, encompassed the majority of the TMAA. Hakamada et al. (2017) derived an abundance estimate of 195-512 (CV=0.754-0.507) with an estimated total of 300 (CV=0.236) sei whales for this stratum during the months of July through August.

Natural Threats

Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

Anthropogenic Threats

Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas.

Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales. Data on entanglement and entrapment in non-U.S. waters are not reported systematically. Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980s. Some of these may have been fin whales instead of sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation may not mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997). The offshore drift gillnet fishery is the only fishery that is likely to "take" sei whales from this stock, but no fishery mortalities or serious injuries to sei whales have been observed. Sei whales, like other large whales, may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

Sei whales are occasionally killed in collisions with vessels. One sei whale was killed in a collision with a vessel off the coast of Washington in 2003 (Waring et al. 2009). From 1986-2019 there has been one confirmed vessel collision with a sei whale off California.

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

Status and Trends

There are insufficient data to undertake an assessment of the sei whale's present status. Due to a lack of comprehensive abundance and distribution data for all three ocean basins, and absence of dedicated systematic surveys, there is no scientifically rigorous estimate of global abundance. The sei whale is endangered as a result of past commercial whaling. A crude estimate of global decline from approximately 250,000 whales before whaling to perhaps 32,000 whales by the 1970s to 1980s is reported (Wiles 2017). 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). Currently, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Although the population in the North Pacific is expected to have grown since being given protected status in 1976, the possible effects of continued unauthorized takes and ongoing threats make this uncertain (Carretta et al. 2021). Ongoing 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.

Diving and Social Behavior

Generally, sei whales make 5 to 20 shallow dives of 20 to 30 sec duration followed by a deep dive of up to 15 min (Gambell 1985b). The depths of sei whale dives have not been studied; however the composition of their diet suggests that they do not perform dives in excess of 300 meters. Sei whales are usually found in small groups of up to 6 individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985b).

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2007). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Mizroch et al. 1984; Rice 1977). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95 percent of their diets (Calkins 1986). The dominant food for sei whales off California during June-August is northern anchovy, while in September-October whales feed primarily on krill (Rice 1977). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollack, capelin, and Atka mackerel (Nemoto and Kawamura 1977). In the Southern Ocean, analysis of stomach contents indicates sei whales consume Calanus spp. and small-sized euphasiids with prey composition showing latitudinal trends (Kawamura 1974). Evidence indicates that sei whales in the Southern Hemisphere reduce direct interspecific competition with blue and fin whales by consuming a wider variety of prey and by arriving later to feeding grounds (Kirkwood 1992). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Little is known about the actual social system of these animals. Groups of two to five individuals are typically observed, but sometimes thousands may gather if food is abundant. However, these large aggregations may not be dependent on food supply alone, as they often occur during times of migration. Norwegian workers call the times of great sei whale abundance "invasion years." During mating season, males and females may form a social unit, but strong data on this issue are lacking.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten 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.

The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 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 Ocean consisted of paired sequences (0.5 to 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 (Richardson et al. 1995c). Source levels of 189 ±5.8 dB re: 1 μPa-m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 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). 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 (NMFS 2018b).

Critical Habitat

NMFS has not designated critical habitat for sei whales.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals (National Marine Fisheries Service 2011a):

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

6.2.6 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 43).

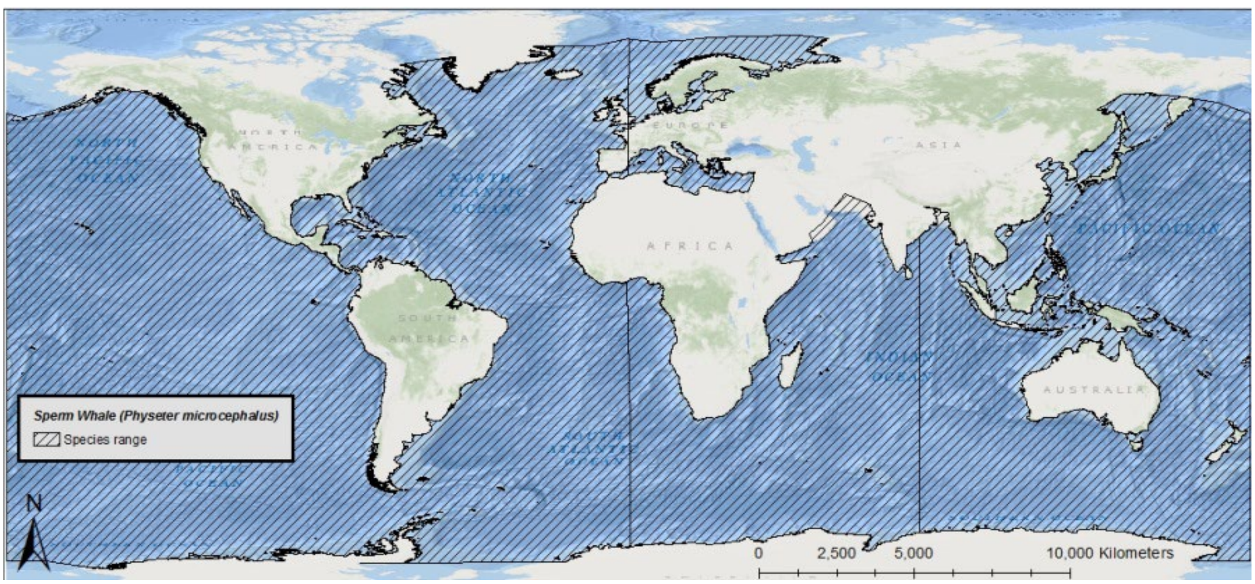


Figure 43. Map identifying the range of the endangered sperm whale.

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 species was originally listed as endangered throughout its range on December 2, 1970 under the precursor to the ESA, the Endangered Species Conservation Act of 1969 (35 FR 8491; June, 2, 1970), and remained on the list of threatened and endangered species after the passage of the ESA in 1973.

Distribution

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. Sperm whale distribute widely throughout the North Pacific Ocean, with movements over 5,000 kilometers, likely driven by changes in prey abundance. Males appear to range more broadly than females (Mizroch and Rice 2013). Sperm whales are found year-round in California waters (Carretta et al. 2021). Sperm whales have been sighted throughout the Hawaiian EEZ, including nearshore waters of the main and Northwestern Hawaiian Islands (NWHI).

<u>Occurrence in the GOA Action Area</u>

Within the Gulf of Alaska, visual and acoustic detections have been documented most frequently on the continental shelf (Rice et al. 2021; Rone et al. 2017). Typically, sperm whale concentrations correlate with areas of high productivity. These areas are generally near drop offs and areas with strong currents and steep topography (Gannier and Praca 2007; Jefferson et al. 2015). Sperm whales are somewhat migratory, as demonstrated by discovery tag data and subsequent satellite tag locational data; three sperm whales satellite-tagged off southeastern Alaska were documented moving far south to waters off Mexico and the Mexico/Guatemala border (Straley et al. 2014).

Sperm whale’s occurrence in the TMAA/WMA would be likely year round in waters greater than 1,000 meters (m) in depth and most often in waters greater than 2,000 m. A recent study found that although they are present year round in the Gulf of Alaska and are potentially present in greater numbers between June and September due to higher numbers of acoustic detections (Diogou et al. 2019; Rice et al. 2021). Sperm whale are somewhat migratory, and passive acoustic monitoring at five sites in the TMAA recorded sperm whale clicks throughout each summer that were most common at the shelf break and offshore (Rice et al. 2021; Rice et al. 2018; Rice et al. 2020).

Population Structure

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

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North Pacific Ocean, with movements over 5,000 kilometers, likely driven by changes in prey abundance. Males appear to range more broadly than females (Mizroch and Rice 2013).

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

Abundance Estimate

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997 (NMFS 2015b). Acoustic surveys have detected the presence of sperm whales year round in the GOA, (Baumann-Pickering et al. 2012a; Debich et al. 2013a; Debich et al. 2014; Moore et al. 2006; Rice et al. 2015a; Rice et al. 2015b; Rice et al. 2018; Rice et al. 2020) (Mellinger et al. 2004a). Sperm whales were not observed during the 2009 GOALS survey, but there were 19 on-effort sightings during the 2013 GOALS II survey, and 25 on-effort sighting during the 2015 survey designed to cover known historical right whale habitat (Rone et al. 2017). During the 2013 GOALS II survey there were also 241 sperm whale acoustic detections from the towed hydrophone array, 174 of which were localized.

Surveys in the Gulf of Alaska in 2009 and 2015, (Rone et al. 2017) estimated 129 (CV = 0.44) and 345 sperm whales (CV = 0.43) in each year, respectively. These estimates are for a small area that was unlikely to include females and juveniles and do not account for animals missed on the trackline; therefore, they are not considered reliable estimates. However, lacking any other abundance estimates for the GOA action area they serve as the best estimate for sperm whale abundance for this consultation.

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 (Carretta et al. 2021). Population estimates are also available for two of three U.S. stocks that occur in the Pacific: the California/Oregon/ Washington stock is estimated to consist of 2,106 individuals (N_{min}=1,332); the Hawaii stock is estimated to consist of 5,707 individuals (N_{min}=4,486) (Carretta et al. 2021). 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.

There is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time.

Natural Threats

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

Anthropogenic Threats

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

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

In U.S. waters in the Pacific, sperm whales have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of nine sperm whales per year from 1991 to 1995 (Barlow et al. 1997).

Interactions between sperm whales and longline fisheries in the Gulf of Alaska have been reported since 1995 and are increasing in frequency (Hill and DeMaster 1998; Hill et al. 1999; Rice 1989). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the Gulf of Alaska from the sablefish longline fishery (Angliss and Outlaw 2008). Sperm whales have also been observed in Gulf of Alaska feeding off longline gear (for sablefish and halibut) at 38 of the surveyed stations (Angliss and Outlaw 2008). Recent findings suggest sperm whales in Alaska may have learned that fishing vessel propeller cavitation (as gear is retrieved) are an indicator that longline gear with fish is present as a predation opportunity (Thode et al. 2007).

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

Status and Trends

The sperm whale is endangered as a result of past commercial whaling. A total of at least 436,000 sperm whales were taken in the North Pacific between 1800 and the end of commercial whaling for this species in 1987 (Carretta et al. 2021). 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 at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

Diving and Social Behavior

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

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

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

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

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

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

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

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity for sperm whales in the North Pacific is reached between 7 and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity between ages 18 and 21, after which they undergo a second growth spurt, reaching full physical maturity at around age 40 (Mizroch and Rice 2013).

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100

Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between one to six kHz and 10 to 16 kHz. Another class of sound, "squeals," are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa-m, although lower source level energy has been suggested at around 171 dB re: 1 µPa-m (Goold and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re: 1 µPa-m (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

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

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between five to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992; Southall et al. 2019c). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and 1 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NMFS 2018b).

Critical Habitat

NMFS has not designated critical habitat for sperm whales.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals (National Marine Fisheries Service 2010b):

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

6.2.7 Chum Salmon – Columbia River ESU

The Columbia River ESU of chum salmon includes naturally spawned chum salmon originating from the Columbia River and its tributaries in Washington and Oregon (Figure 44), and also chum salmon from two artificial propagation programs.

Chum salmon are an anadromous (i.e., adults migrate from marine to freshwater streams and rivers to spawn) and semelparous (i.e., they spawn once and then die) fish species. Adult chum salmon are typically between eight and fifteen pounds, but they can get as large as 45 pounds and 3.6 feet long. Males have enormous canine-like fangs and a striking calico pattern body color (front two-thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) during spawning. Females are less flamboyantly colored and lack the extreme dentition of the males. Ocean stage chum salmon are metallic greenish-blue along the back with black speckles. Chum salmon have the widest natural geographic and spawning distribution of the Pacific salmonids. On March 25, 1999, NMFS listed the Hood Canal summer-run ESU and the Columbia River ESU of chum salmon as threatened (64 FR 14508). NMFS reaffirmed the status of these two ESUs as threatened on June 28, 2005 (70 FR 37160).

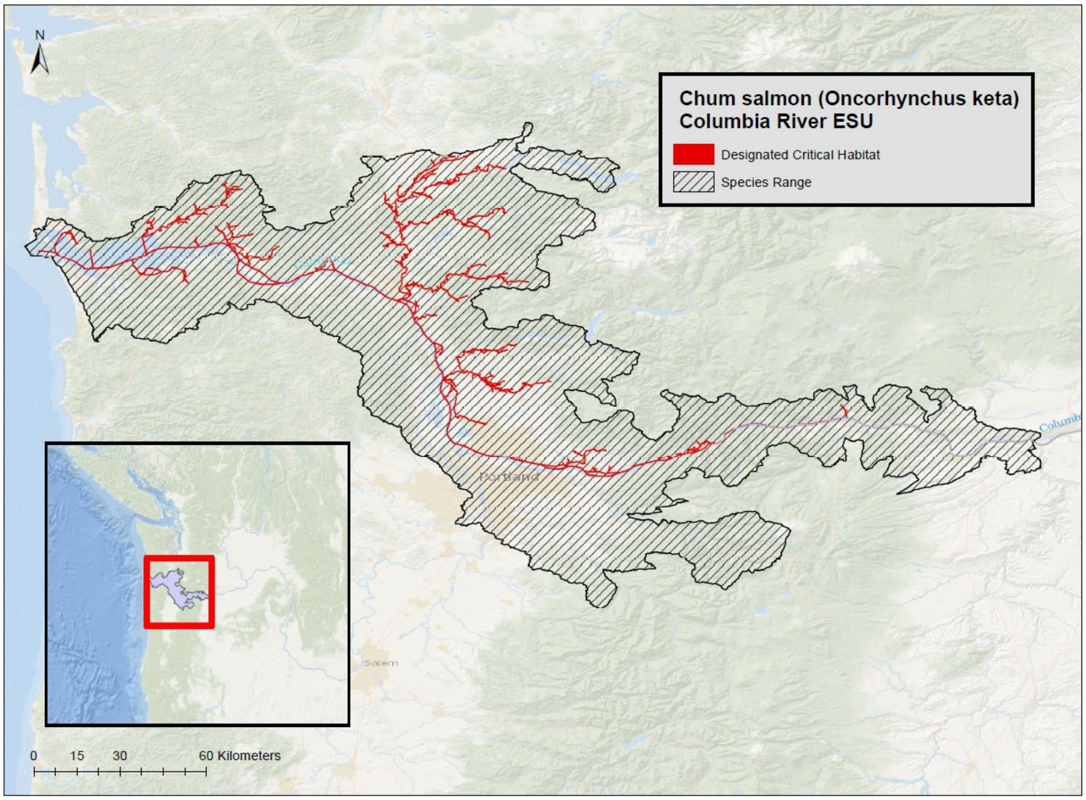

Figure 44. Geographic range and designated critical habitat of chum salmon, Columbia River ESU.

Life History

Most chum salmon mature and return to their birth stream to spawn between three and five years of age, with 60 to 90 percent of the fish maturing at four years of age. Age at maturity appears to follow a latitudinal trend (i.e., greater in the northern portion of the species' range). Chum salmon typically spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to 100 kilometers from the sea. Juveniles out-migrate to seawater almost immediately after emerging from the gravel covered redds (Salo 1991). The survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Chum salmon form schools, presumably to reduce predation

(Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

Chum salmon spend two to five years in feeding areas in the northeast Pacific Ocean, which is a greater proportion of their life history compared to other Pacific salmonids. Chum salmon distribute throughout the North Pacific Ocean and Bering Sea, although North American chum salmon (as opposed to chum salmon originating in Asia), rarely occur west of 175 E longitude (Johnson et al. 1997). North American chum salmon migrate north along the coast in a narrow band that broadens in southeastern Alaska, although some data suggests that chum salmon may travel directly offshore into the north Pacific Ocean (Johnson et al. 1997).

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 chum salmon Columbia River ESU.

Chum salmon populations in the Columbia River historically reached hundreds of thousands to a million adults each year (NMFS 2017a). In the past 50 years, the average has been a few thousand a year. The majority of populations in the Columbia River chum salmon ESU remain at high to very high risk, with very low abundances (NWFSC 2015b). Ford (2011) concluded that 14 out of 17 of chum salmon populations in this ESU were either extirpated or nearly extirpated. Current abundance estimates of the Columbia River ESU of chum salmon are presented in Table 33 below. To estimate abundance of juvenile CR chum salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by NMFS' Northwest Fisheries Science Center (Zabel 2015; Zabel 2017a; Zabel 2017b; Zabel 2018; Zabel 2020). For juvenile natural-origin CR chum salmon is juvenile salmon, an estimated average of 6,626,218 outmigrated over the last five years.

Table 33. Abundance Estimates for the Columbia River ESU of Chum salmon (NMFS 2019b; Zabel 2015; Zabel 2017a; Zabel 2017b; Zabel 2018; Zabel 2020).

Production	Life Stage	Abundance
Natural	Adult	10,644
Natural	Juvenile	6,626,218
Listed Hatchery Intact Adipose	Adult	426
Listed Hatchery Intact Adipose	Juvenile	601,503

Only one population (Grays River) is at low risk, with spawner abundances in the thousands, and demonstrating a recent positive trend. Two other populations (Washougal River and Lower Gorge) maintain moderate numbers of spawners and appear to be relatively stable (NWFSC

2015b). The overall trend since 2000 is negative, with the recent peak in abundance (2010-2011) being considerably lower than the previous peak in 2002.

There are currently four hatchery programs in the Lower Columbia River releasing juvenile chum salmon: Grays River Hatchery, Big Creek Hatchery, Lewis River Hatchery, and Washougal Hatchery (NMFS 2017a). Total annual production from these hatcheries has not exceeded 500,000 fish. All of the hatchery programs in this ESU use integrated stocks developed to supplement natural production. Other populations in this ESU persist at very low abundances and the genetic diversity available would be very low (NWFSC 2015b). Diversity has been greatly reduced at the ESU level because of presumed extirpations and low abundance in the remaining populations (fewer than 100 spawners per year for most populations) (LCFRB 2010; NMFS 2013b).

The Columbia River chum salmon ESU includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. The ESU consists of three populations: Grays River, Hardy Creek and Hamilton Creek in Washington State. Chum salmon from four artificial propagation programs also contribute to this ESU.

Distribution in the Action Area

The oceanic distribution of chum is thought to be the broadest of any Pacific salmon (Neave et al. 1976), with the species found throughout the North Pacific Ocean north of the Oregon/Washington border. In general, chum move north and west along the coast upon entering saltwater, and have moved offshore by the end of their first ocean year (Byron and Burke 2014; Quinn 2005). Myers et al. (1996b) documented maturing chum salmon from Washington and the Columbia River in offshore areas of the Gulf of Alaska. Echave et al. (2012) found that within the Gulf of Alaska, juvenile chum salmon are distributed throughout the inner and middle shelf along the Gulf coastline from Dixon entrance to the eastern Aleutian Islands, but that by the end of their first fall at sea, most fish have moved off the continental shelf into open waters (Quinn 2005). Immature and mature chum salmon are distributed widely throughout the outer portion of the continental shelf and over oceanic waters as far offshore as the U.S. EEZ boundary (Echave et al. 2012). We have no additional information on the distribution, abundance or density of specific chum salmon ESUs within the action area.

Chum salmon are known to be surface-oriented, using the upper 20 meters of the water column 78 percent of the time during the day and 95 percent of the time at night. The remaining time, they can be found down to depths of 60 meters (Ishida et al. 1997). Similarly, Walker et al. (2007) found the average depth of chum salmon to be 16 meters in the North Pacific Ocean.

Status

The majority of the populations within the Columbia River chum salmon ESU are at high to very high risk, with very low abundances (NWFSC 2015b). These populations are at risk of extirpation due to demographic stochasticity and Allee effects. One population, Grays River, is at low risk, with spawner abundances in the thousands and demonstrating a recent positive trend. The Washougal River and Lower Gorge populations maintain moderate numbers of spawners and appear to be relatively stable. The life history of chum salmon is such that ocean conditions have a strong influence on the survival of emigrating juveniles. The potential prospect of poor ocean conditions for the near future may put further pressure on the Columbia River chum salmon ESU (NWFSC 2015b). Freshwater habitat conditions may be negatively influencing spawning and early rearing success in some basins, and contributing to the overall low productivity of the ESU. Columbia River chum salmon were historically abundant and subject to substantial harvest until the 1950s (NWFSC 2015b). There is no directed harvest of this ESU and the incidental harvest rate has been below one percent for the last five years (NWFSC 2015b). Land development, especially in the low gradient reaches that chum salmon prefer, will continue to be a threat to most chum salmon populations due to projected increases in the population of the greater Vancouver-Portland area and the Lower Columbia River overall (Metro 2015). The Columbia River chum salmon ESU remains at a moderate to high risk of extinction (NWFSC 2015b).

Critical Habitat

NMFS designated critical habitat for the Columbia River chum salmon ESU in 2005 (70 FR 52630). Designated critical habitat for the Columbia River chum salmon does not overlap spatially with the GOA action area (Figure 44) and, therefore, will not be considered further in this opinion.

Recovery Goals

The recovery strategy for Columbia River ESU chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated (NMFS 2013a). The primary goal is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence, and the persistence probability of the two Gorge populations improves. For details on Columbia River chum salmon ESU recovery goals, including complete down-listing/delisting criteria, see the NMFS 2013 recovery plan (NMFS 2013a).

6.2.8 Chum Salmon – Hood Canal Summer-Run ESU

Hood Canal summer-run ESU chum include naturally spawned summer-run chum salmon originating from Hood Canal and its tributaries as well as from Olympic Peninsula rivers between Hood Canal and Dungeness Bay (Figure 45). Also, summer-run chum salmon originate from four artificial propagation programs.

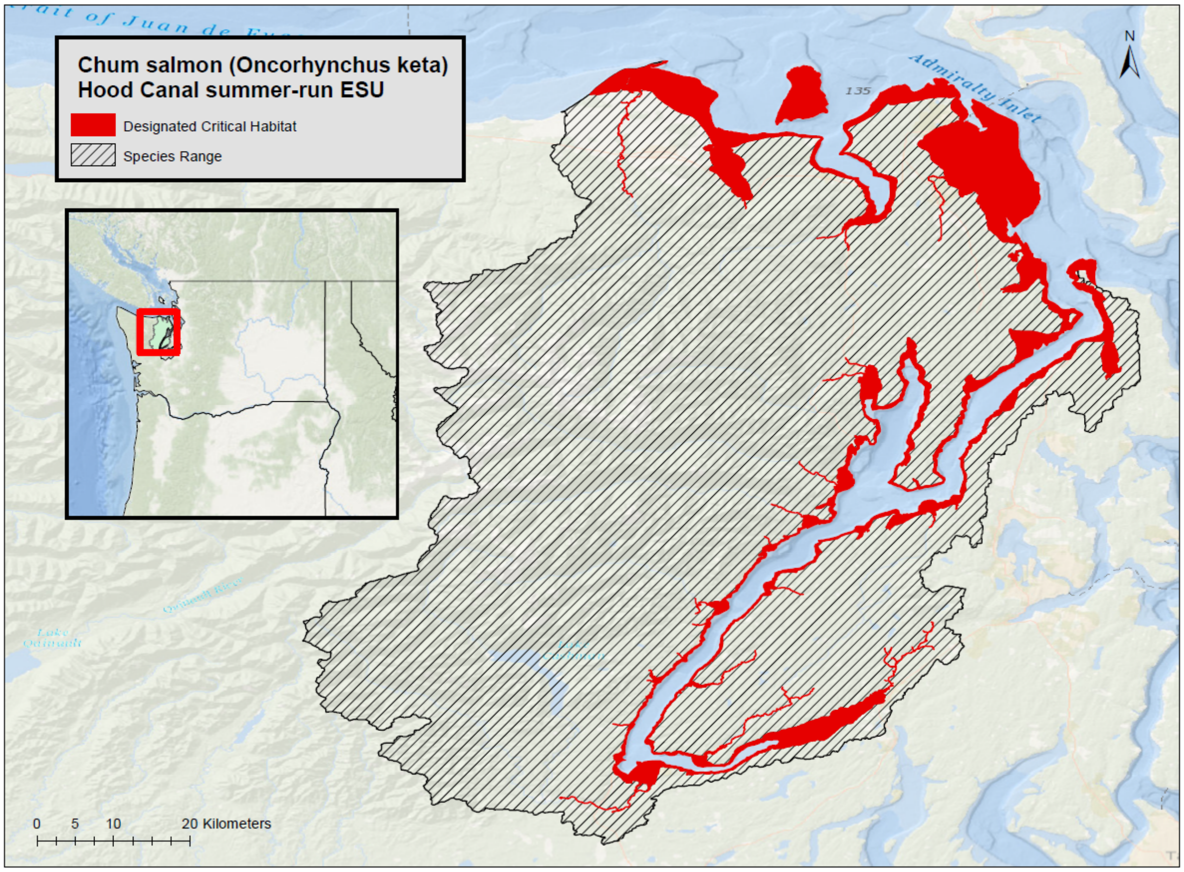

Figure 45. Geographic range and designated critical habitat of chum salmon, Hood Canal ESU.

On March 25, 1999, NMFS listed the Hood Canal Summer-run ESU and the Columbia River ESU of chum salmon as threatened (64 FR 14508). NMFS reaffirmed the status of these two ESUs as threatened on June 28, 2005 (70 FR 37160).

Life History

The general life history of Hood Canal Summer-run ESU chum salmon is the same as that described for Columbia River ESU chum salmon in Section 6.2.7 above.

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 Hood Canal summer-run ESU of chum salmon.

Of the sixteen populations that comprise the Hood Canal Summer-run chum salmon ESU, seven are considered "functionally extinct" (Skokomish, Finch Creek, Anderson Creek, Dewatto, Tahuya, Big Beef Creek and Chimicum). NMFS examined average escapements (geometric means) for five-year intervals and estimated trends over the intervals for all natural spawners and for natural-origin only spawners. For both populations, abundance was relatively high in the 1970s, lowest for the period 1985-1999, and high again from 2005 to 2015 (NWFSC 2015b).

Current abundance estimates of the Hood Canal summer-run ESU of chum salmon are presented in Table 34 and Table 35 below.

Table 34. Hood Canal summer-run juvenile chum salmon hatchery releases (NMFS 2020b).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK - Lilliwaup	2018	Summer	-	150,000
Total Annual Release Number				**-**	**150,000**

Table 35. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2013-2017 (NMFS 2020b).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	1,288	0	0.00%	188,313
Salmon Creek	1,836	0	0.00%	268,531
Snow Creek	311	0	0.00%	45,541
Chimacum Creek	902	0	0.00%	131,971
Population Average[d]	4,337	0	0.00%	634,355
Hood Canal Population				
Big Quilcene River	6,437	0	0.00%	941,450
Little Quilcene River	122	0	0.00%	17,795
Big Beef Creek	10	0	0.00%	1,532
Dosewallips River	2,021	0	0.00%	295,524
Duckabush River	3,172	0	0.00%	463,856
Hamma River	2,944	10	0.34%	432,056
Anderson Creek	3	0	0.00%	376
Dewatto River	95	0	0.00%	13,947
Lilliwaup Creek	857	1,141	57.10%	292,159
Tahuya River	205	299	59.36%	73,777
Union River	2,789	2	0.07%	408,166
Skokomish River	2,154	0	0.00%	314,960
Population Average[d]	20,809	1,452	6.52%	3,255,599
ESU Average	**25,146**	**1,452**	**5.46%**	**3,889,955**

[a] Five-year geometric mean of post fishery natural-origin spawners (2015-2019).

[b] Five-year geometric mean of post fishery hatchery-origin spawners (2015-2019).

[c] Expected number of outmigrants = total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant.

[d] Averages are calculated as the geometric mean of the annual totals (2015-2019).

The overall trend in spawning abundance is generally stable for the Hood Canal population (all natural spawners and natural-origin only spawners) and for the Strait of Juan de Fuca population (all natural spawners). Productivity rates, which were quite low during the five-year period from 2005-2009 (Ford 2011), increased from 2011-2015 and were greater than replacement rates from 2014-2015 for both major population groups (NWFSC 2015b).

There were likely at least two ecological diversity groups within the Strait of Juan de Fuca population and at least four ecological diversity groups within the Hood Canal population. With the possible exception of the Dungeness River aggregation within the Strait of Juan de Fuca population, Hood Canal ESU summer chum salmon spawning groups exist today that represent each of the ecological diversity groups within the two populations (NMFS 2017a). Diversity values (Shannon diversity index) were generally lower in the 1990s for both independent populations within the ESU, indicating that most of the abundance occurred at a few spawning sites (NWFSC 2015b). Although the overall linear trend in diversity appears to be negative, the last five-year interval shows the highest average value for both populations within the Hood Canal ESU.

The Hood Canal summer-run chum salmon ESU includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. The nine populations are well distributed throughout the ESU range except for the eastern side of Hood Canal (Johnson et al. 1997). Two independent major population groups have been identified for this ESU: (1) spawning aggregations from rivers and creeks draining into the Strait of Juan de Fuca, and (2) spawning aggregations within Hood Canal proper (Sands 2009).

Distribution in the Action Area

The general distribution of chum salmon in the action area is discussed in Section 6.2.7 above. We have no additional information on the distribution, abundance or density of specific chum salmon ESUs within the action area.

Status

Recent status reviews (2011 and 2016) indicate some positive signs for the Hood Canal summer-run chum salmon ESU. Diversity has increased from the low levels seen in the 1990s due to both the reintroduction of spawning aggregates and the more uniform relative abundance between populations; considered a good sign for viability in terms of spatial structure and diversity (Ford 2011). Spawning distribution within most streams was also extended further upstream with increased abundance. At present, spatial structure and diversity viability parameters for each population nearly meet the viability criteria (NWFSC 2015b). Spawning abundance has remained relatively high compared to the low levels observed in the early 1990's (Ford 2011). Natural-origin spawner abundance has shown an increasing trend since 1999, and spawning abundance targets in both populations were met in some years (NWFSC 2015b). Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (NWFSC 2015b). Overall, the Hood Canal Summer-run chum salmon ESU remains at a moderate risk of extinction.

Critical Habitat

NMFS designated critical habitat for Hood Canal summer-run chum salmon in 2005 (70 FR 52630). Designated critical habitat for this ESU does not overlap spatially with the GOA action area and, therefore, will not be considered further in this opinion.

Recovery Goals

The recovery strategy for Hood Canal Summer-run chum salmon focuses on habitat protection and restoration throughout the geographic range of the ESU, including both freshwater habitat and nearshore marine areas within a one-mile radius of the watersheds' estuaries (NMFS 2007a). The recovery plan includes an ongoing harvest management program to reduce exploitation rates, a hatchery supplementation program, and the reintroduction of naturally spawning summer chum salmon aggregations to several streams where they were historically present. The Hood Canal plan gives first priority to protecting the functioning habitat and major production areas of the ESU's eight extant stocks, keeping in mind the biological and habitat needs of different life-history stages, and second priority to restoration of degraded areas, where recovery of natural processes appears to be feasible (HCCC 2005). For details on Hood Canal Summer-run chum salmon ESU recovery goals, including complete down-listing/delisting criteria, see the Hood Canal Coordinating Council 2005 recovery plan (HCCC 2005) and the NMFS 2007 supplement to this recovery plan (NMFS 2007a).

6.2.9 Sockeye Salmon – Ozette Lake ESU

On March 25, 1999, NMFS listed the Ozette Lake sockeye salmon as a threatened species (64 FR 14528). When we re-examined the status of this species in 2005, 2011, and 2016, we determined that this ESU still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). The ESU includes all naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries. Also included are sockeye salmon from two artificial propagation programs: the Umbrella Creek Hatchery Program; and the Big River Hatchery Program (79 FR 20802; April 14, 2014). The Umbrella Creek and Big River sockeye hatchery programs (Table 45) were developed in 1982 to augment the beach spawning population and are limited to releases through 2012 (Ford 2011).

Life history

Lake Ozette sockeye salmon are lake-type sockeye salmon. Adult sockeye salmon enter Ozette Lake through the Ozette River from April to early August, and hold three to nine months in the lake before spawning in late October through January. Lake Ozette sockeye salmon spawn in lakeshore upwelling areas and in tributaries. Eggs and alevins remain in gravel redds until the fish emerge as fry in spring. Fry then migrate immediately to the limnetic zone where the fish rear. After one year of rearing, Lake Ozette sockeye salmon emigrate seaward as age 1+ smolts in late spring. The majority of Lake Ozette sockeye salmon return to the lake as age 3+ adults and after holding in the lake spawn as four-year-old fish.

Kokanee are populations of sockeye salmon that become resident in the lake environment over long periods of time. Occasionally, a proportion of the juveniles in an anadromous sockeye salmon population will remain in the lake environment their entire lives and will be observed on the spawning grounds together with their anadromous siblings. These resident, non-migratory progeny of anadromous sockeye salmon parents are referred to as "residual sockeye" and "residuals". Between 5,000 and 10,000 kokanee spawn in small tributaries to Ozette Lake.

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 sockeye salmon, Lake Ozette ESU.

The historical abundance of Ozette Lake sockeye salmon is poorly documented, but may have been as high as 50,000 individuals (Blum 1988). The most recent (1996-2006) escapement estimates (run size minus broodstock take) range from a low of 1,404 in 1997 to a high of 6,461 in 2004, with a median of approximately 3,800 sockeye per year (geometric mean: 3,353) (Rawson et al. 2009a).

Productivity has fluctuated up and down over the last few decades, but overall appears to have remained stable (NWFSC 2015). Given the degree of uncertainty in the abundance estimates, any interpretation of trends of small magnitude or over short time periods is speculative. (NWFSC 2015).

For the Ozette Lake sockeye salmon ESU, the proportion of beach spawners is likely low; therefore, hatchery-originated fish are not likely to affect greatly the genetics of the naturally-spawned population. However, Ozette Lake sockeye have a relatively low genetic diversity compared to other sockeye salmon populations examined in Washington State (Crewson et al. 2001). Genetic differences do occur among age cohorts. However, because different age groups do not reproduce together, the population may be more vulnerable to significant reductions in population structure due to catastrophic events or unfavorable conditions affecting a single year class.

The Ozette Lake sockeye salmon ESU is composed of one historical population (Currens et al. 2009) with multiple spawning aggregations and two populations from the Umbrella Creek and Big River sockeye hatchery programs. Historically, at least four lake beaches were used for spawning; today only two beach spawning locations, Allen's and Olsen's Beaches, are used. Additionally, spawning occurs in the two tributaries of the hatchery programs (NWFSC 2015). The Umbrella creek population is a large component of the total population (averaging over 50% for the last decade of data).

Sockeye and kokanee salmon are known to interact during the fresh-water rearing phase of the sockeye salmon, which coincides with nearly the entire life history phase of kokanee. Genetic evidence analyzed by Hawkins (2004) indicates that hybridization between sockeye and kokanee salmon appears to have been occurring before 1991 and continues to be persistent between the two populations. However, the genetic mixing between sockeye salmon and kokanee is of low enough frequency to maintain the large genetic differences observed between the two populations (Hawkins 2004).

Distribution in the Action Area

In general, it is thought that sockeye follow a similar migration pattern as chum (Section 6.2.7) once they enter the ocean, moving north and west along the coast, and have moved offshore by the end of their first ocean year (Byron and Burke 2014; Quinn 2005). Previously, French et al. (1976) summarized the general migration pattern of sockeye salmon originating in the various tributaries of the northeastern Pacific Ocean from the Alaska Peninsula to the Columbia River. Tag recovery data indicated a general mixing of these stocks during their residence in the northeastern Pacific Ocean. These fish primarily occur east of 160° W and north of 48° N. It is thought that most fish originating from these areas have departed the high seas by early August of their second year at sea, to return to their natal rivers to spawn (French et al. 1976). Tucker et al. (2009) did not observe juvenile sockeye originating from the Columbia River (inclusive of Redfish Lake sockeye) and the Washington coast (inclusive of Lake Ozette sockeye) north of southeast Alaska during any time of the year. In the Gulf of Alaska, Echave et al. (2012)documented that the distribution of juvenile sockeye salmon is generally contained to the continental shelf. Immature sockeye are distributed from the nearshore waters to the U.S. EEZ boundary throughout the entire Gulf (Echave et al. 2012). Similarly, mature sockeye salmon occur in relatively low abundances extending from coastal waters to the U.S. EEZ boundary (Echave et al. 2012). Myers et al. (1996a) also documented maturing sockeye salmon from Washington and the Columbia River in offshore areas of the Gulf of Alaska. We have no additional information on the distribution, abundance or density of specific sockeye salmon ESUs within the action area.

Walker et al. (2007) recorded the vertical distribution of salmonids in North Pacific Ocean using data storage tags. The authors found that the average depth for sockeye was three meters, though the species was found down to 83 meters.

Status

NMFS listed the Ozette Lake sockeye salmon ESU because of habitat loss and degradation from the combined effects of logging, road building, predation, invasive plant species, and overharvest. Ozette Lake sockeye salmon have not been commercially harvested since 1982 and only minimally harvested by the Makah Tribe since 1982 (0 to 84 fish per year); there is no known marine fishing of this ESU. Overall abundance is substantially below historical levels, and whether the decrease in abundance is a result of fewer spawning aggregations, lower abundances in each aggregation, or a combination of both factors is unknown. Regardless, this ESU's viability has not improved, and the ESU would likely have a low resilience to additional perturbations. However, recovery potential for the Ozette Lake sockeye salmon ESU is good, particularly because of protections afforded it based on the lake's location within a national park (NMFS 2009; NMFS 2016).

Critical Habitat

NMFS designated critical habitat for Lake Ozette sockeye salmon in 2005 (70 FR 52630). Designated critical habitat for this ESU does not overlap spatially with the GOA action area and, therefore, will not be considered further in this opinion.

Recovery Goals

We adopted a recovery plan for Lake Ozette sockeye salmon (NMFS 2009b) in May 2009. The criteria of the recovery plan were based upon Rawson et al. (2009b). Recovery criteria include:

- Multiple, spatially distinct and persistent spawning aggregations throughout the historical range of the population (*i.e.,* along the lake beaches and in one or more tributaries).
- One or more persistent spawning aggregations from each major genetic and life history group historically present. Also, genetic distinctness between anadromous sockeye, and kokanee salmon in the lake.
- Abundance between 31,250 and 121,000 adult spawners, over a number of years.

6.2.10 Sockeye Salmon – Snake River ESU

This evolutionarily significant unit, or ESU, includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River basin (Figure 46), and also sockeye salmon from one artificial propagation program: Redfish Lake Captive Broodstock Program. On November 20, 1991 NMFS listed the Snake River sockeye salmon ESU as endangered (56 FR 58619), and reaffirmed the ESU's status as endangered on June 28, 2005.

Life History

Most sockeye salmon exhibit a lake-type life history (i.e., they spawn and rear in or near lakes), though some exhibit a river-type life history. Spawning generally occurs in late summer and fall, but timing can vary greatly among populations. In lakes, sockeye salmon commonly spawn along "beaches" where underground seepage provides fresh oxygenated water. Females spawn in three to five redds (nests) over a couple of days. Incubation period is a function of water temperature and generally lasts 100-200 days (Burgner 1991). Sockeye salmon spawn once, generally in late summer and fall, and then die (semelparity).

Sockeye salmon fry primarily rear in lakes; river-emerged and stream-emerged fry migrate into lakes to rear. In the early fry stage from spring to early summer, juveniles forage exclusively in the warmer littoral (i.e., shoreline) zone where they depend mostly on fly larvae and pupae, copepods, and water fleas. Sub-yearling sockeye salmon move from the littoral habitat to a pelagic (i.e., open water) existence where they feed on larger zooplankton; however, flies may still make up a substantial portion of their diet. From one to three years after emergence, juvenile sockeye salmon generally rear in lakes, though some river-spawned sockeye may migrate to sea in their first year. Juvenile sockeye salmon feeding behaviors change as they transition through life stages after emergence to the time of smoltification. Distribution in lakes and prey preference is a dynamic process that changes daily and yearly depending on many factors including water temperature, prey abundance, presence of predators and competitors, and size of the juvenile. Peak emigration to the ocean occurs in mid-April to early May in southern sockeye populations (lower than 52ºN latitude) and as late as early July in northern populations (62º N latitude) (Burgner 1991). Adult sockeye salmon return to their natal lakes to spawn after spending one to four years at sea. The diet of adult salmon consists of amphipods, copepods, squid and other fish.

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 Snake River ESU of sockeye salmon.

Adult returns over the last several years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014 (NMFS 2015b). Current abundance estimates for the Snake River ESU of sockeye salmon are presented in Table 36 below.

The large increases in returning adults in recent years reflect improved downstream and ocean survival as well as increases in juvenile production since the early 1990s. Although total sockeye salmon returns to the Sawtooth Valley in recent years have been high enough to allow for some level of natural spawning in Redfish Lake, the hatchery program remains at its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting and recolonization of the species' historic range (NMFS 2015b; NWFSC 2015b).

For the Snake River ESU, the Sawtooth Hatchery is focusing on genetic conservation. An overrepresentation of genes from the anadromous population in Redfish Lake exists, but inbreeding is low, which is a sign of a successful captive broodstock program (NMFS 2015b; NWFSC 2015b).

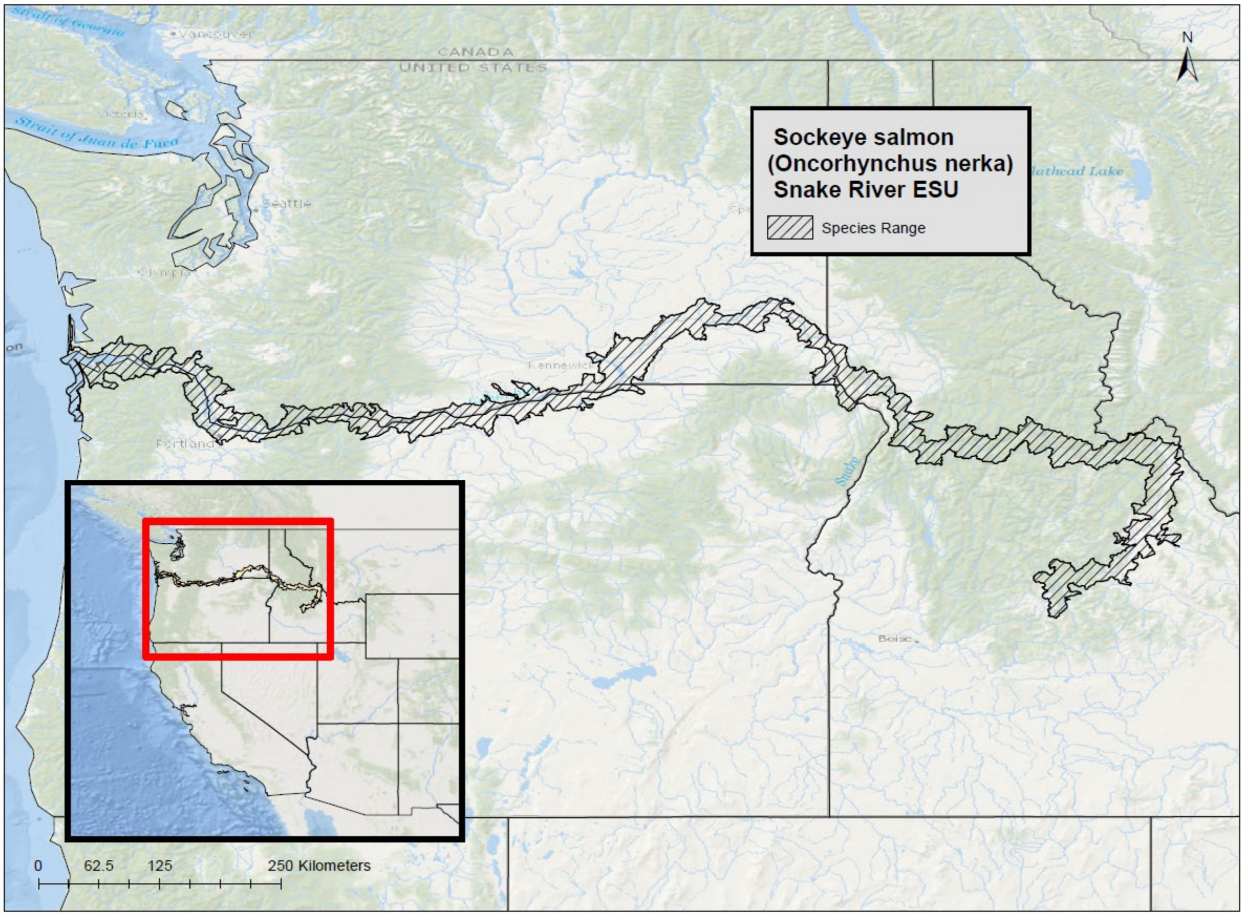

Figure 46. Geographic range of Sockeye salmon, Snake River ESU.

Table 36. Current abundance estimates for Snake River ESU sockeye salmon (NMFS 2020b).

Production	Life Stage	Abundance
Natural	Adult	546
Natural	Juvenile	19,181
Listed Hatchery Adipose Clipped	Adult	4,004
Listed Hatchery Adipose Clipped	Juvenile	242,610

This species includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially-propagated sockeye salmon from the Redfish Lake Captive Broodstock Program (NMFS 2015b; NWFSC 2015b; USDC 2014). The ICTRT treats Sawtooth Valley Sockeye salmon as the single MPG within the Snake River Sockeye salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015b). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015b).

Distribution in the Action Area

The general distribution of sockeye salmon in the action area is discussed in Section 6.2.9 above. We have no additional information on the distribution, abundance or density of specific sockeye salmon ESUs within the action area.

Status

The Snake River sockeye salmon ESU includes only one population comprised of all anadromous and residual sockeye salmon from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program. Historical evidence indicates that the Snake River sockeye salmon once had a range of life history patterns, with spawning populations present in several of the small lakes in the Sawtooth Basin. NMFS listed the Snake River sockeye salmon ESU because of habitat loss and degradation from the combined effects of damming and hydropower development, overexploitation, fisheries management practices, and poor ocean conditions. Adults produced through the captive propagation program currently support the entire ESU. This ESU is still at extremely high risk across all four basic risk measures (abundance, productivity, spatial structure, and diversity) and would likely have a very low resilience to additional perturbations. Habitat improvement projects have slightly decreased the risk to the species, but habitat concerns and water temperature issues remain. The latest 5-year review (NMFS 2022c) indicates that the ESU continues to exhibit extreme low abundance of naturally produced Snake River sockeye salmon and low survival across multiple life-stages, reducing productivity, despite improved water quality regulatory controls at the state level, increased hatchery production and improved hatchery practices. In addition, increasing risks from climate change and broodstock practices that may hamper natural evolutionary changes in run timing necessary to adapt to a warming climate suggest viability of the species has declined and is facing increased risk to persistence (NMFS 2022c). The combination of sustained low population sizes, current abundances only slightly higher than when the species was listed in the early 1990s, predicted negative impacts of climate change on all life stages, poor ocean conditions potentially exacerbated by increasing hatchery fish production across the Pacific, and high levels of predation by pinnipeds in the Lower Columbia River result in this ESU remaining at a high risk of extinction (NMFS 2022c).

Critical Habitat

NMFS designated critical habitat for Snake River sockeye salmon in 1993 (58 FR 68543). Designated critical habitat for the Snake River sockeye salmon does not overlap spatially with the GOA action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

The Snake River ESU-level recovery objectives include: 1) Population-level persistence in the face of year-to-year variations in environmental influences; 2) Combination of abundance and productivity sufficient to sustain a population (in the absence of hatchery supplementation) at levels that will maintain genetic and spatial diversity; 3) Resilience to the potential impact of catastrophic events; 4) Populations distributed in a manner that insulates against loss from a local catastrophic event and provides for recolonization of a population that is affected by such an event; 5) Maintaining long-term evolutionary potential; and 6) Sustaining natural production across a range of conditions, allowing for adaptation to changing environmental conditions. See the 2015 recovery plan for the Snake River sockeye salmon ESU for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2015b).

6.2.11 Steelhead – Lower Columbia River DPS

The Lower Columbia River DPS of steelhead includes naturally spawned steelhead originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive) and excludes such fish originating from the upper Willamette River basin above Willamette Falls (Figure 47). The Lower Columbia River DPS also includes steelhead from seven artificial propagation programs. On March 19, 1998 NMFS listed the Lower Columbia River DPS of steelhead as threatened (63 FR 13347) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

The Lower Columbia River steelhead DPS includes both summer- and winter-run stocks. Summer-run steelhead return sexually immature to the Columbia River from May to November, and spend several months in fresh water prior to spawning. Winter-run steelhead enter fresh water from November to April, are close to sexual maturation during freshwater entry, and spawn shortly after arrival in their natal streams. Where both races spawn in the same stream, summer-run steelhead tend to spawn at higher elevations than the winter-run. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be -1° C (30°F) to 11° C (52°F) (CDFW 2000). The eggs hatch in three to four weeks at 10° C (50°F) to 15° C (59°F), and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

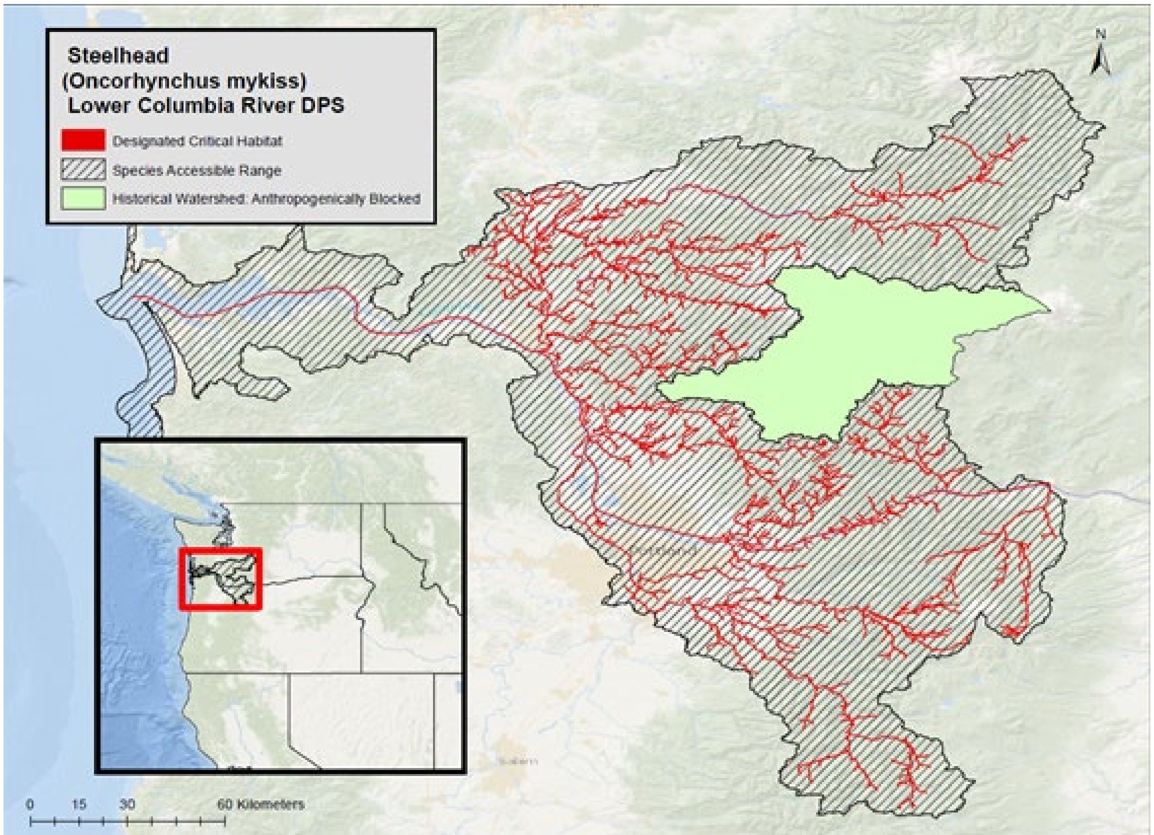

Figure 47. Geographic range and designated critical habitat of Lower Columbia River steelhead.

The majority of juvenile lower Columbia River steelhead remain for two years in freshwater environments before ocean entry in spring. Both winter- and summer-run adults normally return after two years in the marine environment. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

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 lower Columbia River steelhead.

The Winter-run Western Cascade major population group (MPG) includes native winter-run steelhead from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and have remained low, averaging in the hundreds of fish. Notable exceptions to this were the Clackamas and Sandy River winter-run steelhead populations, that are exhibiting recent rises in native origin fish abundance and maintaining low levels of hatchery-origin steelhead on the spawning grounds (NMFS 2016a). In the Summer-run Cascade MPG, there are four summer-run steelhead populations. Absolute abundances have been in the hundreds of fish. In the Winter-run

Gorge MPG both the Lower and Upper Gorge population surveys for winter steelhead are very limited and abundance levels in the Hood River have been low but relatively stable. In the Summer-run Gorge MPG adult abundance in the Wind River remains stable, but at a low level (hundreds of fish). Current abundance estimates for the Lower Columbia River DPS of steelhead are presented in Table 37 below. To estimate abundance of juvenile natural LCR steelhead, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NMFS' Northwest Fisheries Science Center (Zabel 2015; Zabel 2017a; Zabel 2017b; Zabel 2018; Zabel 2020). For juvenile natural-origin LCR steelhead, an estimated average of 352,146 juvenile steelhead outmigrated over the last five years.

Table 37. Current abundance estimates for the Lower Columbia River DPS of steelhead (NMFS 2019b; Zabel 2015; Zabel 2017a; Zabel 2017b; Zabel 2018; Zabel 2020).

Production	Life Stage	Abundance
Natural	Adult	12,920
Natural	Juvenile	352,146
Listed Hatchery Adipose Clipped and Intact	Adult	22,297
Listed Hatchery Adipose Clipped	Juvenile	1,197,156
Listed Hatchery Intact Adipose	Juvenile	9,138

Population trends for the Winter-run Western Cascade MPG are fairly stable. Long and short term trends for three independent populations within the Summer-run Cascade MPG are positive; though the 2014 surveys indicate a drop in abundance for all three. Population trends in the Winter-run Gorge MPG is relatively stable. The overall status of the Summer-run Gorge MPG is uncertain.

Total steelhead hatchery releases in the Lower Columbia River Steelhead DPS have decreased since the last status review, declining from a total (summer and winter run) release of approximately 3.5 million to 3 million from 2008 to 2014. Some populations continue to have relatively high fractions of hatchery-origin spawners, whereas others (e.g., Wind River) have relatively few hatchery origin spawners.

There are four MPGs comprised six summer-run steelhead populations and 17 winter-run populations (NWFSC 2015b). Summer steelhead spawning areas in the Lower Columbia River are found above waterfalls and other features that create seasonal barriers to migration. There have been a number of large-scale efforts to improve accessibility (one of the primary metrics for spatial structure) in this DPS. Trap and haul operations were begun on the Lewis River in 2012 for winter-run steelhead, reestablishing access to historically-occupied habitat above Swift Dam.

In 2014, 1033 adult winter steelhead (integrated program fish) were transported to the upper Lewis River; however, juvenile collection efficiency is still below target levels. In addition, there have been a number of recovery actions throughout the DPS to remove or improve culverts and other small-scale passage barriers.

Distribution in the Action Area

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). Commercial fisheries catch data indicate similar trends (Quinn and Myers 2004). The species spends approximately 1 to 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). Light et al. (1989) mapped the ocean distribution of steelhead in the North Pacific using catch per unit effort data from U.S., Canadian, USSR, and Japanese research vessels fishing with purse seines, gill nets, and longlines. Steelhead were distributed across the North Pacific throughout the year, but were in higher abundance closer to the U.S. and Canadian coasts in spring and winter, and more evenly distributed in summer and fall.

Steelhead hatched in freshwater streams in the Pacific Northwest are known to occur in Alaska marine waters during their juvenile or adult life stages (NMFS 2015a). McKinnell et al. (1997) assessed the distribution of North American hatchery steelhead stock in the Gulf of Alaska and Aleutian Islands using coded wire tag mark and recapture data collected by the NMFS Auke Bay Laboratories in Juneau, Alaska, and the Pacific Biological Station in Nanaimo, British Columbia, from 1981 through 1994. These data showed that tagged steelhead from hatcheries in the upper, middle, and lower Columbia River, the Snake River basin, coastal Washington, and Puget Sound were recaptured in the northern and southern Gulf of Alaska and the Aleutian Islands. These studies indicate that steelhead from all six ESA-listed DPSs considered in this opinion are indeed present in Gulf of Alaska waters. We have no additional information on the distribution, abundance or density of specific steelhead DPSs within the action area.

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 one meter of the water column, with few movements below seven meters.

Status

The Lower Columbia River steelhead had 17 historically independent winter steelhead populations and six independent summer steelhead populations (McElhany et al. 2003; Myers et al. 2006). All historic Lower Columbia River steelhead populations are considered extant. However, spatial structure within the historically independent populations, especially on the Washington side, has been substantially reduced by the loss of access to the upper portions of some basins due to tributary hydropower development. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances (NWFSC 2015b). Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead demographically independent populations (DIPs) were similarly stable, but at low abundance levels. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015b).

Critical Habitat

Critical habitat was designated for the Lower Columbia River steelhead in 2005. Designated critical habitat for the Lower Columbia River steelhead does not overlap spatially with the GOA action area (Figure 47) and, therefore, will not be analyzed further in this opinion.

Recovery Goals

The Lower Columbia River DPS of steelhead are included in the Lower Columbia River recovery plan (NMFS 2013a). For this DPS, threats in all categories must be reduced, but the most crucial elements are protecting favorable tributary habitat and restoring habitat in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama and Sandy subbasins (for winter steelhead), and the East Fork Lewis, and Hood, subbasins (for summer steelhead). Protection and improvement is also need among the South Fork Toutle and Clackamas winter steelhead populations.

6.2.12 Steelhead – Middle Columbia River DPS

The Middle Columbia River DPS of steelhead includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River and excludes such fish originating from the Snake River Basin (Figure 48). Further, this DPS includes steelhead from seven artificial propagation programs. On March 25, 1999 NMFS listed the Middle Columbia River DPS of steelhead as threatened (64 FR 14517) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

Middle Columbia River steelhead populations are mostly of the summer-run type. Adult steelhead enter fresh water from June through August. The only exceptions are populations of inland winter-run steelhead which occur in the Klickitat River and Fifteenmile Creek (Busby et al. 1996). The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30°F to 52°F (CDFW 2000). The eggs hatch in three to four weeks at 50°F to 59°F and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

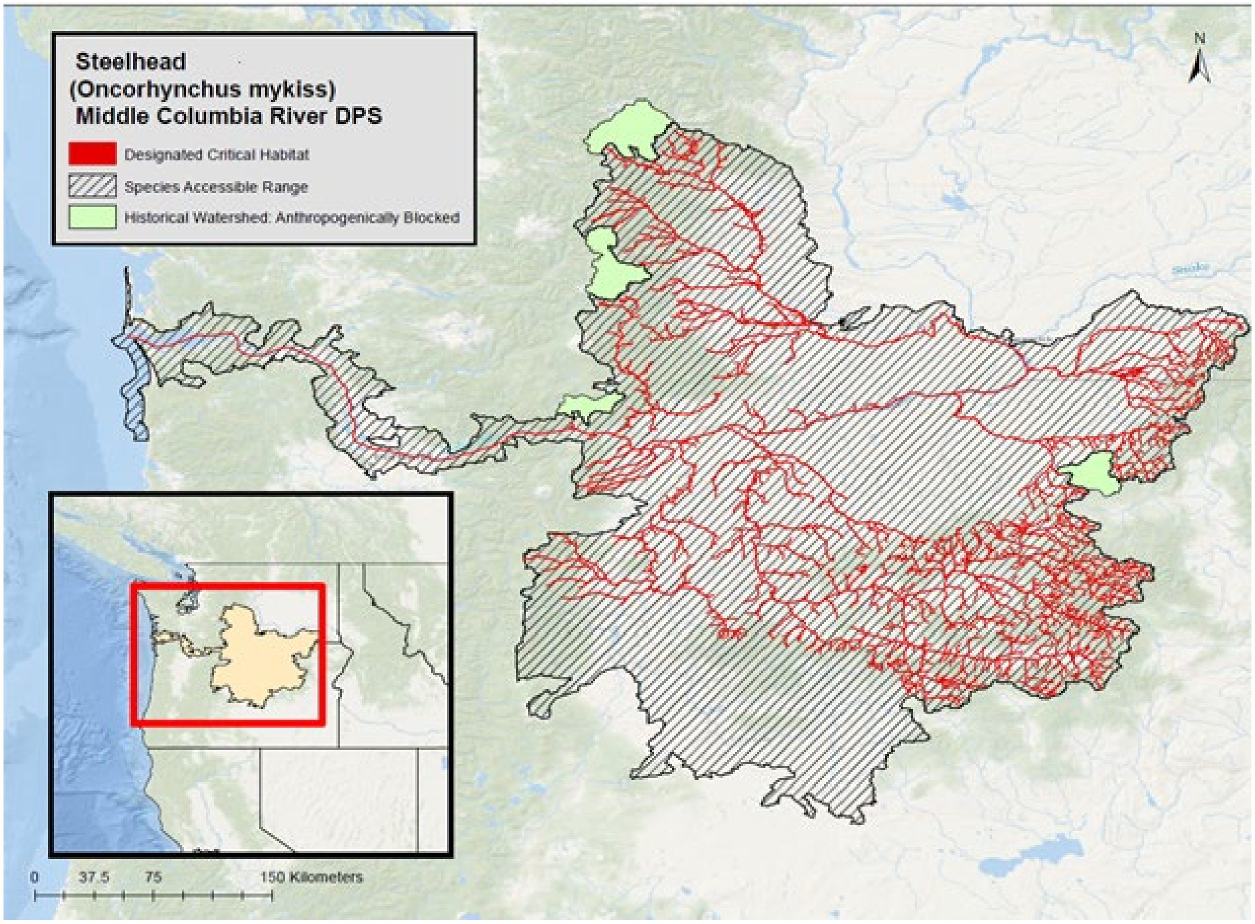

Figure 48. Geographic range and designated critical habitat of Middle Columbia River steelhead.

The majority of juveniles smolt and out-migrate as two-year olds. Most of the rivers in this region produce about equal or higher numbers of adults having spent one year in the ocean as adults having spent two years. However, summer-run steelhead in Klickitat River have a life cycle more like LCR steelhead whereby the majority of returning adults have spent two years in the ocean (Busby et al. 1996). Adults may hold in the river up to a year before spawning. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

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 Middle Columbia River steelhead.

Historic run estimates for the Yakima River imply that annual species abundance may have exceeded 300,000 returning adults (Busby et al. 1996). The five-year average (geometric mean) return of natural Middle Columbia River steelhead for 1997 to 2001 was up from basin estimates of previous years. Returns to the Yakima River, the Deschutes River, and sections of the John Day River system were substantially higher compared to 1992 to 1997 (Good et al. 2005). The five-year average for these basins is 298 and 1,492 fish, respectively (Good et al. 2005). Current abundance estimates for the Middle Columbia River DPS of steelhead are presented in Table 38 below.

Table 38. Current abundance estimates for the Middle Columbia River DPS of steelhead (NMFS 2020b).

Production	Life Stage	Abundance
Natural	Adult	5,052
Natural	Juvenile	407,697
Listed Hatchery Adipose Clipped	Adult	448
Listed Hatchery Adipose Clipped	Juvenile	444,973
Listed Hatchery Intact Adipose	Adult	112
Listed Hatchery Intact Adipose	Juvenile	110,469

There have been improvements in the viability ratings for some of the component populations, but the Middle Columbia River Steelhead DPS is not currently meeting the viability criteria described in the Mid-Columbia Steelhead Recovery Plan.

The recovery team for this DPS identified 17 extant populations (ICTRT 2003; McClure et al. 2005). The populations fall into four MPGs: Cascade eastern slope tributaries (five extant and two extirpated populations), the, the John Day River (five extant populations), the Walla Walla and Umatilla rivers (three extant and one extirpated populations), and the Yakima River (four extant populations.

Distribution in the Action Area

The general distribution of steelhead in the action area is discussed in Section 6.2.11 above. We have no additional information on the distribution, abundance or density of specific steelhead DPSs within the action area.

Status

Within the Middle Columbia River DPS of steelhead, the recovery team for this DPS identified 16 extant populations in four major population groups (Cascades Eastern Slopes Tributaries, John Day River, Walla Walla and Umatilla Rivers, and Yakima River) and one unaffiliated independent population (Rock Creek) (ICTRT 2003). There are two extinct populations in the Cascades Eastern Slope major population group: the White Salmon River and the Deschutes Crooked River above the Pelton/Round Butte Dam complex. Present population structure is delineated largely on geographical proximity, topography, distance, ecological similarities or differences. Using criteria for abundance and productivity, the recovery team modeled a gaps analysis for each of the four MPGs in this DPS under three different ocean conditions and a base hydro condition (most recent 20-year survival rate). The results showed that none of the MPGs would be able to achieve a 5 percent or less risk of extinction over 100 years without recovery actions. It is important to consider that significant gaps in factors affecting spatial structure and diversity also contribute to the risk of extinction for these fish.

In general, result from the latest 5-year review (NMFS 2022a) indicate that the majority of population level viability ratings remained unchanged from the previous 5-year review, and the recent risk trend summarizing the overall trends in risk status for the Middle Columbia River DPS of steelhead since the prior status review remains stable/improving at a moderate risk level (Ford 2022). NMFS (2022a) concluded that the status of this DPS has not improved significantly since the final listing determination in 2006. The biological benefits of habitat restoration and protection efforts have yet to be fully expressed and will likely take another ten to 40 years to result in measurable improvements to population viability (NMFS 2022a).

Critical Habitat

Critical habitat was designated for Middle Columbia River steelhead in 2005 (70 FR 52630) (Figure 49). Designated critical habitat for the Middle Columbia River steelhead does not overlap spatially with the GOA action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2009 recovery plan for the Middle Columbia River steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2009a).

6.2.13 Steelhead – Upper Columbia River DPS

The Upper Columbia River DPS of steelhead includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Yakima River to the U.S.-Canada border. Also, the Upper Columbia River DPS includes steelhead from six artificial propagation programs. On August 18, 1997 NMFS listed the Upper Columbia River DPS of steelhead as endangered (62 FR 43937) and reaffirmed the DPS's status as endangered on January 5, 2006 (71 FR 834).

Life History

All Upper Columbia River steelhead are summer-run steelhead. Adults return in the late summer and early fall, with most migrating relatively quickly to their natal tributaries. A portion of the returning adult steelhead overwinter in mainstem reservoirs, passing over upper-mid-Columbia dams in April and May of the following year. Spawning occurs in the late spring of the year following river entry. Juvenile steelhead spend one to seven years rearing in fresh water before migrating to sea. Smolt out migrations are predominantly year class two and three (juveniles), although some of the oldest smolts are reported from this DPS at seven years. Most adult steelhead return to fresh water after one or two years at sea.

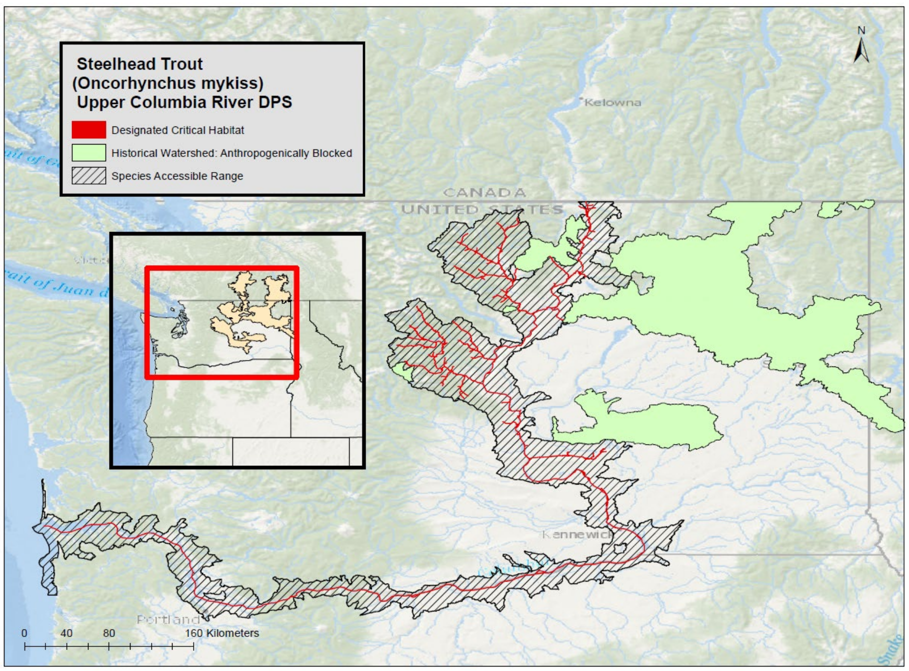

Figure 49. Geographic range and designated critical habitat of upper Columbia River steelhead.

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 Upper Columbia River steelhead.

The most recent estimates of natural-origin spawner abundance for each of the four populations in the Upper Columbia River DPS of steelhead show fairly consistent patterns throughout the years. None of the populations have reached their recovery goal numbers during any of the years (500 for the Entiat, 2,300 for the Methow, 2,300 for the Okanogan, and 3,000 for Wenatchee). Current abundance estimates for the Upper Columbia River DPS of steelhead are presented in Table 39 below.

Table 39. Current abundance estimates for the Upper Columbia River DPS of steelhead (NMFS 2020b).

Production	Life Stage	Abundance
Natural	Adult	3,988
Natural	Juvenile	169,120
Listed Hatchery Adipose Clipped	Juvenile	662,848
Listed Hatchery Intact Adipose	Adult	2,403
Listed Hatchery Intact Adipose	Juvenile	144,067

Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. In spite of recent increases, natural origin abundance and productivity remain well below viability thresholds for three out of the four populations, and the Okanogan River natural-origin spawner abundance estimates specifically are well below the recovery goal for that population. Three of four extant natural populations are considered to be at high risk of extinction and one at moderate risk.

All populations are at high risk for diversity, largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations.

The Upper Columbia River steelhead DPS is composed of three MPGs, two of which are isolated by dams. With the exception of the Okanogan population, the Upper Columbia River populations were rated as low risk for spatial structure.

Distribution in the Action Area

The general distribution of steelhead in the action area is discussed in Section 6.2.11 above. We have no additional information on the distribution, abundance or density of specific steelhead DPSs within the action area.

Status

Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat and unchanged for the Methow (NWFSC 2015b). However, the viability ratings for the Upper Columbia River DPS of steelhead remain at high risk and do not meet the viability criteria recommended in the 2007 recovery plan (Ford 2022). Short-term patterns in those indicators appear to be largely driven by year-to year fluctuations in survival rates in areas outside of these watersheds. All three populations continued to be rated at low risk for spatial structure but at high risk for diversity criteria. (NMFS 2022d) concluded that the status of this

DPS has not improved significantly since the final listing determination in 2006. The biological benefits of habitat restoration and protection efforts have yet to be fully expressed and will likely take another ten to 40 years to result in measurable improvements to population viability (NMFS 2022d).

Critical Habitat

Critical habitat was designated for the Upper Columbia River DPS of steelhead in 2005 (70 FR 52630) (Figure 50). Designated critical habitat for the Upper Columbia River steelhead does not overlap spatially with the GOA action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2007 recovery plan for the Upper Columbia River steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2007b).

6.2.14 Steelhead – Puget Sound DPS

The Puget Sound DPS includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Georgia Strait (Figure 50). Steelhead from six artificial propagation programs are also included. On May 11, 2007 NMFS listed the Puget Sound DPS of steelhead as threatened (72 FR 26722).

Life History

The Puget Sound steelhead DPS contains both winter-run and summer-run steelhead. Adult winter-run steelhead generally return to Puget Sound tributaries from December to April (NMFS 2005b). Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May. Prior to spawning, maturing adults hold in pools or in side channels to avoid high winter flows. Less information exists for summer-run steelhead as their smaller run size and higher altitude headwater holding areas have not been conducive for monitoring. Based on information from four streams, adult run time occur from mid-April to October with a higher concentration from July through September (NMFS 2005b).

The majority of juveniles reside in the river system for two years with a minority migrating to the ocean as one or three-year olds. Smoltification and seaward migration occur from April to mid-May. The ocean growth period for Puget Sound steelhead ranges from one to three years in the ocean (Busby et al. 1996). Juveniles or adults may spend considerable time in the protected marine environment of the fjord-like Puget Sound during migration to the high seas.

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 Puget Sound steelhead.

Abundance of adult steelhead returning to nearly all Puget Sound rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s. Inspection of geometric means of total spawner abundance from 2010 to 2014 indicates that nine of 20 populations evaluated had geometric mean abundances fewer than 250 adults and 12 of 20 had fewer than 500 adults.

Smoothed trends in abundance indicate modest increases since 2009 for 13 of the 22 DIPs. Between the two most recent five-year periods (2005-2009 and 2010-2014), the geometric mean of estimated abundance increased by an average of 5.4 percent. For seven populations in the Northern Cascades MPG, the increase was three percent; for five populations in the Central & South Puget Sound MPG, the increase was 10 percent; and for six populations in the Hood Canal & Strait of Juan de Fuca MPG, the increase was 4.5 percent. However, several of these upward trends are not statistically different from neutral, and most populations remain small. Long-term (15-year) trends in natural spawners are predominantly negative (NWFSC 2015a). Current abundance estimates for the Puget Sound DPS of steelhead are presented in Table 40 and Table 41 below.

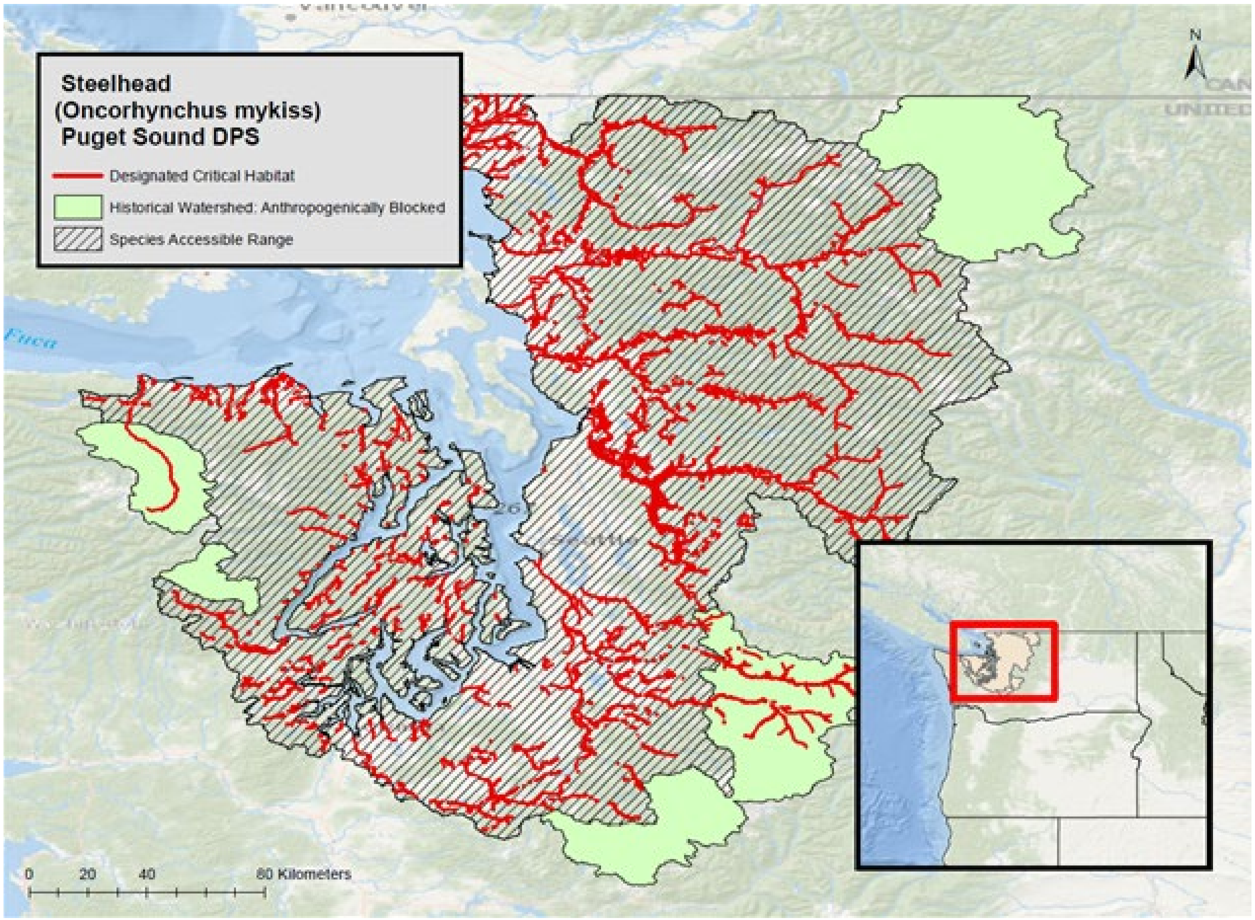

Figure 50. Geographic range and designated critical habitat of Puget Sound DPS steelhead.

Table 40. Expected 2019 Puget Sound steelhead listed hatchery releases (NMFS 2020b).

<table>
<tr><th>Subbasin</th><th>Artificial propagation program</th><th>Brood year</th><th>Run Timing</th><th>Clipped Adipose Fin</th><th>Intact Adipose Fin</th></tr>
<tr><td rowspan="2">Dungeness/Elwha</td><td>Dungeness</td><td>2018</td><td>Winter</td><td>10,000</td><td>-</td></tr>
<tr><td>Hurd Creek</td><td>2018</td><td>Winter</td><td>-</td><td>34,500</td></tr>
<tr><td rowspan="4">Duwamish/Green</td><td>Flaming Geyser</td><td>2018</td><td>Winter</td><td>-</td><td>15,000</td></tr>
<tr><td rowspan="2">Icy Creek</td><td rowspan="2">2018</td><td>Summer</td><td>50,000</td><td>-</td></tr>
<tr><td>Winter</td><td>-</td><td>28,000</td></tr>
<tr><td>Soos Creek</td><td>2018</td><td>Summer</td><td>50,000</td><td>-</td></tr>
<tr><td>Puyallup</td><td>White River</td><td>2018</td><td>Winter</td><td>-</td><td>35,000</td></tr>
<tr><td colspan="4">Total Annual Release Number</td><td>110,000</td><td>112,500</td></tr>
</table>

Table 41. Abundance estimates of Puget Sound steelhead spawner escapements (natural-origin and hatchery-production combined) from 2012-2016 (NMFS 2020b).

Demographically Independent Populations	Spawners	Expected Number of Outmigrants[b]
Central and South Puget Sound MPG		
Cedar River	3	391
Green River	977	111,179
Nisqually River	759	86,323
N. Lake WA/Lake Sammamish	-	-
Puyallup/Carbon River	603	68,646
White River	629	71,638
Hood Canal and Strait of Juan de Fuca MPG		
Dungeness River[c]	26	2,984
East Hood Canal Tribs.	89	10,120
Elwha River	878	99,954
Sequim/Discovery Bay Tribs.	19	2,186
Skokomish River	862	98,066
South Hood Canal Tribs.	73	8,304
Strait of Juan de Fuca Tribs.	173	19,697
West Hood Canal Tribs.	122	13,858
North Cascades MPG		
Nooksack River	1,790	203,631
Pilchuck River	868	98,709
Samish River/ Bellingham Bay Tribs.	977	111,167
Skagit River	8,038	914,353
Snohomish/Skykomish Rivers	1,053	119,762
Snoqualmie River	824	93,772
Stillaguamish River	476	54,170
Tolt River	70	7,988
TOTAL	**19,313**	**2,196,901**

Only two hatchery stocks genetically represent native local populations (Hamma and Green River natural winter-run). The remaining programs, which account for the vast preponderance of production, are either out-of-DPS derived stocks or were within-DPS stocks that have diverged substantially from local populations. The Washington Department of Fish and Wildlife estimated that 31 of the 53 stocks were of native origin and predominantly natural production (Washington Department of Fish and Wildlife (WDFW) 1993).

Fifty-three populations of steelhead have been identified in this DPS, of which 37 are winter-run. Summer-run populations are distributed throughout the DPS but are concentrated in northern Puget Sound and Hood Canal; only the Elwha River and Canyon Creek support summer-run steelhead in the rest of the DPS. The Elwha River run, however, is descended from introduced Skamania Hatchery summer-run steelhead. Historical summer-run steelhead in the Green River and Elwha River were likely extirpated in the early 1900s.

Distribution in the Action Area

The general distribution of steelhead in the action area is discussed in Section 6.2.11 above. We have no additional information on the distribution, abundance or density of specific steelhead DPSs within the action area.

Status

For all but a few putative demographically independent populations of steelhead in Puget Sound, estimates of mean population growth rates obtained from observed spawner or redd counts are declining—typically three to 10 percent annually. Extinction risk within 100 years for most populations in the DPS is estimated to be moderate to high, especially for draft populations in the putative South Sound and Olympic major population groups. Collectively, these analyses indicate that steelhead in the Puget Sound DPS remain at risk of extinction throughout all or a significant portion of their range in the foreseeable future, but are not currently in danger of imminent extinction. The Biological Review for the latest 5-Year Review of the Puget Sound DPS of steelhead identified degradation and fragmentation of freshwater habitat, with consequent effects on connectivity, as the primary limiting factors and threats facing the Puget Sound steelhead DPS. The status of the listed Puget Sound steelhead DPS has not changed substantially since the 2007 listing. Most populations within the DPS are showing continued downward trends in estimated abundance, a few sharply so. The limited available information indicates that this DPS remains at a moderate risk of extinction.

Critical Habitat

NMFS designated critical habitat for Puget Sound steelhead in 2016 (81 FR 9251). Designated critical habitat for the Puget Sound steelhead does not overlap spatially with the GOA action area (Figure 50) and, therefore, will not be analyzed further in this opinion.

Recovery Goals

NMFS published a final recovery plan for the Puget Sound DPS of steelhead on December 20, 2019 (NMFS 2019g). The recovery plan's primary goals are as follows:

- The Puget Sound steelhead DPS achieves biological viability and the ecosystems upon which the DPS depends are conserved such that it is sustainable and persistent and no longer needs federal protection under the ESA; and
- The five listing factors from the ESA, section 4 (a)(1) are addressed. The five listing factors from the ESA, section 4(a)(1), include:
    - The present or threatened destruction, modification, or curtailment of the species' habitat or range;

- Overutilization for commercial, recreational, scientific, or educational purposes;
- Disease or predation;
- Inadequacy of existing regulatory mechanisms; and
- Other natural or human-made factors affecting the species' continued existence.

Delisting criteria for the Puget Sound DPS of steelhead are detailed in NMFS (2019g).

6.2.15 Steelhead – Snake River Basin DPS

The Snake River Basin DPS of steelhead includes naturally spawned steelhead originating below natural and manmade impassable barriers from the Snake River Basin (Figure 51), and also steelhead from six artificial propagation programs. On August 18, 1997 NMFS listed the Snake River Basin DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

Snake River Basin steelhead are generally classified as summer-run fish. They enter the Columbia River from late June to October. After remaining in the river through the winter, Snake River Basin steelhead spawn the following spring (March to May). Managers recognize two life history patterns within this DPS primarily based on ocean age and adult size upon return: A-run or B-run. A-run steelhead are typically smaller, have a shorter freshwater and ocean residence (generally one year in the ocean), and begin their up-river migration earlier in the year. B-run steelhead are larger, spend more time in fresh water and the ocean (generally two years in ocean), and appear to start their upstream migration later in the year. Snake River Basin steelhead usually smolt after two or three years.

The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30°F to 52°F (CDFW 2000). The eggs hatch in three to four weeks at 50°F to 59°F, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

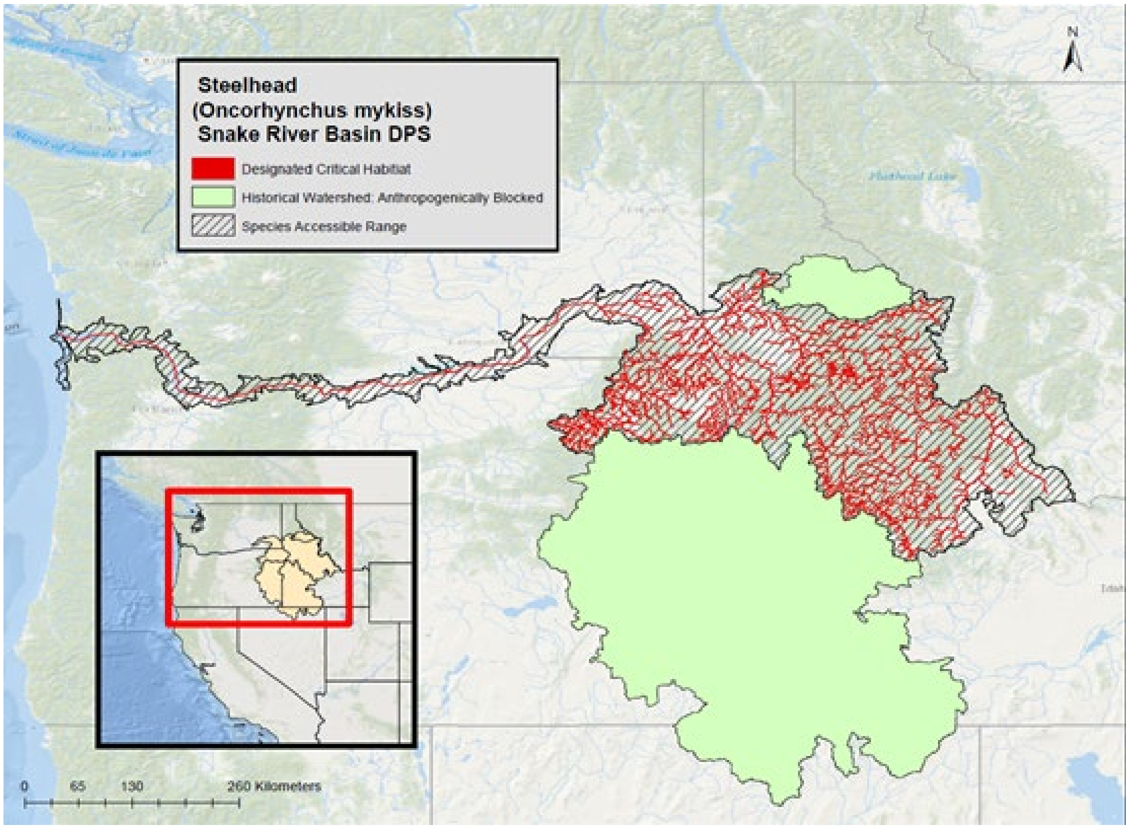

Figure 51. Geographic range and designated critical habitat of Snake River Basin steelhead.

The majority of juveniles smolt and out-migrate as two-year olds. Adults may hold in the river up to a year before spawning. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

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 Snake River Basin steelhead.

There is uncertainty for wild populations of Snake River Basin DPS steelhead given limited data for adult spawners in individual populations. Regarding population growth rate, there are mixed long- and short-term trends in abundance and productivity. Overall, the abundances remain well below interim recovery criteria. Current abundance estimates for the Snake River Basin DPS of steelhead are presented in Table 42 below.

Table 42. Current abundance estimates for the Snake River Basin DPS of steelhead (NMFS 2020b).

Production	Life Stage	Abundance
Natural	Adult	10,547
Natural	Juvenile	798,341
Listed Hatchery Adipose Clipped	Adult	79,510
Listed Hatchery Adipose Clipped	Juvenile	3,300,152
Listed Hatchery Intact Adipose	Adult	16,137
Listed Hatchery Intact Adipose	Juvenile	705,490

Distribution in the Action Area

The general distribution of steelhead in the action area is discussed in Section 6.2.11 above. We have no additional information on the distribution, abundance or density of specific steelhead DPSs within the action area.

Status

Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan being written by NMFS based on the updated status information available for this review, and the status of many individual populations remains uncertain (NMFS 2022b; NWFSC 2015b). The Grande Ronde MPG is tentatively rated as viable; more specific data on spawning abundance and the relative contribution of hatchery spawners for the Lower Grande Ronde and Wallowa populations would improve future assessments. A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations. Ford (2022) completed an updated viability assessment for the Snake River Basin steelhead DPS and concluded that recent sharp population abundance declines in the past five years warrant close monitoring of population abundance over the next 5-year review period to determine the need for an elevated biological risk status for this DPS (NMFS 2022b).

Critical Habitat

Critical habitat was designated for this species in 2005 (70 FR 52630). Designated critical habitat for the Snake River Basin steelhead does not overlap spatially with the GOA action area (Figure 51) and, therefore, will not be analyzed further in this opinion.

Recovery Goals

NMFS published a final recovery plan for the Snake River Basin DPS of steelhead on November 30, 2017 (NMFS 2017d). The ESA recovery goal for Snake River Basin steelhead is that: The ecosystems upon which the steelhead depend are conserved such that the DPS is self-sustaining in the wild and no longer need ESA protection. More information on the Snake River Basin DPS' recovery goals and delisting criteria are found in NMFS (2017d).

6.2.16 Steelhead – Upper Willamette River DPS

This DPS includes naturally spawned anadromous winter-run *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to and including the Calapooia River (Figure 52). On March 25, 1999 NMFS listed the Upper Willamette River DPS of steelhead as threatened (64 FR 14517) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

Native steelhead in the Upper Willamette are a late-migrating winter group that enters fresh water in January and February (Howell et al. 1985). Upper Willamette River steelhead do not ascend to their spawning areas until late March or April, which is late compared to other West Coast winter steelhead. Spawning occurs from April to June 1. The unusual run timing may be an adaptation for ascending the Willamette Falls, which may have facilitated reproductive isolation of the stock. The smolt migration past Willamette Falls also begins in early April and proceeds into early June, peaking in early- to mid-May (Howell et al. 1985). Smolts generally migrate through the Columbia via Multnomah Channel rather than the mouth of the Willamette River. As with other coastal steelhead, the majority of juvenile smolts outmigrate after two years; adults return to their natal rivers to spawn after spending two years in the ocean. Repeat spawners are predominantly female and generally account for less than 10 percent of the total run size (Busby et al. 1996).

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 upper Willamette River steelhead.

For the Upper Willamette steelhead DPS, the declines in abundance noted during the previous status review continued through 2010 to 2015, and accessibility to historical spawning habitat remains limited, especially in the North Santiam River. Although the recent magnitude of these declines is relatively moderate, NMFS Northwest Fisheries Science Center (NWFSC 2015b) notes that continued declines would be a cause for concern.

Recent estimates of escapement in the Molalla River indicate abundance is stable but at a depressed level, and the lack of migration barriers indicates this

limitation is likely due to habitat degradation (NWFSC 2015b). In the North Santiam, radio-tagging studies and counts at Bennett Dam between 2010 and 2014 estimate the average abundance of returning winter-run adults is following a long-term negative trend (NWFSC 2015b). In the South Santiam live counts at Foster Dam indicate a negative trend in abundance from 2010-2014, and redd survey data indicate consistent low numbers of spawners in tributaries (NWFSC 2015b). Radio-tagging studies in the Calapooia from 2012-2014 suggest that abundances have been depressed but fairly stable, however long-term trends in redd counts conducted since 1985 are generally negative (NWFSC 2015b). Current abundance estimates for the Upper Willamette River DPS of steelhead are presented in

Table 43 below.

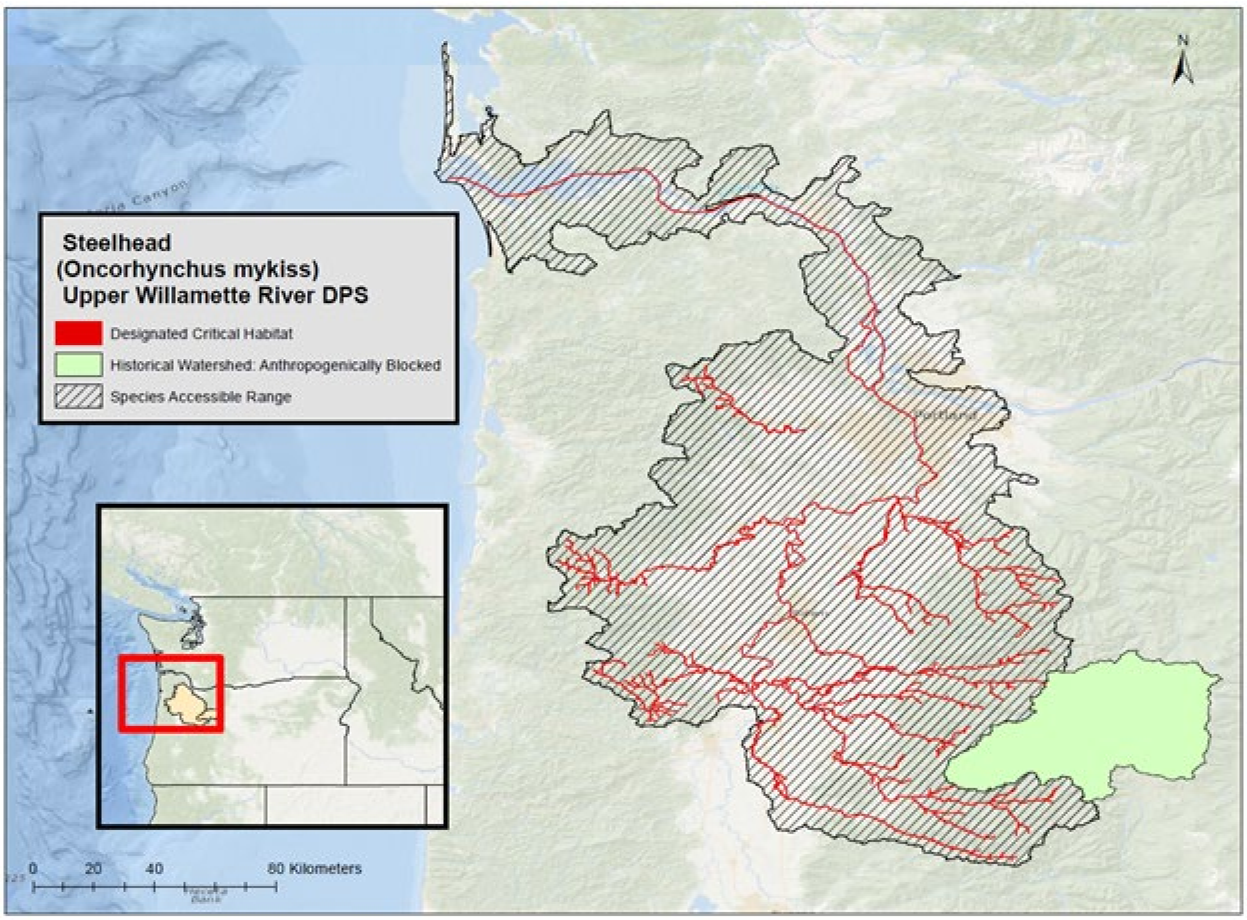

Figure 52. Geographic range and designated critical habitat of upper Willamette River steelhead.

Table 43. Current abundance estimates for the Upper Willamette River DPS of steelhead (NMFS 2019b).

Production	Life Stage	Abundance
Natural	Adult	2,912
Natural	Juvenile	143,898

Genetic analysis suggests that there is some level introgression among native late-winter steelhead and summer-run steelhead (Van Doornik et al. 2015), and up to approximately 10 percent of the juvenile steelhead at Willamette Falls and in the Santiam Basin may be hybrids (Johnson et al. 2013). While winter-run steelhead have largely maintained their genetic distinctiveness over time (Van Doornik et al. 2015), there are still concerns that hybridization will decrease the overall productivity of the native population. In addition, releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter-run juvenile steelhead (NWFSC 2015b).

Historical observations, hatchery records, and genetics suggest that the presence of Upper Willamette River DPS steelhead in many tributaries on the west side of the upper basin is the result of recent introductions. Nevertheless, the Willamette/Lower Columbia Technical Recovery Team recognized that although west side Upper Willamette River DPS steelhead does not represent a historical population, those tributaries may provide juvenile rearing habitat or may be temporarily (for one or more generations) colonized during periods of high abundance. Hatchery summer-run steelhead that are released in the subbasins are from an out-of-basin stock, and are not part of the DPS, nor are stocked summer steelhead that have become established in the McKenzie River (ODFW and NMFS 2011).

Distribution in the Action Area

The general distribution of steelhead in the action area is discussed in Section 6.2.11 above. We have no additional information on the distribution, abundance or density of specific steelhead DPSs within the action area.

Status

Four basins on the east side of the Willamette River historically supported independent populations for the Upper Willamette River DPS steelhead, all of which remain extant. Data indicate that currently the two largest populations within the DPS are the Santiam River populations. Mean spawner abundance in both the North and South Santiam River is about 2,100 native winter-run steelhead. However, about 30 percent of all habitat has been lost due to human activities (McElhany et al. 2007). The North Santiam population has been substantially affected by the loss of access to the upper North Santiam basin. The South Santiam subbasin has lost habitat behind non-passable dams in the Quartzville Creek watershed. Notwithstanding the lost spawning habitat, the DPS continues to be spatially well distributed, occupying each of the four major subbasins. Overall, the declines in abundance noted during the previous review continued through the period 2010-2015 (NWFSC 2015b). There is considerable uncertainty in many of the abundance estimates, except for perhaps the tributary dam counts.

Critical Habitat

NMFS designated critical habitat for this species in 2005. Designated critical habitat for the Upper Willamette River steelhead does not overlap spatially with the GOA action area (Figure 52) and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2011 recovery plan for the Upper Willamette River steelhead DPS (NMFS 2011) for complete down-listing/delisting criteria for recovery goals for the species.

7 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 CFR 402.02). The following information summarizes the principal natural and human-caused phenomena in the GOA action area believed to affect the survival and recovery of ESA-listed species (from Section 6.2 above) in the action area.

7.1 Global Climate Change

There is a large and growing body of literature on past, present, and anticipated future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov). This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur in the action area as the result of climate change. We address climate change as it has affected ESA-listed species and continues to affect species, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited to our cumulative effects analysis (Section 9), it is discussed here to provide a comprehensive analysis of the effects of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats both within and outside of the action area.

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

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

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1.0°C from 1901 through 2016 (Hayhoe et al. 2018). The IPCC Special Report on the Impacts of Global Warming (2018) (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2°C above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3°C per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (Allen et al. 2018). Annual average temperatures have increased by 1.8°C across the contiguous U.S. since the beginning of the 20th century, with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). In the past 60 years, average air temperatures across Alaska have increased by approximately 3.0°F, and winter temperatures have increased by 6.0°F (IPCC 2014). In the Chukchi Sea, August sea surface temperatures are warming more than 4.5 times faster than other oceans, at a rate of 1.3°F per decade since the 1980s. Some of the most pronounced effects of climate change in Alaska include disappearing sea ice, shrinking glaciers, thawing permafrost, and changing ocean temperatures and chemistry (IPCC 2014).

Changes in the abundance and productivity of biological populations in the North Pacific have often been associated with large-scale modes of climate variability. These climatic events can alter habitat conditions and prey distribution for ESA-listed species (Beamish 1993; Hare and Mantua 2001; Mantua et al. 1997); (Benson and Trites 2002; Mundy 2005; Mundy and Cooney 2005; Stabeno et al. 2004). The Pacific Decadal Oscillation, which describes spatio-temporal variability in North Pacific sea surface temperature (SST), correlates with much of this variability. The Pacific Decadal Oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific Decadal Oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005).

Starting in October 2013, a strong and long-lasting high pressure ridge caused a mass of anomalously warm water to form in the North Pacific Ocean (Amaya et al. 2020; Cheung and Frolicher 2020; Cornwall 2019; Hobday et al. 2016; Holdbrook et al. 2019; National Park Service 2019; Sanford et al. 2019). Known colloquially as "the blob," this event represents the longest lasting heat wave globally over the past decade, with continued warm conditions occurring through 2019 (Suryan et al. 2021). Water temperatures ranged from between four and ten degrees Fahrenheit (°F) warmer than average, depending on the date and location of measurement. The warm water mass split into three areas between 2013 and 2018: one in the Gulf of Alaska between 2015 and 2016 (now in the Bering Sea); one off the coast of Canada, Washington, and Oregon; and one off the California/Mexico coast. In 2019, sea surface temperatures in the Gulf of Alaska remained warmer than average. Three periods with heat wave conditions, where the sea surface temperature was elevated above the 90th percentile for more than five consecutive days, occurred between July and September 2019 (Alaska Fisheries Science Center 2020). While the persistent 2019 GOA marine heatwave conditions ended in December, 2019, residual heat remains at depth in 2020, and potential effects from the previous warm years (2014–2016 and 2019) may still be evident in the ecosystem (NPFMC 2020). Species-specific changes in abundance, reproductive success, and distribution occurred in the GOA 2014–2019 period, and not all have recovered, although evidence has not been found of shifts to a new ecosystem state. Litzow et al. (2020) evaluated the ecological consequences of the 2014-2019 "blob" warming event in the Gulf of Alaska across multiple trophic levels and taxa. Although their models found no evidence for wholesale ecosystem reorganization during this period, nonstationary relationships among climate and community variables suggest the ongoing possibility of novel patterns of ecosystem functioning with continued warming.

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Evans and Bjørge 2013; IPCC 2014; Kintisch 2006; Learmonth et al. 2006; MacLeod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Becker et al. 2018b; Silber et al. 2017; Simmonds and Isaac 2007), recent research has indicated a range of consequences already occurring. Additional ecosystem level consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, ocean acidification, fewer nutrients, and decreased ocean oxygen levels (Doney et al. 2012). Changes in the marine ecosystems caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish.

Ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. High latitude oceans have naturally lower saturation states of calcium carbonate minerals than more temperate or tropical waters (Fabry et al. 2009), making Alaska's oceans more susceptible to the effects of ocean acidification. Large inputs of low-alkalinity freshwater from glacial runoff and melting sea ice reduce the buffering capacity of seawater to changes in pH (Reisdorph and Mathis 2014). As a result, seasonal undersaturation of aragonite has been detected in the Bering Sea, Glacier Bay, and the Chukchi Sea (Fabry et al. 2009; Reisdorph and Mathis 2014). By 2050, all of the Arctic Ocean is predicted to be undersaturated with respect to aragonite (Feely et al. 2009).

Changes in seawater chemistry as a result of ocean acidification could have severe consequences for calcifying organisms, particularly pteropods. Pteropods are a type of zooplankton that form shells from aragonite, are abundant in high latitude surface waters, and form the base of many food webs (Orr et al. 2005). Pteropods are prey for many species of carnivorous zooplankton; fishes including salmon, mackerel, herring, and cod; and baleen whales (Orr et al. 2005), and are often considered an indicator species for ecosystem health. Under increasingly acidic conditions, pteropods may not be able to grow and maintain shells, and it is uncertain if they may be able to evolve quickly enough to adapt to changing ocean conditions (Fabry et al. 2009). Ocean acidification may cause a variety of species- and ecosystem-level effects in high latitude ecosystems. Species-level effects may include reductions in the calcification rates of numerous planktonic and benthic species, alteration of physiological processes such as pH buffering, hypercapnia, ion transport, acid-base regulation, mortality, metabolic suppression, inhibited blood-oxygen binding, and reduced fitness and growth (Fabry et al. 2008). Ecosystem effects could include altered species compositions and distributions, trophic dynamics, rates of primary productivity, and carbon and nutrient cycling (Fabry et al. 2008).

Effects of ocean acidification on ESA-listed fish most likely occur through ecological mechanisms mediated by changes to the food web (Busch et al. 2013; Crozier et al. 2019). Taxa directly affected by declining marine pH include invertebrates such as pteropods, crabs, and krill. Physiological effects of acidification may also impair olfaction, which could hinder salmonid homing ability, along with other developmental effects (Crozier et al. 2019).

Climate change models by Woodworth-Jefcoats et al. (2017) projected that zooplankton densities would decline across the North Pacific region. Such declines would be amplified relative to declines in phytoplankton densities. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. Leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. Hazen et al. (2012) predicted up to 35 percent change in core habitat for some key Pacific species based on climate change scenarios predicated on the rise in average sea surface temperature by 2100. McMahon and Hays (2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes.

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

Climatic conditions affect salmonid abundance, productivity, spatial structure, and diversity through direct and indirect impacts at all life stages (e.g., Crozier et al. 2008; Independent Science Advisory Board 2007; Lindley et al. 2007; Moyle et al. 2013; Wainwright and Weitkamp 2013). Studies examining the effects of long-term climate change to salmon populations have identified a number of common mechanisms by which climate variation is likely to influence salmon sustainability. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance (NMFS 2019d). Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior. Expected behavioral responses include shifts in seasonal timing of important life history events, such as the adult migration, spawn timing, fry emergence timing, and the juvenile migration. Indirect effects on salmon mortality, growth rates and movement behavior are also expected to follow from changes in the freshwater habitat structure and the invertebrate and vertebrate community, which governs food supply and predation risk (Crozier et al. 2008; Independent Science Advisory Board 2007; Petersen and Kitchell 2001).

Crozier et al. (2019) conducted an extensive analysis on ESA-listed salmonid and steelhead vulnerability to climate change. Nearly all listed populations faced high exposures to projected increases in stream temperature, sea surface temperature, and ocean acidification. The highest vulnerability scores for extrinsic effects (anthropogenic stressors) occurred in interior and southern regions where climate is expected to change the most. Populations ranked as the most vulnerable to climate change overall were California Central Valley Chinook salmon, California and southern Oregon coho salmon, Snake River Basin sockeye salmon, and Columbia and Willamette River spring-run Chinook salmon (Crozier et al. 2019).

In the marine ecosystem, salmon may be affected by warmer water temperatures, increased stratification of the water column, intensity and timing changes of coastal upwelling, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Independent Science Advisory Board 2007; Mauger et al. 2015). Salmon 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 under multiple IPCC warming scenarios. For chum salmon, pink salmon, coho salmon, sockeye salmon and steelhead, they predicted contractions in suitable marine habitat of 30-50 percent by the 2080s, with an even larger contraction (86-88 percent) for

Chinook salmon under the medium and high emissions scenarios. Northward range shifts are a climate response expected in many marine species, including salmon (Cheung et al. 2015). However, salmon populations are strongly differentiated in the northward extent of their ocean migration, and hence will likely respond individualistically to widespread changes in sea surface temperature (NMFS 2019d). In a meta-analytical review of multiple peer-reviewed papers on green sturgeon, Rodgers et al. (2019) reported that elevated temperatures significantly reduce growth and hatching success and increase the incidence of larval deformities.

The adaptive capacity of threatened and endangered salmonid species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation (NMFS 2019d). Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change are more likely to reduce long-term viability and sustainability of salmon populations, although the character and magnitude of these effects will likely vary within and among ESUs (NMFS 2019d).

7.2 Whaling and Hunting

Large whale population numbers in the action area have historically been impacted by commercial whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the Endangered Species Act of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were captured and killed in the Pacific Ocean with an unknown number of additional animals captured and killed before 1900 (Perry et al. 1999). Sei whales 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 were reported killed by commercial whalers in the North Pacific between 1910 and 1965 (Ohsumi and Wada. 1972); 46,000 fin whales between 1947and 1987 (Rice 1984); and 25,800 sperm whales (Barlow et al. 1997). North Pacific right whales were heavily exploited in the 19th century, affecting an estimated 26,500 to 37,000 between 1839 and 1909 (Scarff 2001b). These whaling numbers represent minimum catches, as illegal or underreported catches are not included. Since the end of large-scale commercial whaling, the primary threat to these species has been eliminated. However, as described in greater detail in the *Status of the Species* section of this opinion, many whale species have not recovered from those historic declines.

Despite the current moratorium on large-scale commercial whaling, catch of some species still occurs in the Pacific Ocean, whether it be under objection of the IWC, for aboriginal subsistence purposes, or under an International Whaling Commission special permit. For example, from 1985 through 2013, an estimated 1,089 sei whales and 444 sperm whales were harvested. In 2019, Japan withdrew from the International Whaling Commission and resumed commercial whaling within its waters (BBC News 2019; Nishimura 2019; Victor 2018). Japan had set an annual quota of 227 whales until the end of 2019, which included 52 minke whales, 150 Bryde's whales, and 25 sei whales (Nishimura 2019); the annual quota set for 2020 was 383 whales total (Hurst 2020). Although ongoing whaling operations occur outside of the action area, it is likely that some of the whales found in those waters may be part of the same North Pacific populations that are also present seasonally in the action area for this consultation.

Aboriginal subsistence whaling catch limits by the IWC exist in various places around the world. (International Whaling Commission 2020)(International Whaling Commission 2020)(International Whaling Commission 2020)(International Whaling Commission 2020)(International Whaling Commission 2020)(International Whaling Commission 2020) For example, the IWC quotas for 2019–2025 are for a total of 980 gray whales with no more than 140 landed in any one year by native people in Chukotka (Russia) and Washington State (International Whaling Commission 2020). The number of marine mammals taken for subsistence purposes in the vicinity of the action area, or that migrate through the action area, is inconsistently reported or not publicly available data. Subsistence killing of marine mammals by Russian and Alaska Natives that occurs in the North Pacific, Chukchi Sea, and Bering Sea affects marine mammal stocks that may be present in the action area. In Russian waters in 2013, there were 127 gray whales “struck” during subsistence whaling by the inhabitants of the Chukchi Peninsula between the Bering and Chukchi Sea (Ilyashenko et al. 2014). These gray whales taken in Russian waters may be individuals from either the endangered Western North Pacific stock or the non-ESA listed Eastern North Pacific stock that may migrate through the action area.

In addition to whales, pinniped populations found within the action area are hunted for aboriginal subsistence purposes, including the endangered Western DPS of Steller sea lion (Wolfe et al. 2012). Data were collected on Alaska Native harvest of Steller sea lions for seven communities on Kodiak Island for 2011 and 15 communities in Southcentral Alaska in 2014. The Alaska Native Harbor Seal Commission and Alaska Department of Fish and Game estimated a total of 20 adult sea lions were harvested on Kodiak Island in 2011, and 8 sea lions were harvested in South Central Alaska in 2014, with adults comprising 84 percent of the harvest (Muto et al. 2018a). Stranded Steller sea lions with evidence of human induced trauma are regularly reported in Alaska. From 2016 through 2020, a total of 26 Steller sea lions with (either confirmed or suspected) firearm injuries were reported to the Alaska Marine Mammal Strandings program.

7.3 Fisheries

In this section we address the impacts to ESA-listed fishes in the action area from commercial fisheries bycatch (Section 7.3.1), and the impacts to marine mammals in the action area from entanglement in commercial fishing gear (Section 7.3.2).

7.3.1 Bycatch of Endangered and Threatened Fishes

In addition to being subject to capture in fisheries closer to their natal rivers, ESA-listed salmon from the U.S. West Coast are caught in several fisheries that operate in Gulf of Alaska waters.

These fisheries include the following: groundfish fisheries managed by NMFS under the Fishery Management Plan for Groundfish of the Gulf of Alaska; salmon fisheries under the Fishery Management Plan for the Salmon Fisheries in the EEZ off Alaska; Pacific salmon fisheries that operate under the Pacific Salmon Treaty between the U.S. and Canada; and State of Alaska managed commercial, recreational (personal use), sport, and subsistence fisheries for Pacific salmon that operate in the Gulf of Alaska.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) is the primary law that governs fishing in U.S. federal waters, ranging from 3 to 200 miles offshore. First passed in 1976, the MSA created eight regional fishery management councils to manage our nation's marine fishery resources. The North Pacific Fishery Management Council manages federal fisheries in Alaska. NMFS implements the policies and measures recommended by the Council. The Fishery Management Plan (FMP) for the Salmon Fisheries in the EEZ off the Coast of Alaska is unique in that it closes a majority of Alaska EEZ waters to commercial salmon fishing, and facilitates State management of the few salmon fisheries in the EEZ. A commercial troll fishery is authorized in the EEZ off Southeast Alaska, but the majority of the remaining EEZ off Central and Western Alaska is closed to commercial salmon fishing (inclusive of the portion of the Gulf of Alaska TMAA inside the EEZ).

Annual accounting of catch in salmon troll fisheries occurs on a cycle that begins October 1 and ends September 30 each year. The troll fishery consists of three periods: (1) a winter fishery that occurs from October through April, (2) a spring fishery that occurs in May and June, and (3) a summer fishery that occurs from July through September. The winter troll fishery is managed to a guideline harvest level of 45,000 Chinook salmon (excluding Alaska hatchery add-on). The catches in spring troll fisheries are typically lower than winter or summer troll catches, as these fisheries generally target Alaskan hatchery produced Chinook salmon. Chinook salmon retention periods during summer troll fisheries are managed to target remaining allowable season-total troll catch after the winter and spring fisheries have occurred, although other factors may be taken into consideration, including status of local wild stocks. With the exception of directed gillnet harvest for Chinook salmon in some terminal areas as described in the Transboundary Rivers chapter of the 2009 Pacific Salmon Treaty agreement, all other net harvest of Chinook salmon is incidental to the harvest of other species. Sport fisheries generally occur throughout the year, however, bag limits may vary annually depending on the level of allowable catch.

In April 2019, NMFS completed section 7 consultation on the Delegation of Management Authority for Specified Salmon Fisheries to the State of Alaska(NMFS 2019f). The biological opinion concluded that the following ESU's of Chinook salmon were likely to be adversely affected by these fishery operations: Lower Columbia River ESU, Snake River Fall-run ESU, Upper Willamette River ESU, and Puget Sound ESU. The incidental take of these ESA-listed Chinook salmon ESUs in the Southeast Alaska fisheries varies from year to year depending on a number of environmental and ecological factors, but is limited on an annual basis by the provisions of Chapter 3, Annex IV of the Pacific Salmon Treaty Agreement that define the limits of catch and total mortality or exploitation rate for each fishery.

Groundfish fisheries (including pollock, cod, flatfish, sablefish, rockfish, and other species) do occur in the action area and are known to incidentally capture ESA-listed salmonids. By regulation, up to 800,000 metric tons of groundfish may be harvested annually from the GOA (50 CFR 679.20(a)). In 2018, approximately 427,000 metric tons of groundfish were authorized for harvest in the GOA. Annual prohibited species catch limits in groundfish fisheries have been established by the North Pacific Fishery Management Council for Chinook salmon in the central and western GOA. The annual catch limit for Chinook salmon in the directed central and western GOA pollock trawl fisheries is 18,316 and 6,684 individuals, respectively. Additionally in the central and western GOA non-pollock fisheries, 3,600 Chinook salmon are permitted for the catcher/processor sector, and 3,900 Chinook salmon in the catcher vessel sector (NPFMC 2015). The amount of Chinook salmon incidental caught in the GOA groundfish fisheries in 2018 was 16,909 fish.

Only a small percentage of Chinook incidental bycatch in the GOA would be expected to be from ESA-listed populations. Coded-wire tagged Chinook salmon recovered as bycatch in GOA fisheries are comprised of stocks originating from Alaska, British Columbia, Washington, Idaho, and Oregon (Masuda 2019; Masuda 2021).(Masuda 2021) Since 1981, coded-wire tagged Chinook salmon recovered in GOA groundfish fisheries have originated from the following ESA-listed ESUs: Lower Columbia River, Snake River fall run, Snake River spring/summer run, Upper Columbia River spring run, and the Upper Willamette River.

7.3.2 Entanglement of Marine Mammals in Fishing Gear

Marine mammals may be impacted by fisheries through entanglement in actively fished gear or derelict fishing gear. The vast majority of documented cases of baleen whale entanglements with fishing gear are from actively fished gear (NOAA 2014a). Entanglement in fishing gear can result in lethal and sub-lethal trauma to marine mammals including drowning, injury, reduced foraging, reduced fitness, and increased energy expenditure (van der Hoop et al. 2017a; Van der Hoop et al. 2016; van der Hoop et al. 2017b). Estimated numbers of mortality and serious injury resulting from entanglement in fishing gear are minimum estimates, as some proportion of interactions go unobserved. For example, whales may swim away with portions of the net, not allowing fishery observers or fishers to document the interaction (Carretta et al. 2014).

The NMFS Alaska Marine Mammal Stranding Network database has records of 199 large whale entanglements between 1990 and 2016. Of these, 67 percent were humpback whales. During this time frame, 29 percent of humpback entanglements in Alaska were with pot gear and 37 percent were with gillnet gear. Most humpbacks get entangled with gear between the beginning of June and the beginning of September, when they are on their nearshore foraging grounds in Alaska waters. From 2009 to 2013, an average of 0.8 humpback whales per year in waters off of Alaska from the western North Pacific stock and an average of 7.3 individuals from the central North Pacific stock were seriously injured or killed due to entanglements with commercial fishing gear (Muto and Angliss 2015). Gray, beluga, bowhead, fin, and sperm whales have also been reported as entangled in Alaska waters over the past decade. Five sperm whales have been seriously injured between 2010 and 2014 in the GOA sablefish long line commercial fishery (Helker et al. 2015; Helker et al. 2017).

The minimum estimated mortality rate of western Steller sea lions incidental to all U.S. commercial fisheries is 32 sea lions per year, based on a combination of observer data and stranding data. From 2016 through 2020 there were a total of 58 confirmed reports of entangled Steller sea lions in the Alaska Marine Mammal Stranding Network database.

NMFS (2019f) determined that the incidental take of Mexico DPS humpback whales and Western DPS Steller sea lions is reasonably certain to occur as a result of interaction with Southeast Alaska salmon fisheries. ESA-listed species interactions with these fisheries considered as take in the biological opinion include entanglement in a net or other components of gear such as buoy extender lines or other types of salmon fishing lines that could result in or contribute to an entanglement. The amount of take from Southeast Alaska salmon fisheries exempted in the ITS for the Southeast Alaska salmon fisheries opinion is about two Mexico DPS humpback whale interactions on average each year (including about one resulting in mortality or serious injury), and about four Western DPS Steller sea lion interactions on average each year (all four of which could result mortality or serious injury).

7.4 Vessel Strike

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes (Rockwood et al. 2021; Winkler et al. 2020). Ship strikes with marine mammals can lead to death by massive trauma, hemorrhaging, broken bones, or propeller wounds. While massive wounds can be immediately fatal, if injury is more superficial, whales may survive the collision (Silber et al. 2010).

Large numbers of cargo, fishing, cruise, and other ships transit Alaskan waters each year (see Section 7.5.2 below for details). The vast majority of reported whale-vessel interactions in this region occur in Southeast Alaska where commercial vessel traffic coincides with large aggregations of humpback whales in narrow straits and passageways (Figure 53). From 1978-2011, 108 whale-vessel collisions were reported within 200 miles of Alaska's coastline, 25 of which are known to have resulted in the mortality(Neilson et al. 2012). Most of these (86 percent) were humpback whales. Other species included fin whale, sperm whale, gray whale, and beluga whale. Neilson et al. (2012) also reported most vessels that strike whales in Southeast Alaska are less than 49 feet long, occur at speeds over 13 knots, and occur between May and September. Although calves and juveniles are smaller in size, they tend to spend more time at the surface and are, therefore, especially vulnerable to collisions with vessels (Carrillo and Ritter 2010; Laist et al. 2001).

Muto et al. (2021) reported a mean annual mortality due to ship strike of 0.3 for Western North Pacific humpbacks based on data from 2014-2018. Because all of these ship strike events occurred in the area where the two humpback stocks overlap, the mortality and serious injury was assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales. During this time period (2014-2018), none of the reported humpback whale vessel strikes occurred in the Gulf of Alaska. According to Helker et al. (2015), only one vessel strike of a marine mammal occurred in the Gulf of Alaska from 2009 to 2013, an unidentified whale struck in 2012 that was assumed to not be injured by the incident due to the slow speed of the vessel at the time of the collision. From 2013-2020, the following total number of confirmed large whale vessel strikes were reported to the Alaska Region Marine Mammal Strandings program, by species: 38 humpback whales, five fin whales, and one sperm whale (two unidentified whales were also reported). Based on information in the IWC ship strike database, Winkler et al. (2020) noted seven known whale strikes (6 definite and 1 probable) were reported in the Gulf of Alaska from 1820-2019. Based on information from the NMFS Alaska Region Stranding Database, there have been a total of four reported ship strikes of Steller sea lions within Alaska from 2000-2017, three in Southeast Alaska (Sitka) and one in the Gulf of Alaska.

It is important to note that many more vessels strikes (than those reported) may occur but go unnoticed, while others may occur and subsequently not get reported. Carcass recovery rates have been estimated for various cetacean species including 17 percent for right whales, 6.5 percent for killer whales, less than five percent for grey whales, and 3.4 percent for sperm whales (Rockwood et al. 2017). The proportion of vessel strike related strandings that are either unnoticed or unreported is likely higher in sparsely populated coastal areas (e.g., the majority of Alaska) as compared to more densely populated coastal areas (Ransome et al. 2021). NMFS has implemented regulations to minimize harmful interactions between vessels and humpback whales in Alaska (see 50 CFR §§ 216.18, 223.214, and 224.103(b)). Vessel requirements in these regulations include: 1) not approaching within 100 yards of a humpback whale, or cause a vessel or other object to approach within 100 yards of a humpback whale, 2) not placing a vessel in the path of oncoming humpback whales causing them to surface within 100 yards of vessel, 3) not disrupting the normal behavior or prior activity of a whale, and 4) operating vessel at a slow, safe speed when near a humpback whale.

NMFS implemented Whale Sense Alaska in 2015, which is a voluntary program developed in collaboration with the whale-watching industry that recognizes companies who commit to responsible practices. In 2016, NMFS and the National Park Service launched Whale Alert, another voluntary program that receives and shares real-time whale sightings with controlled access to reduce the risk of ship strike and contribute to whale avoidance. NMFS's guidelines for approaching marine mammals also discourage vessels approaching within 100 yards of haulout and rookery locations, which may reduce the risk of vessel interactions with Steller sea lions.

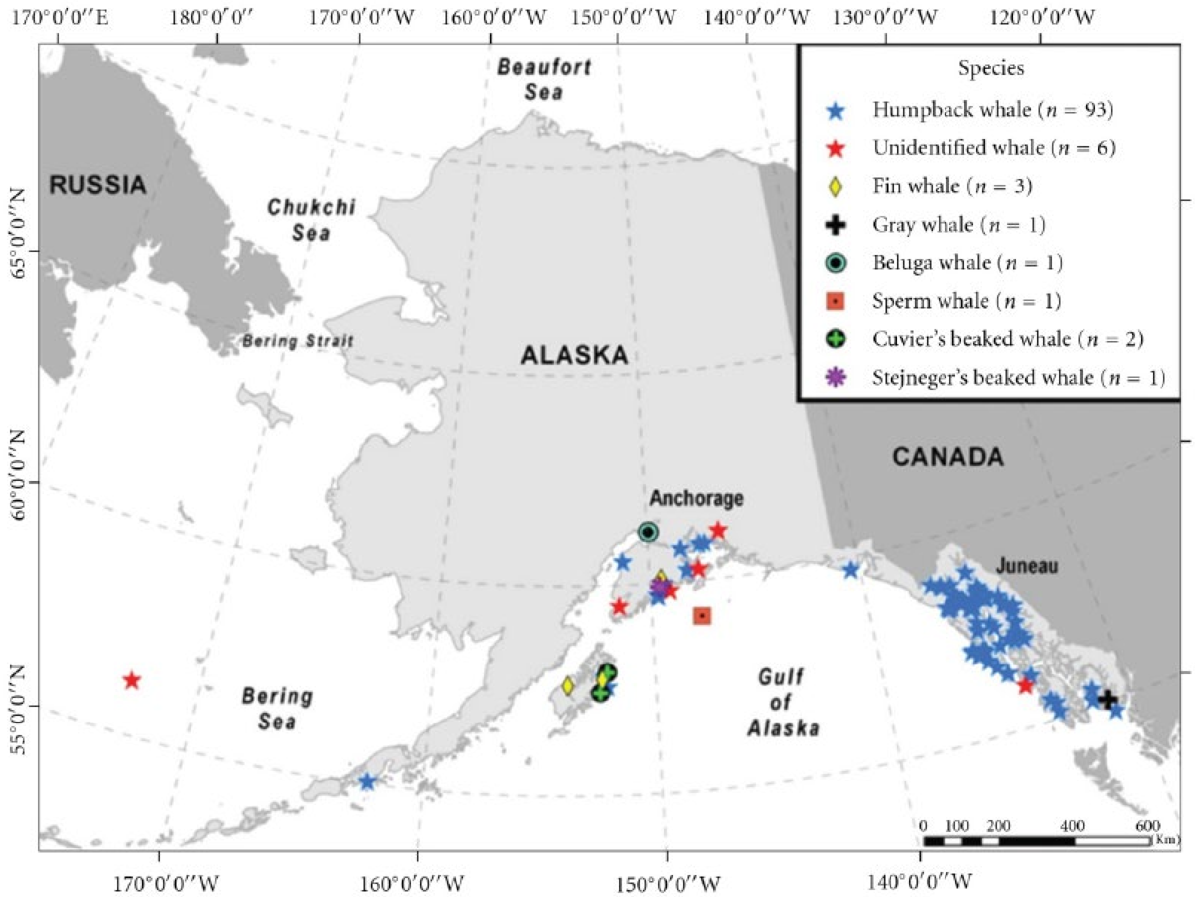

Figure 53. Location of whale-vessel collision reports in Alaska by species 1978-2011 (n=108) (Neilson et al. 2012).

7.5 Ocean Noise

The ESA-listed species that occur in the action area are regularly exposed to a variety of sources of natural and anthropogenic sounds. There is a large and variable natural component to the ambient noise level as a result of events such as earthquakes, rainfall, waves breaking, and lightning hitting the ocean as well as biological noises such as those from snapping shrimp, other crustaceans, fishes, and the vocalizations of marine mammals (Crawford and Huang 1999; Hildebrand 2004b; Patek 2002). Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise levels are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil, gas and mineral exploration, underwater construction, geophysical (seismic) surveys, Naval and other sources of sonar, and underwater explosions (Hatch and Wright 2007b; Richardson et al. 1995c). Several studies have shown that anthropogenic sources of noise have significantly increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994; NRC 2000; NRC 2003; NRC 2005;

Richardson et al. 1995c). Much of this increase is due to increased shipping, as ships have become more numerous and of larger tonnage (NRC 2003).

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

7.5.1 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 2004a). Low frequency systems, which are designed for long-range detection (Popper et al. 2014a), will not be used by the Navy as part of the proposed action. Signal transmissions are emitted in patterned sequences that may last for days or weeks. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonar 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 to 235 dB re 1μPa-m (Hildebrand 2004a). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments, however, fish finders are operated in both deep and shallow areas.

Within the action area, the primary source of active sonar that could result in impacts to ESA-listed marine mammals is from Navy activities. Details on the types and levels of active sonar from Navy activities in the action area are provided in Section 3 (above) and in the Navy's Final SEIS (Navy 2022a). A discussion of the effects of active sonar on ESA-listed marine mammals can be found in our effects analysis below (Section 8.2.1.1).

7.5.2 Vessel Sound and Commercial Shipping

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

Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans and other mechanical power sources. Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 14 to 962 feet at speeds of 10 knots and at a distance of 500 yards (457.2 meters) from the hydrophone. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 µPa-m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower.

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009; McKenna et al. 2012; NRC 2003). Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Anderwald et al. 2013; Erbe et al. 2014; Foote et al. 2004; Guerra et al. 2014; Hatch and Wright 2007a; Hildebrand 2005; Holt et al. 2008; Kerosky et al. 2013; May-Collado and Quinones-Lebron 2014; Melcon et al. 2012; Richardson et al. 1995b; Williams et al. 2014). McKenna et al. (2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from Automatic Identification System (AIS). On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 lPa2 20 to 1000 Hz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 Hz while container ship and tanker noise was predominantly below 40 Hz. The tanker had less acoustic energy in frequencies above 300 Hz, unlike the container and bulk carrier. 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.

Figure 54 depicts shipping vessel density provided by the automated identification system data for the area from Alaska to the Pacific Northwest in 2013. Vessels calling at ports in Alaska, including Anchorage and Prince William Sound, may travel directly through the Gulf of Alaska. As a result, commercial vessel noise is the main source of underwater anthropogenic noise in the action area (Wiggins et al. 2017). Commercial vessel traffic running adjacent to the coast in the action area may be adjacent to or run through portions of the designated critical habitat for North Pacific right whales and BIAs for ESA listed fin, gray, and humpback whales (Ferguson et al. 2015a; Wiggins et al. 2017).

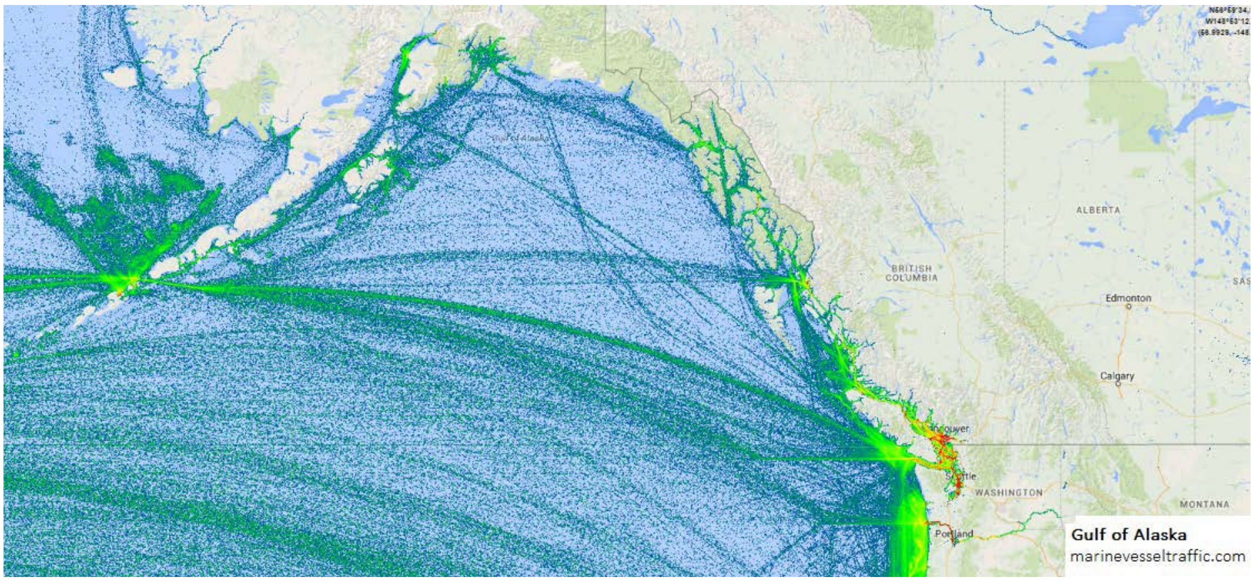

Figure 54. 2013 Shipping Traffic Density Map for the GOA (Available from, http://www.marinevesseltraffic.com).

The Southeast Alaska Vessel Traffic Study analyzed large vessel activity in Southeast Alaska from Icy Bay to Dixon Entrance (Nuka 2012). In 2012, 28 cruise ships were scheduled to make 450 voyages through Southeast Alaska. The study estimated the future maximum cruise ship voyage capacity for Southeast Alaska to be 850 voyages per season. Cruise ships comprise 19 percent of large vessel activity (e.g., cruise ships, passenger vessels with overnight accommodations, freighters/tankers, and barges with tugs) in Southeast Alaska and typically operate in the area about five months out of the year. Ferries, passenger vessels with overnight accommodations, and cruise ships comprise 67 percent of the vessel activity. Dry freight cargo barges, tank barges, and freight ships (log and ore carriers) comprise another 30 percent of the vessel activity (Nuka 2012). Typically, two barges provide fuel for Southeast Alaska each month, carrying diesel, heating oil, aviation gas, and gasoline from Washington (and occasionally Nikiski) to replenish shore side tank farms. An additional 'resident' barge takes fuel from Ketchikan and provides supplies for the smaller communities or industrial activities (Nuka 2012). Two freight barge companies provide approximately 180 service runs from Seattle to Southeast Alaska each year. Freight barges traveling to and from Western Alaska pass through the Inside Passage 150-190 times each year without stopping at a Southeast Alaska port (Nuka 2012).

7.6 Marine Mammal Strandings and Unusual Mortality Events

When a marine mammal swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). 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). Marine mammals are subjected to a variety of natural and anthropogenic factors acting alone or in combination that may cause animals to strand (Geraci et al. 1999; Geraci and Lounsbury 2005). Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, and aging (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. 2005), vessel strike (Geraci and Lounsbury 2005; Laist et al. 2001), fisheries interactions (Read et al. 2006), entanglement (e.g., Saez et al. 2013; 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. 1995c). 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 cetaceans 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. Due to the remoteness of beach cast animals, climatic conditions (wind storms) and sparse human population, observed stranded carcasses in Alaska represent a minimum estimate of regional mortality within the population (NMFS 2017b).

Humpback whales are the most common large cetacean species reported stranded in the Alaska Region (Figure 55). An average of 11.9 humpback whales were reported stranded in the Alaska region per year from 2000 through 2019 (Savage 2021). Approximately two-thirds of the humpback whale strandings reports from 2010 through 2016 were from carcasses observed in the GOA (NMFS 2017b). Vessel strike, entanglement in fishing gear, and killer whale predation were the leading causes of death for those whales were the cause could be identified (NMFS 2017b). In examining photos of dead humpback whales in the GOA between 2010 and 2014, 56 percent had indications of killer whale predation such as rake marks or bite wounds, missing mandible or tongue (NMFS 2017b). While fin whales are one of the most common cetacean species in the action area, fin whale strandings are not commonly observed. From 2000 through 2019, an average of 1.4 fin whales were reported stranded in the Alaska region per year (Savage 2021). Four fin whale strandings were reported in 2020 in Alaska, two of which were from the GOA, and one of which was attributed to vessel strike (Savage et al. 2021). Documented sperm whale strandings in the Alaska region are also rare, averaging about one report per year from 2000-2020 (Savage 2021). About eight percent of large whale strandings in the Alaska region are not identified to species. Unidentified whales likely reflect the state of postmortem decomposition, quality of submitted photographs, or the difficulty conducting field observations during inclement weather.

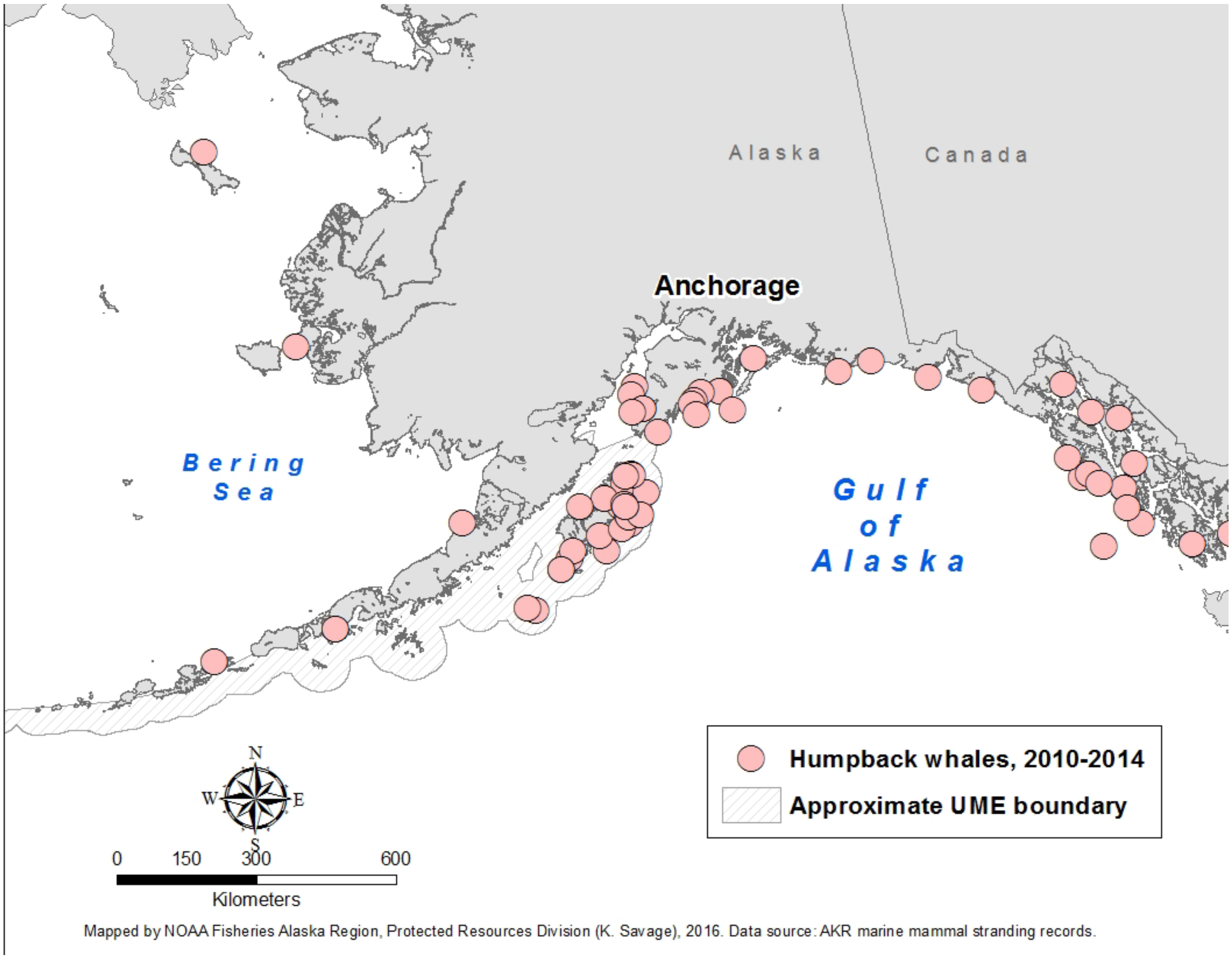

Figure 55. Location of dead Alaska humpback whale strandings from 2000 to 2014, and approximate boundary of the 2015 fin whale UME (NMFS 2017b).

In 2015, NOAA Fisheries declared an unusual mortality event (UME) for large whale strandings in the Western Gulf of Alaska. Under the Marine Mammal Protection Act, an UME is defined as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." Between May 22 and June 17, 2015, 12 finback whales were observed stranded around Kodiak Island and the western Gulf of Alaska (NMFS 2017b). The atypical nature of these strandings, i.e. high number of mortalities in a relatively short period of time and small space, was sufficient to characterize the cluster as an UME. Throughout the remainder of 2015, reports of all dead large whales observed within the general UME boundaries (Figure 56) were compiled (NMFS 2017b). By the end of 2015, in addition to the 12 fin whales,

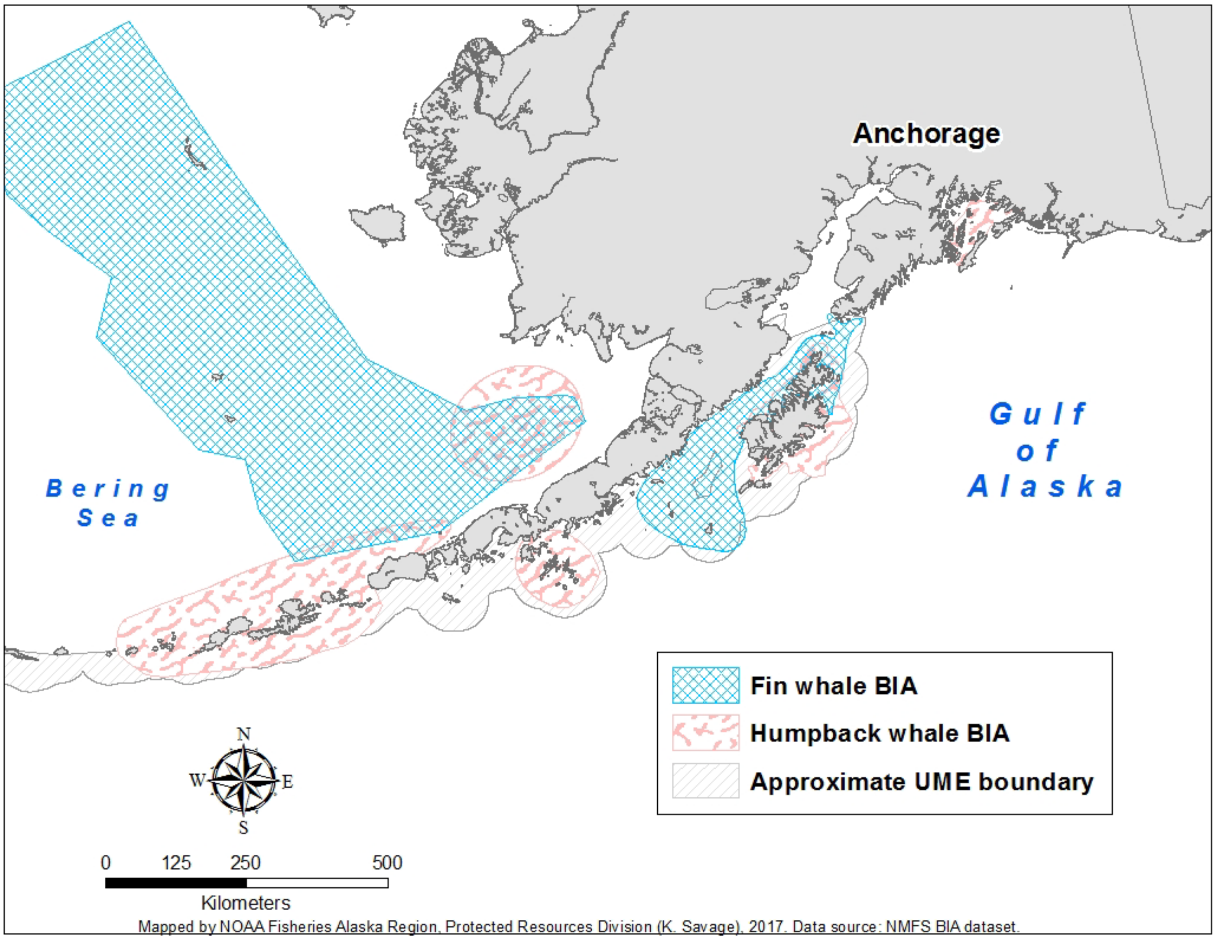

Figure 56. Biologically Important Areas (BIA) for fin whales and humpback whales in the Gulf of Alaska and the spatial boundary of the 2015 Unusual Mortality Event (UME) (NMFS 2017b).

Alaskan reports of 22 humpback whales, two gray whales and four unidentified whales had been received. An analysis of the likely cause of this UME did not reveal a definitive cause but did determine that sonar/seismic testing, radiation, and predation likely did not contribute to the UME. Because the strandings were concurrent with anomalous physical and biological shifts in the 2015 Alaskan marine environment, and accompanying mass mortalities of avian species and northern sea otters, the UME was likely one of many indicators of broader, complex and dynamic ecologic change and therefore these ecologic changes were most likely a contributory factor to the UME (NMFS 2017b).

7.7 Pollutants and Contaminants

Marine ecosystems receive pollutants from local, regional, and international sources, and their levels and sources are, therefore, difficult to identify and monitor (Grant and Ross 2002). Sources for marine pollutants include municipal, industrial, and household wastewater as well as atmospheric transport (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata 1993).

Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Garrett 2004; Grant and Ross 2002; Hartwell 2004).

Exposure to pollution and contaminants have the potential to cause adverse health effects in marine species. For threatened and endangered populations, these pollutant effects can be especially deleterious, as they could work in concert along with other stressors, leading to reduced fitness for an individual. Numerous factors can affect concentrations of persistent pollutants in marine mammals, such as age, sex and birth order, diet, and habitat use (Mongillo et al. 2012). Pollutant contaminant load increases with age, and females can pass on contaminants to offspring during pregnancy and lactation (Addison and Brodie 1987; Borrell et al. 1995). Pollutants can be transferred from mothers to juveniles at a time when their bodies are undergoing rapid development, putting juveniles at risk of immune and endocrine system dysfunction later in life (Krahn et al. 2009).

The accumulation of persistent organic pollutants (POPs), including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2016), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al. 2007). POPs may also facilitate infectious disease emergence and lead to the creation of susceptible "reservoirs" for new pathogens in contaminated marine mammal populations (Ross 2002). Because POPs are both ubiquitous and persistent in the environment, marine mammals, sea turtles, and other forms of marine life will continue to be exposed to POPs for all of their lives. The effects of POPs to ESA-listed species are unknown and not directly studied. Possible sub-lethal and long-term effects include impacts to reproduction, immune function, and endocrine activity.

NMFS conducted a section 7 consultation on the effects of activities associated with the Alaska Federal/State Preparedness Plan for Response to Oil & Hazardous Substance Discharge/Releases (NMFS 2015a). The Unified Plan Biological Opinion includes a detailed review of oil and other hazardous materials spills in Alaska marine waters from 1995-2012. Although the historical spill record does not give direct information about future spills, it does help identify high risk areas and shows that spills have occurred throughout the marine waters of Alaska, but primarily in coastal, nearshore areas (Figure 57). While oil and hazardous materials spills typically do not occur in offshore waters of the TMAA/WMA that define the action area, migratory marine species transiting in and out of the TMAA/WMA could still be impacted by the effects of nearshore spills.

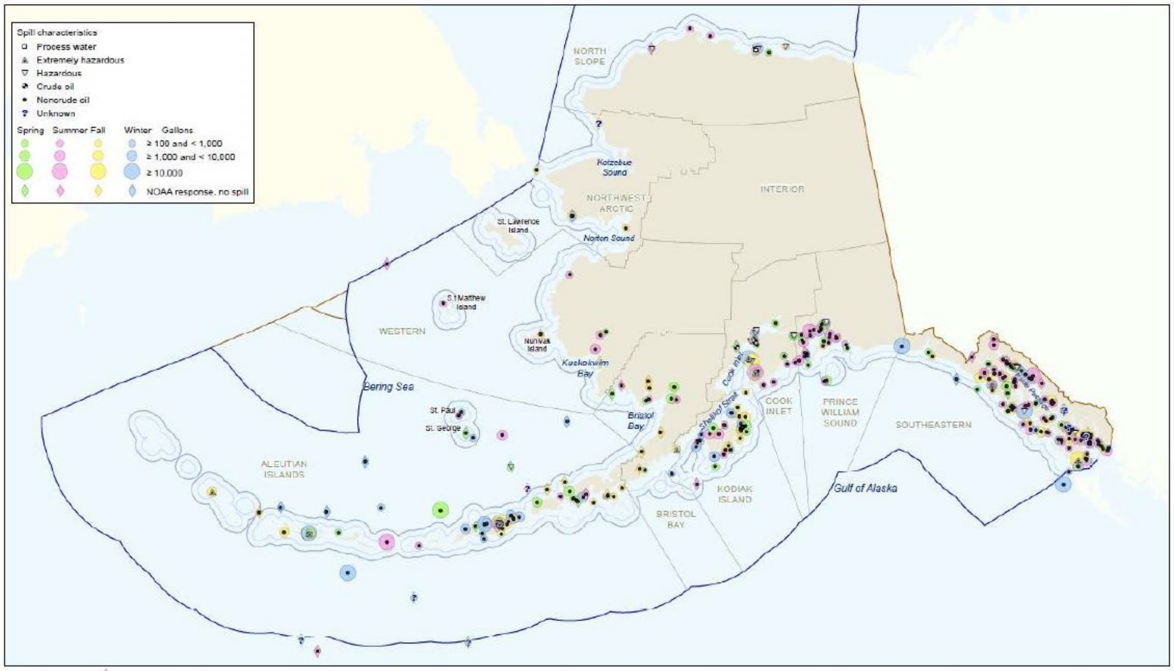

Figure 57. Hazardous materials spills reported in Alaska marine waters from 1995-2012 (NMFS 2015a).

The Clean Water Act of 1972 (CWA) has several sections or programs applicable to activities in offshore waters. Section 402 of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges into waters of the United States. In 2013, the EPA issued a NPDES vessel general permit which provides permit coverage nationwide for discharges (e.g., grey water, black water, coolant, bilge water, ballast, and deck wash) incidental to the normal operation of commercial vessels greater than 79 feet in length (EPA 2013).

7.8 Oil and Gas Development

Offshore oil and gas development in Alaska poses a number of threats to listed marine species, including increased ocean noise, risk of hydrocarbon spills, production of waste liquids, habitat alteration, increased vessel traffic, and risk of ship strike. Seismic surveys are conducted by towing long arrays of sensors affixed to wires at approximately 10 knots behind large vessels following a survey grid. High power air cannons are fired below the water surface, and the sound waves propagate through the water and miles into the seafloor. The noise generated from seismic surveys has been linked to behavioral disturbance of wildlife, masking of cetacean communication, and potential auditory injury in the marine environment. Seismic surveys are often accompanied by test drilling. Test drilling involves fewer direct impacts than seismic exploration, but the potential risks of test drilling, such as oil spills, may have broader consequences.

While the vast majority of oil and gas exploration and development in Alaska occurs in the Chukchi Sea Bering Sea Research Area, oil and gas development also occurs closer to the action area for this consultation within Cook Inlet in the Gulf of Alaska Research Area. As noted above, oil spills that occur in the nearshore waters of the Gulf of Alaska can impact migratory marine species that transit in and out of the TMAA/WMA. Robertson and Campbell (2020) compiled a dataset from several sources of oil spills larger than one barrel that could be associated with Cook Inlet oil and gas exploration, development, or production infrastructure or activities from 1966-2019. A total of 292 spills were included in the dataset. The largest number (189) and 79 percent of the volume (12,421 barrels [bbl]) of recorded spills were attributed to crude oil. Most spills (213) were between 1–10 bbl, totaling a volume of 765 bbl. Only 4 spills exceeded 1,000 bbl each, but these totaled 7,100 bbl by comparison. Seventy-five (75) spills were in the range of 10–1,000 bbl totaling 7,770 bbl. The oil fields with highest numbers of spills are the legacy fields that have been operating the longest: Trading Bay (65), Swanson River (47), and Middle Ground Shoal (37). Likewise, the infrastructure components with the largest number of spills have been operating in Cook Inlet for more than 50 years: Kenai Pipeline (23) and Cook Inlet Pipeline (13) (Robertson and Campbell 2020).

On March 24, 1989, the Exxon Valdez left Port Valdez, Alaska, and ran aground on Bligh Reef, about 43 kilometers to the southwest in Prince William Sound, AK. The vessel spilled at least 40.8 million liters (35,500 tonnes) of crude oil (Barron et al. 2020). Oil contaminated 738 kilometers of the shoreline in Prince William Sound and then exited into the Gulf of Alaska where it oiled another 2,100 kilometers of shoreline along the Alaska Peninsula through the Shelikof Strait including Cook Inlet and Kodiak Island (Figure 58). Acute toxic effects from oil ingestion, inhalation, smothering, drowning, and hypothermia included mortality of 250,000 seabirds, 2800 sea otters, 300 harbor seals, 250 bald eagles, up to 22 killer whales, and billions of salmon and herring eggs (Barron et al. 2020). In addition to acute toxicity, polycyclic aromatic hydrocarbons likely exerted embryotoxic effects in fish that included teratogenesis, chromosomal aberrations, and acute mortality through photoenhanced toxicity.

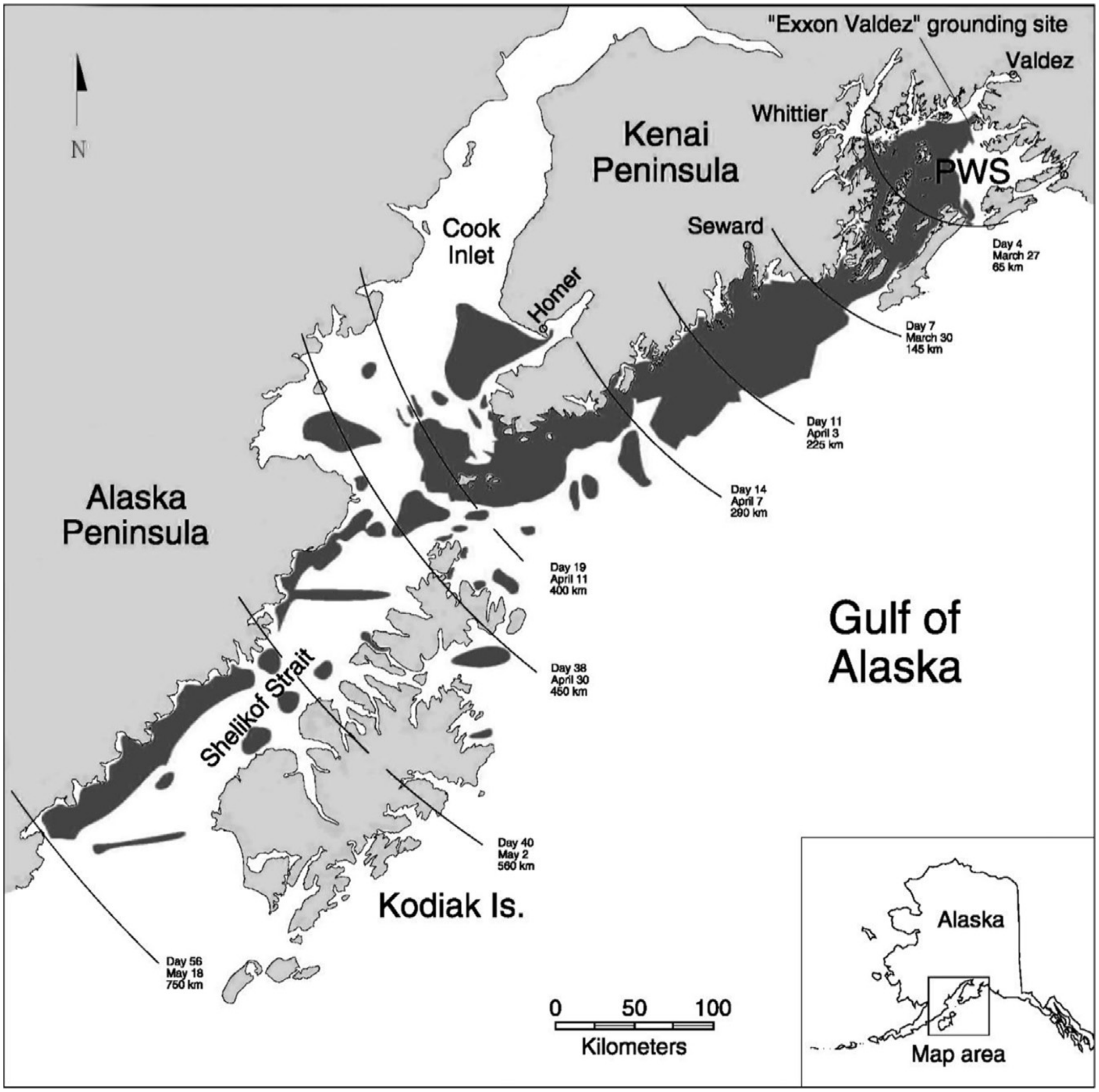

Figure 58. Map showing the spill affected region and timeline as Exxon Valdez oil progressed southwest out of Prince William Sound and into the northern Gulf of Alaska (Barron et al. 2020).

7.9 Marine Debris

Anthropogenic marine debris is prevalent throughout the action area, originating from a variety of oceanic and land-based sources. Debris can be introduced into the marine environment by its improper disposal, accidental loss, or natural disasters (Watters et al. 2010), and can include plastics, glass, derelict fishing gear, derelict vessels, or military expendable materials. Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it.

As noted above in the fisheries interactions section of the Environmental Baseline, entanglement or entrapment in derelict fishing gear can pose a threat to many of the species considered in this opinion. The vast majority of reported cases of entangled baleen whales in the U.S. are humpbacks, with most of these interactions likely involving actively fished, rather than derelict, gear (Program 2014). In Alaska, only 24 percent of documented entanglements were from unknown sources, possibly including marine debris, with the rest of the cases being from a known fishery and likely being actively fished (Jensen et al. 2009). As noted previously, it is likely that some animals interact with fishing gear outside of the action area, become entangled, and bring that gear with them when they migrate to the action area. For example, 10 humpbacks with entangled gear observed in Hawaii have also been sighted with entangled gear in Alaska, with one animal traveling over 2,450 nautical miles with gear attached (Lyman 2012).

Anthropogenic marine debris can also be accidentally consumed while foraging. For cetaceans, the rate of increase of ingestion of plastic debris appears to be a growing concern (Baulch and Perry 2014). This can have significant implications for an animal’s survival, potentially leading to starvation or malnutrition, or internal injuries from consumption. In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impaction was the cause of both deaths. Jacobsen et al. (2010) speculated that the debris likely accumulated over many years, possibly in the North Pacific gyre that would carry derelict Asian fishing gear into eastern Pacific waters.

7.10 Military Operations

The Department of Defense conducts joint training exercises with the Departments of Navy, Army, Air Force, and Coast Guard in the GOA TMAA between April and October. Ongoing military training activities in the action area are discussed here as part of the environmental baseline because they have been the subject of past consultations. The Navy categorizes training exercises into functional warfare areas called primary mission areas. Most training exercises conducted within the TMAA fall into one of the following eight primary mission areas: Anti-air warfare; Strike warfare; Anti-submarine warfare; Anti-surface warfare; Electronic warfare; and Naval special warfare. Details regarding each warfare area and activity levels can be found in Section 4 of this opinion (Description of the Proposed Action) and in the Gulf of Alaska Navy Training Activities Supplemental Final EIS/OEIS (Navy 2016).

In April 2017, NMFS completed a section 7 consultation on U.S. Navy GOA training activities occurring from 2017 through 2022 (Phase II). NMFS consulted with the Navy and with the NMFS Permits Division, pursuant to section 7 of the ESA, on the training activities and the issuance of the proposed rule and draft LOA under section 101(a)(5)(A) of the MMPA for GOA activities. NMFS concluded that these activities were not likely to jeopardize the continued existence of any endangered or threatened species and would not result in the destruction or adverse modification of critical habitat during the five-year period of the MMPA rule or continuing into the reasonably foreseeable future (NMFS 2017c). The effects analysis for the previous opinion determined that no marine mammals are likely to die or be wounded or injured as a result of their exposure to the Navy's GOA activities.

The following levels of marine mammal incidental take from acoustic stressors in the form of behavioral harassment and/or TTS by species were exempted from the prohibition of take under ESA section 9 for GOA Phase II training exercises on an annual basis: 47 blue whale; 1,291 fin whale; six sei whale; 98 sperm whale; seven humpback whale Mexico DPS; one humpback whale Western North Pacific DPS; three North Pacific right whale; and 286 Steller sea lion Western DPS (NMFS 2017c). As noted in the GOA Phase II opinion, the instances of harassment for marine mammals would generally represent 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 and, therefore, would represent disruptions of the normal behavioral patterns of the marine mammals that have been exposed. These disruptions are not expected to result in fitness consequences to the animals exposed (NMFS 2017c).

Incidental take resulting from explosives was also expected for GOA Phase II training exercises for the following ESA-listed salmonid ESUs/DPSs: coho salmon - lower Columbia River ESU and Oregon Coast ESU; chum salmon - Hood Canal ESU and Columbia River ESU; steelhead - Upper Columbia River DPS, Snake River basin DPS, Lower Columbia River DPS, Upper Willamette River DPS, Middle Columbia River DPS, and Puget Sound DPS. NMFS determined that no greater than 0.006 percent of any ESA-listed salmonid ESU or DPS would be injured or killed from Navy GOA activities, and most salmon ESUs and steelhead DPSs would be affected at much lower levels.

7.11 Scientific Research

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

Research on the ESA-listed species considered in this opinion may be granted an exemption to the ESA take prohibitions of section 9 through the issuance of section 10(a)(1)(A) permits.

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

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

In 2019, NMFS concluded ESA section 7 consultation on a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Cetaceans pursuant to Section 10(a) of the ESA and Section 104 of the MMPA (NMFS 2019a). For the large whales species considered in this opinion, the biological opinion for this programmatic consultation found that individual animals may experience stress, minor injury from active acoustic playbacks, biopsy sampling, or tagging, or behavioral alterations due to research and enhancement activities. However, effects to individual whales are expected to be short-term (generally hours or days), and injury from biopsy sampling is expected to heal within weeks. Tags are not expected to cause a hindrance to swimming because of the small size and mass of the tag compared to the size of the whales. Behavioral and physiological responses that may be exhibited by whales upon tagging are expected to return to baseline within minutes of tag attachment. None of the research and enhancement activities permitted by NMFS under this research programmatic consultation are expected to result in any fitness consequence for individual whales. As such, the biological opinion concluded that the proposed research activity types and levels are not anticipated to impede the recovery objectives and are not expected to cause a reduction in the likelihood of survival and recovery of any species of ESA-listed whale. The number of researchers and their proposed research and enhancement activities remain relatively consistent over time; and thus, the frequency of these research and enhancement activities are not expected to significantly change in the foreseeable future (NMFS 2019a), including as a result of the proposed action as discussed in other sections of this opinion.

In 2019, NMFS completed ESA section 7 consultation on fisheries and ecosystem research survey activities conducted by the Alaska Fisheries Science Center and the International Pacific Halibut Commission in the Gulf of Alaska, Bering Sea, and Chukchi Sea/Beaufort Sea. The anticipated annual lethal take level of ESA-listed salmon exempted for this research activity is shown in Table 44 (see 4th column). The anticipated level of lethal take from these research activities represents no more than 0.6 percent of the estimated abundance for any of the salmonid

ESUs consulted on in these opinions. The effects of the losses would be small, and because they would not be expected to disproportionately affect any one population within an ESU, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population) (NMFS 2019e). This research survey biological opinion concluded that the level of incidental and directed take of salmonids during research activities each year, particularly in terms of potential mortality, represents a very small reduction in abundance that is not likely to significantly impact any ESA-listed salmonids over time.

Table 44. Total anticipated annual lethal take level of ESA-listed salmon (by ESU) exempted in the NMFS Alaska Fishery Science Center (fourth column) research survey activity biological opinion (note: combined lethal take includes exempted take for these ESUs from NMFS Southwest and Northwest Fishery Science Center research survey opinions) (NMFS 2020a).

Species and Listing Unit	Life Stage	Baseline Lethal Take (SWFSC and NWFSC)	Annual Lethal Take Requested by AFSC	Combined Lethal Take
Puget Sound Chinook	Adult	46	10	56
Lower Columbia River Chinook	Adult	18	21	39
Upper Willamette River Chinook	Adult	15	14	29
Upper Columbia River Spring-run Chinook	Adult	9	3	12
Snake River Fall-run Chinook	Adult	14	12	26
Snake River Spring/summer-run Chinook	Adult	9	5	14
Hood Canal Summer-run Chum	Adult	9	77	86
Columbia River Chum	Adult	9	31	40
Lower Columbia River Coho	Adult	49	16	65
Snake River Sockeye	Adult	8	1	9
Ozette Lake Sockeye	Adult	8	1	9

Based on the 2019 Alaska Fishery Science Center fishery and ecosystem research biological opinion, NMFS expects that two sperm whales may be injured or killed by entanglement in research survey longline fishing gear, both of which could be taken in the GOA. NMFS also anticipates the following listed cetacean species considered in this opinion may be taken by acoustic noise produced by research survey gear in the GOA (estimated annual takes in GOA shown in parentheses): blue whale (1); fin whale (36); humpback whale Western North Pacific DPS (1); humpback whale Mexico DPS (13); North Pacific right whale (1); sei whale (1); and sperm whale (3).

7.12 The Impact of the Baseline on Listed Resources

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed species considered in this opinion. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, whaling, fisheries entanglement and bycatch), whereas others result in more indirect (e.g., a fishery that impacts prey availability, marine debris) or non-lethal (e.g., whale watching, anthropogenic sound, scientific research, climate change) impacts. Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult and, to our knowledge, no such analysis exists. This becomes even more difficult considering that most of the species in this opinion are wide-ranging and subject to stressors in locations well beyond the action area.

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

8 EFFECTS OF THE ACTION

"Effects of the action" refers to the direct and indirect effects of an action on the species or 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 still are reasonably certain to occur.

In Section 5, we identified the potential stressors created by the Navy's training activities. This section begins with a summary table of our effects determinations by stressor category for each ESA-listed species considered during this consultation (Table 45). This serves as a cross reference for the sections to follow that provide the analyses supporting these effects determinations. This table also lists the overall effects determination for each species. In Section 0, we provided a complete list of ESA-listed species and designated critical habitat that may be affected by the proposed action. Further, in Section 6.1 we explained that some ESA-listed species and designated critical habitat were not likely to be adversely affected by any of the stressors associated with the proposed action (i.e., overall determination labeled as "NLAA" in Table 45). This is because any effects on these species were extremely unlikely to occur such that they were discountable, or the size or severity of the impact was so low as to be insignificant, including those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. The ESA-listed species and designated critical habitat addressed in Section 6.1 are included in the summary table below because this table reflects all species and critical habitat considered in this opinion.

In this section, we focus on those species that are likely to be adversely affected by one or more stressors created by the proposed action. This section is organized by taxa (i.e., cetaceans and fish) because the species within each taxa often respond to stressors in similar ways.

In Section 8.1, we discuss the stressors associated with the proposed action that we determined are not likely to adversely affect all species from a particular taxa (i.e., stressors labeled as "NLAA" in Table 45). We do not carry these stressors forward in our effects analysis since there is no meaningful potential for these stressors to affect the survival or recovery of species within the particular taxa. Finally, in Section 8.2, we summarize the analysis for the stressor and taxa (i.e., cetaceans and fish) combinations that are likely to result in adverse effects to species within the taxa (labeled as "LAA" in Table 45).

Table 45. NMFS ESA effects determinations by stressor and overall effects determination for each ESA-listed species (LAA = likely to adversely affect; NLAA = not likely to adversely affect).

		Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		
ESA-Listed Species	Overall Determination	Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	Secondary Stressors
Marine Mammals															
Blue whale	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fin whale	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Gray whale – Western North Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback whale – Mexico DPS	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species		***Acoustic Stressors***				***Explosive Stressors***	***Energy Stressors***	***Physical Disturbance and Strike Stressors***			***Entanglement Stressors***		***Ingestion Stressors***		
	Overall Determination	***Sonar & Other Transducers***	***Vessel Noise***	***Aircraft Noise***	***Weapons Noise***	***Explosions***	***In-Air Electromagnetic Devices***	***Vessels & In-Water Devices***	***Military Expended Material***	***Seafloor Devices***	***Wires & Cables***	***Decelerators/Parachutes***	***Military Expended Materials - Munitions***	***Military Expended Materials – Other than Munitions***	***Secondary Stressors***
Humpback whale – Western North Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
North Pacific Right Whale	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei whale	LAA	LAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sperm whale	LAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steller sea lion – Western DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Marine Reptiles															

ESA-Listed Species	Overall Determination	Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	
Leatherback sea turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fishes															
Chinook salmon – California Coastal ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook salmon – Central Valley Spring-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook salmon – Lower Columbia River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	Overall Determination	Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	
Chinook salmon – Puget Sound ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook salmon – Sacramento River Winter-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook salmon – Snake River Fall-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook salmon – Snake River Spring/Summer Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	Overall Determination	Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	
Chinook salmon – Upper Columbia River Spring-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook salmon – Upper Willamette River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chum salmon – Columbia River ESU	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chum salmon – Hood Canal Summer-Run ESU	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Coho salmon – Central California Coast ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	Overall Determination	Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	
Coho salmon – Lower Columbia River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Coho salmon – Oregon Coast ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Coho salmon – Southern Oregon and Northern California Coasts ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green Sturgeon – Southern DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	Overall Determination	Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	
Sockeye salmon – Ozette Lake ESU	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sockeye salmon – Snake River ESU	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – California Central Valley DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Central California Coast DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Lower Columbia River DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	***Overall Determination***	***Acoustic Stressors***				***Explosive Stressors***	***Energy Stressors***	***Physical Disturbance and Strike Stressors***			***Entanglement Stressors***		***Ingestion Stressors***		***Secondary Stressors***
		Sonar & Other Transducers	***Vessel Noise***	***Aircraft Noise***	***Weapons Noise***	***Explosions***	***In-Air Electromagnetic Devices***	***Vessels & In-Water Devices***	***Military Expended Material***	***Seafloor Devices***	***Wires & Cables***	***Decelerators/Parachutes***	***Military Expended Materials - Munitions***	***Military Expended Materials – Other than Munitions***	
Steelhead – Middle Columbia River DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Northern California DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Puget Sound DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Snake River Basin DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – South-Central California Coast DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-Listed Species	Overall Determination	Acoustic Stressors				Explosive Stressors	Energy Stressors	Physical Disturbance and Strike Stressors			Entanglement Stressors		Ingestion Stressors		Secondary Stressors
		Sonar & Other Transducers	Vessel Noise	Aircraft Noise	Weapons Noise	Explosions	In-Air Electromagnetic Devices	Vessels & In-Water Devices	Military Expended Material	Seafloor Devices	Wires & Cables	Decelerators/Parachutes	Military Expended Materials - Munitions	Military Expended Materials – Other than Munitions	
Steelhead – Southern California DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Upper Columbia River DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead – Upper Willamette River DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

8.1 Stressors Not Likely to Adversely Affect ESA-listed Species

The following sections discuss stressors we determined may affect, but are not likely to adversely affect ESA-listed cetaceans (Section 8.1.1) and fish (8.1.2) considered in this opinion because the effect of the stressors would be insignificant or discountable. For analysis of the effects to ESA-listed species, note that the discussion in this section is organized by taxa (i.e., cetaceans and fishes) because the pathways for effects for these stressors is generally the same by taxa and, in most cases, we would not expect different effects at the species level. While there is variation among species within each taxa, the species within each taxa share many similar life history patterns and other factors (e.g., morphology) which make them similarly vulnerable (or not) to the stressors caused by the proposed action.

8.1.1 Cetaceans

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 whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale. Our analyses for these stressors and cetaceans are summarized below.

8.1.1.1 Acoustic Stressors – Cetaceans

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. We determined that these acoustic stressors are not likely to adversely affect ESA-listed cetaceans. Additional discussion of the acoustic stressors associated with the proposed action is included in Section 5.1 above. The effects of additional acoustic stressors, which we determined are likely to adversely affect blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale are discussed in Section 8.2.1.1.

8.1.1.1.1 Effects of Vessel Noise on Cetaceans

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

Cetaceans could be exposed to a range of vessel noises within their hearing range. The Navy vessels 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, responses of cetaceans in the action area to vessel noise disturbance would include startle responses, avoidance, or other behavioral reactions, physiological stress responses, or no measurable response.

In the case of the proposed action, blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale are either not likely to respond to Navy vessel noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering.

Additionally, the effects of any temporary masking specifically from Navy vessels are expected to be of a short duration and not result in meaningful changes to an animal's ability to communicate or detect biologically relevant cues given 1) the intermittent and sporadic nature of Navy vessel activity, 2) the fact that the sound (i.e. vessel) and the receiver (whale) are both moving continuously and likely in different directions, 3) the background noise levels in the action area independent of Navy vessels, and 4) the small percentage of vessel traffic Navy vessels represent in the action area (as discussed in Section 5.1.3 above). Therefore, the effects of vessel noise on blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale from Navy vessels are considered insignificant. Thus, we conclude that the effects of vessel noise resulting from the proposed action may affect, but are not likely to adversely affect these species.

8.1.1.1.2 Effects of Aircraft Noise on Cetaceans

Additional information on aircraft as a potential stressor associated with the proposed action can be found in Section 5.1.4.

In most instances, exposure of a marine mammal to fixed-wing aircraft, helicopters, and unmanned aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead during training activities as part of the proposed action. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields, as well as on vessels at sea in 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 also startle marine mammals, but these events are transient and happen infrequently at any given location within the action area. Additionally, aircraft would pass quickly overhead, typically at altitudes above 3,000 feet, which would make cetaceans unlikely to hear the sound unless at the surface resting and therefore not likely to respond.

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

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

8.1.1.1.3 Effects of Noise from Weapons Firing, Launch, and Impact on Cetaceans

Activities using weapons would be conducted as described in Section 3 of this opinion. Additional discussion on weapons noise as a potential stressor is included in Section 5.1.5. The use of weapons during training could occur almost anywhere within the action area. Noise associated with large caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would typically occur at locations greater than 12 nautical miles from shore for safety reasons. Small- and medium-caliber weapons firing could occur throughout the action area.

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

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

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

8.1.1.1.4 Effects of Nitrogen Decompression and Acoustically-induced Bubble Formation due to Sonar Exposures

In this section we discuss two potential effects resulting from exposure to Navy sonar in the action area that we determined are not likely to adversely affect ESA-listed cetaceans. These are nitrogen decompression and bubble formation that may occur in blood and other tissue of an animal exposed to this stressor. In Section 8.2, we discuss all other effects resulting from Navy sonar exposure that are likely to adversely affect ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale in the action area.

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. 2009). 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 such as extended dive durations at greater depths (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). Costidis and Rommel (2016) suggest that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes (e.g., sperm whales) 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. 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. 2009). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation may be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al. 2009).

A fat embolic syndrome (out of place fat particles, typically in the bloodstream) was identified by 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 bloodstream.

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 cetaceans, nor has it been observed in 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 likelihood of ESA-listed cetaceans getting “the bends” following sonar acoustic exposure is extremely low. Therefore, the likelihood of effects from nitrogen decompression in ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale from Navy sonar as a result of the proposed action is extremely unlikely and thus discountable.

Acoustically-induced Bubble Formation Due to Sonars

A suggested cause of injury to cetaceans 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 of exposure. 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 cetaceans can cause the blood and some tissues to become supersaturated (Ridgway and Howard 1979). The dive patterns of some cetaceans (e.g., non-ESA listed beaked whales) are predicted to induce greater supersaturation (Houser et al. 2001). If rectified diffusion were possible in cetaceans 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, suggested by Crum et al. (2005), 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 cetacean 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 likely 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 cetaceans (Fahlman et al. 2009; Fahlman et al. 2014b; Houser et al. 2001; Saunders et al. 2008). In addition, such high exposure levels would only occur in very close proximity to the most powerful Navy sonars. For these reasons, we believe that ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale injury resulting from acoustically induced bubble formation during Navy GOA activities to be extremely unlikely, and therefore discountable. Thus, we conclude that acoustically induced bubble formation that may result from Navy activities considered in this opinion may affect, but are unlikely to adversely affect these species.

8.1.1.1.5 Effects of Other Acoustic Sources Not Quantitatively Analyzed

Several of the acoustic sources associated with the Navy's proposed action were not quantitatively analyzed in terms of their effects on ESA- blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale. These include the following: broadband sound sources; Doppler sonar; fathometers; hand-held sonar; imaging sonar; high-frequency acoustic modems; tracking pingers; acoustic releases; and side-scan sonars (see Section 1 above for details). When used during routine training activities, and in a typical environment, these 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 ESA-listed species 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 re 1 μPa within ten meters and less than 120 dB re 1 μPa within 100 meters of the source. Ranges would be even shorter for a source less than 160 dB re 1 μPa source level. As discussed above (Section 2.2.2), we assume that marine mammals would not exhibit a behavioral response when exposed to such low source levels.
- 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 exclude the possibility of any significant impact on an ESA-listed species (actual source parameters are classified). Even if there is a possibility that some species may be exposed to and detect some of these sources, any response is expected to be short term and insignificant.

Therefore, the acoustic sources described above associated with Navy GOA activities would result in insignificant effects, if any, depending on the particular source considered on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale and thus may affect, but are unlikely to adversely affect these species.

8.1.1.2 Physical Disturbance and Strike Stressors – Cetaceans

This section summarizes the analyses of the potential effects of physical disturbance and strike of ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale during GOA TMAA/WMA activities resulting from in-water devices, military expended materials (including non-explosive practice munitions and fragments from high-explosive munitions), and seafloor devices. The effects of vessel strike on cetaceans are analyzed in Section 8.1.1.3 below.

8.1.1.2.1 Effects of In-water Devices on Cetaceans

In-water devices include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles and unmanned undersea vehicles and towed devices that are used throughout the action area and are discussed in Section 5.2.2. 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 cetaceans throughout the action area. Mitigation includes the use of Lookouts and watch personnel that have been trained to identify marine mammals and requiring underway vessels and in-water devices that are towed from manned surface platforms to maintain a specified safe distance from marine mammals (See Section 4.6.1). 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 cetacean 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 to the animal. Therefore, potential effects on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale from in-water devices are discountable (in the case of strike) or insignificant (in the case of behavioral response). Thus, we conclude that physical disturbance caused by in-water devices associated with the proposed action may affect, but is unlikely to adversely affect these species.

8.1.1.2.2 Effects of Military Expended Materials on Cetaceans

While no strike of marine mammals from military expended materials has ever been reported or recorded, the possibility of a strike still exists. We considered the potential for ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale strike resulting from GOA TMAA/WMA activities involving the following types of military expended materials: 1) all sizes of non-explosive practice munitions, 2) fragments from high-explosive munitions, 3) expendable targets and target fragments; and 4) expended materials other than munitions, such as sonobuoys, expended bathythermographs, and torpedo accessories.

Given the large geographic area involved and the relatively low densities of ESA-listed cetaceans in the action area, we do not believe such interactions are likely. Additionally, while disturbance or strike from any expended material as it falls through the water column is possible, it is extremely unlikely because the objects will slow in velocity as they sink toward the bottom (e.g., guidance wires sink at an estimated rate of 0.2 meters per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile cetacean species.

The Navy will implement procedural mitigation to avoid or reduce potential impacts on marine mammals from explosive gunnery activities (Section 4.6.1.4). The mitigation applies only to activities using surface targets. The potential risk to marine mammals and sea turtles during events using airborne targets is limited to the animal being directly struck by falling MEM. There is no potential for direct impact from the explosives because the detonations occur in air. Based on the extremely low potential for projectile fragments to co-occur in space and time with a marine mammal at or near the surface of the water, the potential for a direct strike is negligible. In addition, the Navy has proposed procedural mitigation for vessel movement and towed-in water devices to limit the potential for strikes of marine mammals where military expended materials are used in offshore environments (see Section 4.6.1 for details).

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

8.1.1.2.3 Effects of Seafloor Devices on Cetaceans

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 blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale. Given their mobility and the low densities in areas where seafloor devices would likely be used, it is extremely unlikely that ESA-listed marine mammals would 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 on the ocean bottom 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 is expected to be minimal and temporary. Therefore, behavioral avoidance of seafloor devices by ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale is insignificant. Thus, we conclude that physical disturbance caused by sea-floor devices associated with the proposed action may affect, but is unlikely to adversely affect these species.

8.1.1.3 Vessel Strike – Cetaceans

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. 2010; 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).

Large Navy vessels (greater than 18 meters in length) within the GOA 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, and submarines generally operate at speeds in the range of 8 and 13 knots, while a few specialized vessels can travel at faster speeds. By comparison, this is slower than most commercial vessels where normal design 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 generally reduces the design speed by only a few knots, given that 21 knots would be considered slow, 18 knots is considered “extra slow,” and 15 knots is considered “super slow” (Bonney and Leach 2010). Small Navy craft (less than 50 feet in length), have much more variable speeds (0–50 knots or more, depending on the mission). While these speeds are considered averages and representative of most events, some Navy vessels need to operate outside of these parameters during certain situations. Differences between most Navy ships and commercial ships also include the following disparities:

- The Navy has several standard operating procedures for vessel safety that could result in a secondary benefit to marine mammals through a reduction in the potential for vessel strike, as described in Section 4.5.1 Vessel Safety.
- Many Navy ships have their bridges positioned closer to the bow, offering good visibility ahead of the ship.
- There are often aircraft associated with the training activity, which can detect marine mammals in the vicinity or ahead of a vessel’s present course.
- Navy ships are generally much more maneuverable than commercial merchant vessels if marine mammals are spotted and it becomes necessary to change direction.
- Navy ships operate at the slowest speed possible consistent with either transit needs, or training need. While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include being better able to spot and avoid objects in the water, including marine mammals.
- In many cases, Navy ships will likely move randomly or with a specific pattern within a sub-area of the action area for a period of time, from one day to two weeks, as compared to straight line point-to-point commercial shipping.
- Navy overall crew size is much larger than merchant ships, allowing for more potential observers on the bridge.
- 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.
- The Navy will implement mitigation to avoid potential impacts from vessel strikes on marine mammals. Mitigation includes training Lookouts and watch personnel with the Marine Species Awareness Training (which provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures) (see Section

4.6.1.1), and requiring vessels to maneuver to maintain a specified distance from marine mammals during vessel movements (see Section 4.6.1.6).

Navy vessel/whale strike records have been kept since 1995, and there have been no Navy vessel strikes to any marine mammals in the action area as of the writing of this consultation. The projected Navy vessel use has not significantly changed over time and is not projected to significantly change under the current proposed action. For the GOA Phase III proposed action, the estimated Navy vessel activity would be up to 126 vessel days per year (i.e., up to six surface combatant vessels for an exercise lasting up to 21 days), or 3,024 steaming hours per year. The expansion of the GOA action area for Phase III to include the WMA provides for a larger geographical area that the Navy can operate vessels, but does not affect the number of activities, vessels or steaming hours, or the manner in which the Navy operates vessels (speeds, lookouts, standard operating procedures, etc.).

While it is possible for a vessel to strike a marine mammal during the course of training activities in the GOA action area, we do not believe that a vessel strike of a cetacean is reasonably likely to occur. As stated previously, the Navy has been training in the action area for years and no such incident has occurred. Additionally, the Navy vessels participating in training exercises employ minimization measures to reduce the likelihood for a surface vessel to strike a large whale (i.e., lookouts, minimum approach distances as discussed in section 4.6.1 of this opinion). Consequently, NMFS has determined that the likelihood of vessel strike during training over the seven-year period of the MMPA rule and continuing into the reasonably foreseeable future is extremely unlikely and thus discountable. Because discountable vessel strike resulting from the proposed action may affect, but is not likely to adversely affect ESA-listed blue whales, fin whales, Mexico DPS humpback whales, North Pacific right whales, Western North Pacific gray whales, sei whales, or sperm whales and vessel strike.

8.1.1.4 Entanglement Stressors – Cetaceans

Expended materials from Navy activities that may pose an entanglement risk include wires, cables, decelerators, and parachutes. Interactions with these materials could occur at the sea surface, in the water column, or on the seafloor. Additional discussion of entanglement stressors, in general, is included in Section 5.3.

8.1.1.4.1 Effects of Entanglement from Wires and Cables on Cetaceans

There has never been a reported or recorded instance of a marine mammal entangled in military expended materials despite the Navy expending materials in the action area (and other range complexes) for decades. NOAA (2014a) conducted a review of entanglement of marine species in marine debris with an emphasis on species in the U.S. The review did not document any known instances where military expended materials 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) 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 activities using military expended materials in the western Atlantic (Navy 2018a). Knowlton et al. (2012) reported that of the 626 individuals whales observed the vast majority showed evidence of entanglement involving non-mobile pot gear and nets used for fishing. Baulch and Perry (2014) reported that nearly 98 percent of documented cetacean entanglements worldwide were from abandoned, lost, or derelict fishing gear.

If encountered, it is extremely unlikely that a cetacean would get entangled in a fiber optic cable, sonobuoy wires, or guide wire during the short period of time these expended materials are in the water column as they sink and settle 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 resist coiling or the forming of loops), the likelihood of cetacean entanglement from cables and wires is extremely low. Fiber optic cable is brittle and would be expected to break if kinked, twisted or sharply bent. Thus, the physical properties of the fiber optic cable would not allow the cable to loop, greatly reducing the likelihood of entanglement.

For the reasons cited above, it is extremely unlikely that ESA-listed marine mammals will become entangled in military expended wires and cables in the action area. The effects from entanglement of ESA-listed blue whales, fin whales, Mexico DPS humpback whales, North Pacific right whales, Western North Pacific gray whales, sei whales, or sperm whales in wires and cables are, therefore, discountable. Thus, we conclude that entanglement in wires and cables due to the proposed action may affect, but is unlikely to adversely affect these species.

8.1.1.4.2 Effects of Entanglement from Decelerators and Parachutes on Cetaceans

The majority of the decelerators and parachutes used for GOA TMAA/WMA activities are in the small size category (see 5.3.2 above) and are associated with sonobuoys. Both small- and medium-sized decelerators and parachutes are made of cloth and nylon and have weights attached to their short attachment lines (i.e., from 0.3 to 5.8 meters). The majority of parachutes/decelerators would not remain suspended in the water column for more than a few minutes as the attached weights speed the sinking of materials to the seafloor. Small and medium decelerators/parachutes with weights are expected to remain at the surface for five to 15 seconds before the housing sinks to the seafloor where it becomes flattened (Navy 2021).

Some large or extra-large decelerators/parachutes are also proposed for use in the action area. In contrast to small and medium parachutes, large parachutes do not have weights attached and may remain at the surface or are suspended in the water column for some time prior to eventual settlement onto the seafloor. However, a limited number of these items are proposed for use (i.e., ten large parachutes annually) in the GOA action area. The small number of large or extra-large parachutes proposed for use annually, and generally low species densities, reduces the potential for ESA-listed marine mammals to encounter and become entangled in these items. In addition, 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 would further reduce the potential entanglement of cetaceans in decelerators/parachutes.

As noted above, the vast majority of large whale entanglements have been associated with 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 and parachutes. There are a number of key differences between decelerators/parachutes and fishing gear that result in the likelihood of entanglement in these materials being significantly lower than the likelihood of entanglement in fishing gear. First, as noted above, except for a small number of large decelerators/parachutes, most decelerators/parachutes used by the Navy sink quickly to the seafloor and do not remain suspended in the water column for extended periods of time. This is in contrast to fishing gear which can remain in the water column for days or weeks at a time. Additionally, parachutes would be highly visible in the water column, likely alerting a nearby animal to the presence of the obstacle. By contrast, fishing gear may consist of some buoys and traps that are visible, but often contains hundreds of feet of rope or line in between these items that is often not visible by design. Finally, the cords associated with parachutes are, at most, 80 feet long. In contrast, typical gear associated with some fisheries has hundreds of feet of rope suspended in the water column.

There is the potential for a bottom-feeding cetacean (e.g., sperm whale) to become entangled when they are foraging in areas where parachutes have settled onto the seafloor. For example, if bottom currents are present, the canopy may temporarily billow and pose a greater entanglement threat. However, the likelihood of bottom currents causing a billowing of a parachute and being encountered by an ESA-listed cetacean is considered extremely unlikely.

In summary, based on their deep-water location of use, their sinking rate, their degradation rate, and the low density of ESA-listed marine mammals, it is extremely unlikely that these species would become entangled in small or medium decelerators or parachutes. Based on the limited number deployed, the standard operating procedure to recover decelerators/parachutes to the maximum extent practicable, and the low density of ESA-listed marine mammals, and it is extremely unlikely that these species would become entangled in large or extra-large decelerators or parachutes. Therefore, potential effects on ESA-listed blue whales, fin whales, Mexico DPS humpback whales, North Pacific right whales, Western North Pacific gray whales, sei whales, or sperm whales from entanglement in decelerators or parachutes are discountable. Thus, we conclude that entanglement in decelerators and parachutes due to the proposed action may affect, but is unlikely to adversely affect these species.

8.1.1.5 Ingestion Stressors – Cetaceans

Additional discussion on ingestion stressors is included in Section 5.4. The munitions and other materials small enough to be ingested by ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale are small- and medium-caliber projectiles, broken pieces of firing targets, chaff, flare caps, and shrapnel fragments from explosive ordnance. Other military expended materials (e.g., non-explosive bombs or surface targets) are considered too large for ESA-listed cetaceans to consume and are made of metal a cetacean would not be able to break-apart to ingest.

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

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

Some Styrofoam, plastic endcaps, and other small military expended materials (e.g., chaff, flare pads, pistons) may float for some time before sinking. However, these items are likely too small to pose a risk of intestinal blockage to any cetacean that happened to encounter it. Chaff is composed of fine fibers of silicon dioxide coated with aluminum alloy. Due to its light weight and small size this floating material can be carried great distances in both air and water currents. Their dispersal in wind and water results in chaff fibers likely occurring in low densities on the ocean surface. Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military training (Arfsten et al. 2002; Force 1997; Hullar et al. 1999). Similar to chaff, flare pads and pistons are also relatively small and float in sea water. Given the small size, low densities, and low toxicity of chaff or flare expended materials, any accidental ingestion by ESA-listed marine mammals feeding at the ocean surface is not expected to result in an injury or an increased likelihood of injury from significant disruption of normal behavioral patterns such as breeding, feeding, or sheltering. Chaff cartridge plastic end caps and pistons and flare pads would also be released into the marine environment during Navy activities, where they may persist for long periods, and therefore could be ingested by marine mammals while initially floating on the surface and sinking through the water column. However, these materials would eventually sink to the seafloor where they would be less likely to be ingested by 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, because we expect smaller military expended materials would likely pass through marine mammals with no adverse effects, the effects of this stressor (i.e., ingestion of small expended materials) are insignificant. Since ingestion of military expended material of sufficient size to result in adverse effects on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale is extremely unlikely, the effects of this stressor (i.e., ingestion of large expended materials) are discountable. While baleen whales could accidentally ingest chaff or flare remains, if this occurs the effects of these stressors on those individuals exposed are expected to be so minor as to be insignificant. Therefore, we conclude the ingestion of expended materials from activities associated with the proposed action may affect, but is not likely to adversely affect blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale.

8.1.1.6 Stressors Resulting in Effects to Cetacean Habitat or Prey

This section analyzes potential impacts to ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale exposed to stressors through impacts to their habitat or prey. The stressors evaluated in this section include: 1) explosives, 2) explosive byproducts and unexploded munitions, 3) metals, and 4) chemicals.

8.1.1.6.1 Explosives

In this section, we discuss the anticipated effects of explosives within the TMAA on the prey of blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale. Explosives would not be used within the Continental Shelf and Slope Mitigation Area (Section 4.6.2) or the WMA.

In-air explosions may impact other species in the food web, including prey species that marine mammals feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. In addition, physical effects of an underwater blast would be far greater than in-air blasts; however, prey that are near the waters surface might have behavioral reactions to the sound that does penetrate the air-water interface. 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 GOA TMAA explosives on blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale through impacts to their prey are insignificant. Therefore, we conclude that impacts to prey species from the use of explosives associated with the proposed action may affect, but are not likely to adversely affect blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale.

8.1.1.6.2 Explosive Byproducts and Unexploded Munitions

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

The concentration of munitions, explosives, expended material, or devices in any one location in the action area are expected to be a small fraction of that from the sites described above in

Section 5.1.2. As a result, explosion by-products and unexploded munitions are not anticipated to have adverse effects (i.e., no measureable effects are anticipated) on water quality or marine mammal prey abundance in the action area. For this reason, the effects of explosive byproducts and unexploded munitions on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale through impacts on prey and water quality are considered insignificant. Therefore, we conclude that impacts to prey and water quality from explosive byproducts and unexploded munitions associated with the proposed action may affect, but are not likely to adversely affect these species.

8.1.1.6.3 Metals

Metals are introduced into seawater and sediments as a result of training 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 et al. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013b) indicate metal contamination is highly localized and that bioaccumulation resulting from munitions cannot be demonstrated. Specifically, in sampled marine life living on or around munitions on the seafloor, metal concentrations could not be definitively linked to the munitions because comparison of metals in sediment next to munitions show relatively little difference in comparison to other baseline marine sediments used as a control (Koide et al. 2016). Research has demonstrated that some smaller marine organisms are attracted to metal munitions as a hard substrate for colonization or as shelter (Kelley et al. 2016; Smith and Marx Jr. 2016), but this would not have an effect on the availability of marine mammal prey. The research cited above indicates that metals introduced into the action area are unlikely to have measureable impacts on ESA-listed marine mammal prey or habitat. Thus, the effects of metals introduced into seawater and sediments as a result of GOA TMAA/WMA activities on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale through impacts to their prey or habitat are insignificant and thus may affect, but are not likely to adversely affect these species.

8.1.1.6.4 Chemicals

Several Navy training activities introduce chemicals into the marine environment that are potentially harmful in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed marine mammals or their prey. Chemicals introduced are principally from flares and propellants for missiles and torpedoes. Properly functioning flares, 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). Given the dynamic nature of the environment (currents, tides, etc.), long-term impacts from perchlorate in the environment near the expended item are not expected. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on ESA-listed marine mammal prey or habitat.

In summary, we find it extremely unlikely that ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale would be exposed to toxic levels of explosives, explosive byproducts, metals, or chemicals resulting from the proposed action. This is based on the information provided above regarding the potential for explosives and byproducts, metals, and chemicals to indirectly affect these species through habitat and prey availability impacts. Therefore, the effects of secondary stressors from Navy GOA activities on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale are considered discountable. Thus, we conclude that habitat and prey availability impacts due to exposure to explosives, explosive byproducts, metals, or other chemicals resulting from the proposed action may affect, but are not likely to adversely affect these species.

8.1.2 Fishes

We determined that several of the acoustic stressors and all of the energy stressors, entanglement stressors, ingestion stressors, and potential secondary stressors are not likely to adversely affect the ESA-listed fish species considered in the opinion (see Table 32). 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 consultation 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.

8.1.2.1 Acoustic Stressors – Fishes

The discussion below focuses on a subset of the acoustic stressors associated with the proposed action. We determined that these acoustic stressors are not likely to adversely affect ESA-listed fishes. The effects of explosives, which we determined was likely to adversely affect ESA-listed fishes, is discussed in Section 8.2.2 below.

8.1.2.1.1 Effects of Vessel Noise on ESA-listed Fishes

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. Training events involving vessel movements occur intermittently and range in duration from a few hours up to a few weeks. Navy vessel traffic could occur anywhere within the action area. See Section 5.1.3 for a general discussion of vessel noise as a potential stressor associated with the proposed action.

Individuals from all ESA-listed fishes may be exposed to sound from vessel movement during Navy training 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. For example, 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. 2004). Smith et al. (2004) 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. 2004). 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. (2015) demonstrated physiological effects of increased noise (playback of boat noise) on coastal giant kelpfish. The fish exhibited 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, they are less likely to be 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). As a result, 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. 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. The only impacts expected from exposure to Navy vessel noise for fishes would be temporary and short-term, and may include auditory masking, physiological stress, or minor changes in behavior.

Therefore, exposure to vessel noise for fishes could result in short-term behavioral or physiological responses (e.g., avoidance and 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, long-term masking of biologically relevant cues, or significantly disrupt normal behavioral patterns. For these reasons, exposure to vessel noise is not expected to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Therefore, the likely effects of vessel noise on ESA-listed fish in the action area are considered insignificant, and thus not likely to cause adverse effects.

8.1.2.1.2 Effects of Aircraft Noise on ESA-listed Fishes

See Section 5.1.4 for a general discussion of aircraft noise as a potential stressor associated with the proposed action.

Individuals from all ESA-listed fishes may be exposed to aircraft-generated overflight noise throughout the action area. Should sound transmit from aircraft travel into the water column, it would likely only penetrate shallow depths 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. 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. Steelhead are more likely to occupy the upper portion of the water column compared to other salmonids considered in this opinion.

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 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 behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. As such the effects from aircraft overflight noise on ESA-listed fish in the action area are considered insignificant and thus may affect, but are not likely to adversely affect these species.

8.1.2.1.3 Effects of Weapons Noise on ESA-listed Fishes

See Section 5.1.5 for a general discussion of weapons noise as a potential stressor associated with the proposed action.

ESA-listed fishes at the surface of the water could be exposed to weapons noise, in a narrow footprint under a weapons trajectory. In general, these are impulsive sounds generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. 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 a startle response or avoidance and could expose fishes to multiple shots within a few seconds. The firing of a weapon may have several components of associated noise including sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sounds would be reflected at the air-water interface. Underwater sounds would be strongest just below the surface and directly under the firing point. 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. For weapons noise that have sound characteristics that could cause adverse effects, because these activities are brief in duration and widely dispersed throughout the action area, accumulation of levels high enough to cause these effects is extremely unlikely. As with the other acoustic 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. Any effects on ESA-listed fishes in the action area from weapons noise are anticipated to be minor, temporary, intermittent, and are not expected to lead to a significant disruption of normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. As such, the effects from weapons noise on ESA-listed fish in the action area are considered insignificant, and thus may affect, but are not likely to adversely affect these species.

8.1.2.1.4 Effects of Sonar and Transducers on ESA-Listed Fishes

General categories and characteristics of Navy sonar systems proposed for use during activities considered in this biological opinion are described in Sections 4.2 and 5.1.1.

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. 2012; Kane et al. 2010; Popper et al. 2014a; Popper et al. 2007b; Popper et al. 2013). Some short-term hearing impairment could occur, as well as brief 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 and all hear primarily below 2 kHz. 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) was determined to be the best approach for our analyses. Of the ESA-listed fish species considered in this opinion that possess a swim bladder, none have a swim bladder that is associated with hearing. Thus, the sound criteria used for our analysis of the acoustic effects on fishes are based upon fishes with swim bladders not involved in hearing.

Exposure to Surveillance Towed Array Sensor System (SURTASS) low-frequency active sonar has been tested at maximum received levels of 193 dB re 1 µPa (218 dB SEL_{cum}) and has not been shown to cause mortality or any injury in fish with swim bladders (Kane et al. 2010; Popper et al. 2007b). 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. Although this laboratory study exposed the fish to low-frequency active sonar pulses for time intervals that would be substantially longer than what would occur in the wild (e.g., unconfined fishes), the exposed fish did not experience mortality 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 a temporary hearing loss of 10 to 20 dB immediately after exposure to high intensity 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, although 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, one study on juvenile herring survival found that 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 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, the ESA-listed fishes evaluated in this opinion are not considered as sensitive to sound exposures and associated hearing damage as herring.

In another mid-frequency active sonar experiment, Halvorsen et al. (2012) 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; 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 one to five 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 two 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) 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 (1990) 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. 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 gourami 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. 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. 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. The recommended criteria and thresholds in the 2014 ANSI Technical Report are used to predict potential impact to fishes from sonar and transducers. These criteria are discussed above in Section 2.3 Criteria and Thresholds to Predict Impacts to Fishes.

Because of the sheer number and diversity of fishes, only a limited number of species have had hearing capabilities tested. Figure 59 below, provides a summary of hearing threshold data from available literature to demonstrate the potential overall range of frequency detection for each hearing group. 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 59 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).

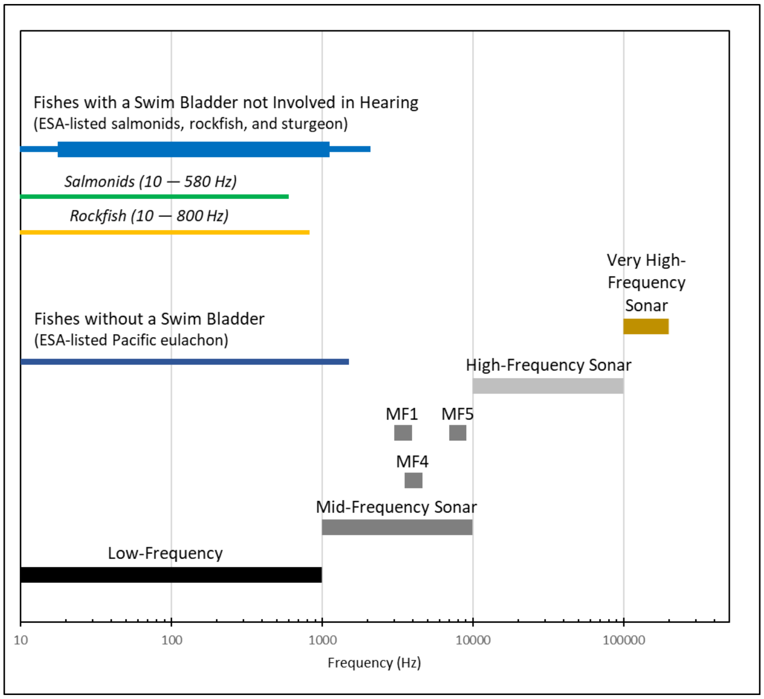

Figure 59. Hearing frequency ranges (pressure) of some ESA-listed fish groups compared to Navy defined sonar classes. Sources: (Hawkins and Johnstone 1978; Popper 2008; Popper et al. 2007a; Popper et al. 2014b; Tavolga and Wodinsky 1963).

Figure 59 Notes: Thin blue lines represent the estimated minimum and maximum range of frequency detection for each group. All hearing groups are assumed to hear down to 0.01 kHz regardless of available data. Thicker portions of each blue line represent the estimated minimum and maximum range of best sensitivity for that group. Currently, no data are available to estimate the range of best sensitivity for fishes without a swim bladder. When available, hearing data for specific ESA-listed species, or surrogate species, are provided (see green and yellow lines). Although the horizontal black, grey and brown bars represent each sonar class graphically, not all sources within each class would operate at all the displayed frequencies. Example mid-frequency classes are provided to further demonstrate this. kHz = kilohertz, MF1 = 3.5 kHz, MF4 = 4 kHz, MF5 = 8 kHz.

The Navy's proposed action does not include any activities involving low frequency sonar use. 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. Based upon the fish hearing and frequency overlap, the ESA-listed fishes considered in this biological opinion would have limited ability to detect mid-frequency active sonar frequencies, and would not likely be able to detect mid-frequency active sonar sources proposed by the Navy for use within the GOA TMAA (i.e., bins MF1, MF4, or MF5). Further, none of the fish species considered in this opinion can detect high- and very high-frequency sonars and other transducers. Therefore, ESA-listed fish species considered in this opinion are extremely unlikely to be affected by either mid-frequency or high-frequency Navy sonar sources. As such, the effects from sonar and other transducers on ESA-listed fish are considered discountable, and thus may affect, but are not likely to adversely affect these species.

8.1.2.2 Physical Disturbance and Strike Stressors – Fish

Below we summarize the likely impacts of the various types of physical disturbance, including the potential for strike, during training activities within the action area from 1) vessels and in-water devices, 2) military expended materials, including non-explosive practice munitions and fragments from high-explosive munitions, and 3) seafloor devices. For a general discussion of physical disturbance and strike stressors associated with the proposed action see Section 5.2.

8.1.2.2.1 Effects of Vessels and In-water Devices on Fish

Vessel traffic and in-water device use during Navy training activities could occur throughout the GOA action area. ESA-listed salmonids spend at least some time in the upper portions of the water column and, therefore, may also be susceptible to vessel strike, although reported ship strikes for these species are extremely rare. 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 fish 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 50–350 meters. When the vessel passed over them, some fish responded with sudden escape responses that involved movement away from the vessel laterally or through downward compression of the school.

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). It is possible that fish 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 to the animal.

Given the anticipated low density of the ESA-listed fish species in the action area, the ability of these species to maneuver to avoid any oncoming vessels, the low number of vessels associated with GOA TMAA/WMA activities relative to non-military traffic in the area, and the lack of documented cases of Navy vessels or in-water devices striking these species (or any other fish species) in the action area, it is extremely unlikely that a Navy vessel associated with GOA TMAA/WMA activities will strike an ESA-listed fish species. Any behavioral or stress response from fish avoiding an oncoming vessel or in-water device would be short-term, temporary and have no lasting impact on individual fitness. Therefore, potential effects on ESA-listed fish species from vessels and in-water devices are discountable (in the case of strikes) or insignificant (in the case of behavioral or stress response), and thus may affect, but are not likely to adversely affect these species.

8.1.2.2.2 Effects of Military Expended Materials on Fish

This section summarizes 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. 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. 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 0.2 meters per second; heavier items such as non-explosive munitions would likely sink faster, but would still be slowed as they sink to the bottom), and can be avoided by highly mobile organisms such the fish considered in this opinion.

In summary, it is extremely unlikely that an ESA-listed fish will be struck by military expended materials and the effects are, therefore, discountable and thus may affect, but are not likely to adversely affect these species. 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, the effects of behavioral avoidance of military expended materials sinking through the water column is insignificant, and thus may affect, but is not likely to adversely affect ESA-listed fish.

8.1.2.2.3 Effects of Seafloor Devices on Fish

The types of activities that use seafloor devices include items placed on the seafloor, dropped on the seafloor, or that move along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles (Navy 2021). The likelihood of any ESA-listed fish encountering seafloor devices is extremely low given the densities of these species near the seafloor and in areas where such devices would be found. If encountered, ESA-listed fish would be expected to ignore or avoid any slowly moving or stationary device on the seafloor. In summary, potential effects on the ESA-listed fish species considered in this opinion from seafloor devices are extremely unlikely and considered discountable, and thus may affect, but are not likely to adversely affect listed fish.

8.1.2.3 Entanglement Stressors – Fish

In this section we analyze the effects of entanglement stressors on ESA-listed fish. For a general discussion of entanglement stressors associated with the proposed action see Section 5.3.

For pelagic species, including salmonids, the risk of entanglement in Navy expended materials is unlikely given their body shape and ability to avoid materials that could entangle them in the water column. Although it is possible that some species of fish could become entangled in guidance wires and fiber optic cables, the risk for most fish species is considered low. 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 2021). Therefore, if this becomes looped around a fish, 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. Due to 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 and 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 fish and have breaking strengths much greater than that of guidance wire and fiber optic cables used during Navy activities.

Similarly, sonobuoy surface antennae, float units, and subsurface hydrophones 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 pounds. 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 feet 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 would likely be broken by a fish that swims into it; 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. 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 fish becoming entangled.

Similar to interactions with other types of marine debris (e.g., fishing gear, plastics), interactions with Navy deployed parachutes and decelerators have the potential to result in mortality, adverse sub-lethal effects, and behavioral responses if a fish encounters them. While parachutes and decelerators could potentially be encountered by fish at the sea surface, in the water column, or on the seafloor, in general, ESA-listed salmonids are not likely to encounter parachutes and decelerators at the surface or on the seafloor since these species typically don't occupy these portions of the water column in the action area where such materials would be expended. While steelhead are more likely to occur in the upper portion of the water column, as compared to other salmonids considered in this opinion, encounters with parachutes and decelerators floating at the surface would still be extremely unlikely.

Parachutes used by the Navy in the GOA action area range in size from 18 to 48 inches, but the vast majority of expended decelerator/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 five to 15 seconds before the decelerator/parachute and its housing sink to the seafloor. Entanglement of a fish in a parachute assembly at the surface or within the water column would be unlikely, because the parachute would either have to land directly on the fish or the fish would have to swim into it before it sinks.

Large decelerators and parachutes may pose a higher degree of risk for ESA-listed fish because these parachutes have long lines (large chutes have 28 cords, approximately 40 to 70 feet long; extra-large chutes have 64 cords, up to 82 feet long), associated with them. Additionally, large parachutes are not weighted with anything to help them sink rapidly, and could remain suspended in the water column for an extended period of time. However, the chance of an encounter is remote given the relatively small number of the large parachutes proposed to be deployed, and even smaller number that would not be recovered. Numbers of decelerators and parachutes currently being used and proposed are found in Table 31. There have been no reported incidences of ESA-listed fish entanglements involving Navy decelerators or parachutes on any past Navy consultations within the GOA or in any other Navy operating areas. As a standard operating procedure, the Navy recovers decelerators/parachutes to the maximum extent practicable. Given the vast area over which any one of these large parachutes would be deployed and the limited number of them deployed annually, the chances of an ESA-listed fish encountering them and becoming entangled is extremely low. During activities that involve recoverable targets (e.g., aerial drones), the Navy recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. This standard operating procedure could further reduce the potential entanglement of ESA-listed fish in decelerators/parachutes.

In summary, for the reasons discussed above, the likelihood of ESA-listed fish species becoming entangled with expended materials such as parachutes, decelerators, cables, or wires is extremely unlikely. Therefore, we consider the effects from entanglement stressors on the ESA-listed fish species considered in this opinion to be discountable, and thus may affect, but are not likely to adversely affect listed fish.

8.1.2.4 Ingestion Stressors – Fish

ESA-listed fish occurring in the action area have the potential to ingest military expended materials resulting from GOA TMAA/WMA activities. The Navy expends the following types of materials during training 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).

Most of the items that could be ingested by ESA-listed fish would be expended in the offshore portion of the action area. Pelagic species, such as salmonids, are more likely to ingest expended materials floating in the water column. Military expended materials that could 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). If an ESA-listed fish accidentally ingested such an item at or near the surface it would likely expel it after determining it was not a prey item. Expended materials made of metal would sink quickly through the water column before settling on the seafloor. Once the item sinks to the seafloor, it would be unavailable for ingestion by pelagic species. Shiny fragments of sinking munitions in the water column could attract and be ingested by fast, mobile predators that chase moving prey. However, this is an unlikely scenario considering: 1) the small amount of time such objects would be in the water column and, 2) that highly mobile predators would be expected to evacuate an area where an explosion has just occurred. In addition, ESA-listed species are relatively rare and dispersed throughout the offshore portion of the action area, which further decreases the likelihood that one would encounter sinking expended materials in the water column.

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, we consider the effects from ingestion stressors on the ESA-listed fish species considered in this opinion to be discountable, and thus this stressor may affect, but is not likely to adversely affect these species.

8.1.2.5 Stressors Resulting in Effects to Fish Habitat or Prey

Stressors from training activities that could result in secondary or indirect effects on ESA-listed fish via impacts to habitat, prey, sediment, and water quality include explosives and byproducts, metals, and chemicals.

In-air explosions near the surface could impact other species in the food web, including prey species that the ESA-listed fish species considered in the opinion feed upon. The impacts of explosions would differ depending on the type of prey species in the area of the blast. Explosions may reduce available prey items for ESA-listed fish species by either directly killing prey or by scaring them from the area. In addition to physical effects of the blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that could include swimming to the surface or scattering away from the source. The abundance of fish prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Any of these scenarios would likely be short-term and temporary, only occurring during activities involving explosives, with no lasting effect on prey availability or the pelagic food web expected. Due to the infrequent use of Navy explosives and the limited locations at which explosives are used (off the shelf and beyond 4,000 meter depths), it is not expected their use will have a persistent effect on prey availability or the health of the aquatic food web. As highly mobile, open water predators, salmonids would not likely be adversely affected by such short-term, localized impacts to their prey base in the open ocean. Thus, the effects of explosives on ESA-listed salmonids via impacts on their prey are considered insignificant, and thus not likely to adversely affect these species.

In terms of explosive byproducts, high-order explosions consume most of the explosive material, creating typical combustion byproducts. Explosion by-products associated with high order detonations present no indirect stressors to marine ESA-listed species because most byproducts are common in seawater and the rest are quickly diluted below appreciable levels. Explosive byproducts are not expected to result in detectable changes in sediment or water quality. Low-order explosives leave more explosive material in the water but this material is not water soluble, degrades quickly, and is quickly dispersed. The levels of explosive materials and byproducts are not detectable above background levels one to two meters from a degrading source. As such, the effects of explosive byproducts on ESA-listed fish species considered in this opinion via impacts on water quality are extremely unlikely and considered discountable, and thus not likely to cause adverse effects to these species.

Metals can be introduced into seawater and sediments as a result of Navy training activities involving ship hulks, targets, munitions, and other military expended materials (Environmental Sciences Group, 2005). Fish could be exposed to released metals through contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Certain metals are harmful to fish at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) (Wang and Rainbow 2008). Most metals used in Navy expendables are benign, and all corroding metals would either be diluted into the ocean currents or be sequestered in the sediments immediately surrounding the source (Navy 2022a). Concentrations of metals in seawater are considerably lower than concentrations in sediments. As such, it is extremely unlikely that fish would be indirectly impacted by toxic metals via the water at exposure concentration levels that could result in harmful toxic effects given the vast open ocean area over which metals would be released. Metals deposited on the sea floor will be buried in sediment and slowly degrade over time. ESA-listed fish species that feed primarily in the water column and are not benthic associated species (i.e., salmonids) would not likely come into contact with metals in marine sediments.

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 et al. 2016; Kelley et al. 2016; Koide et al. 2016; Navy 2013b) indicate metal contamination is highly localized and that bioaccumulation resulting from munitions cannot be demonstrated. Specifically, in sampled marine life living on or around munitions on the seafloor, metal concentrations could not be definitively linked to the munitions 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). Based on the available information, it is extremely unlikely that metals introduced into the action area would have adverse effects on ESA-listed fish prey or habitat. Thus, the effects of metals introduced into seawater and sediments as a result of GOA TMAA/WMA activities on ESA-listed fish species, either directly or through impacts on their prey or habitat, are extremely unlikely and considered discountable, and thus not likely to cause adverse effects.

Several GOA TMAA/WMA activities introduce chemicals into the marine environment that are potentially harmful to fish in higher concentrations. However, rapid dilution would be expected and toxic concentrations are unlikely to be encountered by ESA-listed 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 environment. Research has demonstrated that perchlorate does not bioconcentrate or bioaccumulate, which is consistent with the expectations for a water-soluble compound (Furin et al. 2013). Given the dynamic nature of the environment (currents, tides, etc.), long-term impacts from perchlorate in the environment near the expended item are not expected. It is extremely unlikely that perchlorate from failed expendable items would compromise water quality to the point that it would result in adverse effects on ESA-listed fish prey or habitat. Thus, the effects of chemicals introduced into seawater and sediments as a result of GOA TMAA/WMA activities on ESA-listed fish species, either directly or through impacts on their prey or habitat, are insignificant, and thus not likely to adversely affect these species.

8.2 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 – blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale;
2) Stressors from in-air explosives – blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale, and chum salmon (Columbia River and Hood Canal ESUs), sockeye salmon (Ozette Lake and Snake River ESUs), and steelhead (six DPSs).

In the following sections, we consider the exposures that could cause an effect on ESA-listed species that are likely to co-occur with the effects of sonar and explosives on the environment in space and time, and identify the nature of that co-occurrence. We consider the frequency and intensity of exposures that could cause an effect on the ESA-listed species listed above and, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or subpopulation(s) those individuals represent. We also consider the responses of the ESA-listed species to exposure.

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

8.2.1 Cetaceans

In the sections below we analyze the effects of stressors resulting from the proposed action that are likely to adversely affect ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale, including sonar and other transducers, and explosives.

8.2.1.1 Sonar and Other Transducers

As described in Section 5.1.1, 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.

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 animals. 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. 2007). 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 sound source.

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 due to exposure to pressure waves. Non-auditory injury (i.e., other than PTS) and mortality of ESA-listed marine mammals from sonar and other transducers is considered extremely unlikely under normal conditions, and is, therefore, discountable and, thus, not considered further in this opinion for marine mammals[4].

Noise-induced hearing loss is a 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 or communication of a biologically-important sound is interfered with by a second sound (e.g., noise from Navy training activities). Behavioral responses range from brief distractions to avoidance of a sound source to prolonged flight. The sections below provide additional information on the potential effects of sonar and other transducers on marine mammals. We use this information to discuss the likely effects of Navy sonar use on ESA-listed cetaceans in our exposure, response, and risk analyses that follow.

8.2.1.1.1 Hearing Loss and Auditory Injury

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received level, temporal pattern, and duration. The frequencies affected by hearing loss will vary depending on the frequency of the noise, with frequencies at and above the noise frequency most strongly affected (i.e., higher amount of threshold shift). The amount of hearing loss may range from slight to profound. Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. Hearing threshold shifts in mid-frequency cetaceans exposed to non-impulsive sound (e.g., active sonar tones) has been investigated in multiple studies (e.g., Finneran et al. 2010; Finneran et al. 2005; Finneran and Schlundt 2013; Mooney et al. 2009a; Mooney et al. 2009b).

Hearing loss is typically quantified in terms of threshold shift — the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of threshold shift measured usually decreases with increasing recovery time — the amount of time that has elapsed since a noise exposure. If the threshold shift eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is considered temporary or TTS. If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is determined to be permanent or PTS. Figure 60 shows two

[4] 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.

hypothetical threshold shifts: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

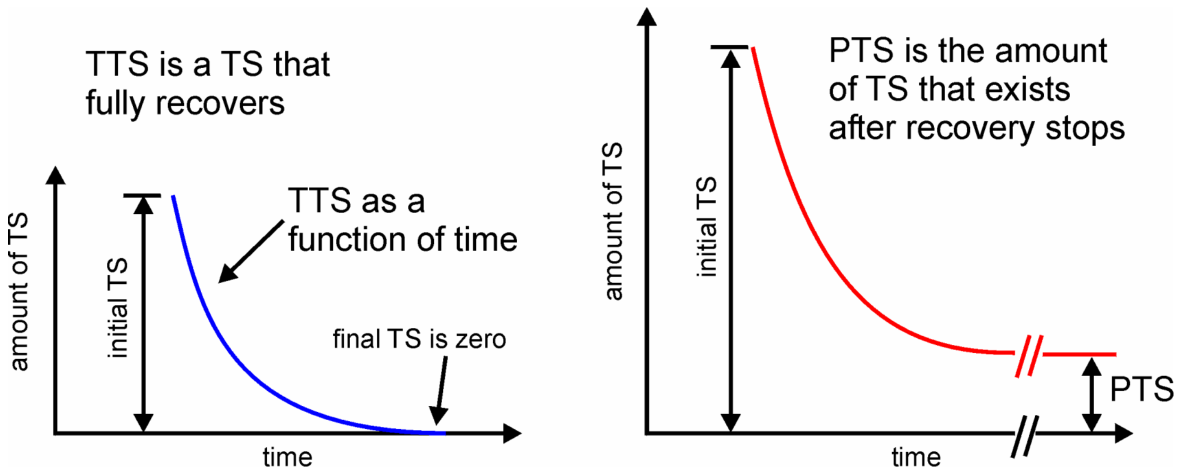

Figure 60. Two hypothetical temporary threshold shifts.

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). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure, resulted in acute loss of nerve terminals and delayed degeneration of the cochlear nerve in mice. Lin et al. (2011) found a similar result in guinea pigs with a TTS in auditory-evoked potential up to approximately 50 dB, measured 24 hours post-exposure resulting in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury because exposures producing high levels of TTS (40 to 50 dB measured 24 hours after exposure) — but no PTS — may result in auditory injury or impairment.

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). Further, TTS and PTS are mutually exclusive because an exposure that produces TTS cannot also produce PTS within the same frequency band in the same individual (Reichmuth et al. 2019). If an initial threshold shift results in only partial recovery, resulting in some amount of PTS, the difference between the initial threshold shift and the PTS is not called TTS. As TTS increases, the likelihood that additional exposure or duration to sound will result in PTS and/or other injury also increases. An exception to this is that researchers might not be able to observe gradual growth of TTS with increased levels of sound exposure before onset of PTS (Reichmuth et al. 2019). Similarly, PTS can occur without measurable behavioral modifications (Reichmuth et al. 2019). Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS. The specific upper limit of TTS is based on experimental data showing amounts of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury. We only need to know the upper limit for TTS before some PTS or injury is possible.

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

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

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological measures producing larger amounts of TTS compared to psychophysical measures (Finneran et al. 2007; Finneran et al. 2015).
- The amount of TTS varies with the hearing test frequency. The higher the SPL, the higher the TTS induced at frequencies higher than the exposure frequency (e.g., 1-2 kHz down-sweeps); below 148 dB re 1 μPa, the maximum TTS was at 6.5 kHz, whereas above 148 dB re 1 μPa, the maximum TTS was at 9.2 kHz. (Kastelein et al. 2014b). For high level exposures to tonal or octave band sounds, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Mooney et al. 2009a; Nachtigall et al. 2004; Popov et al. 2013; Popov et al. 2011; Reichmuth et al. 2019; Schlundt et al. 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range; i.e., narrowband exposures can produce broadband (greater than one octave) TTS.
- The amount of TTS usually increases with exposure SPL and duration, and is correlated with SEL, especially if the range of exposure durations is relatively small (Kastak et al.

2007; Kastelein et al. 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 cetacean experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.

- The amount of TTS depends on the exposure frequency. Sounds that are well below the frequency level of best sensitivity are less hazardous than those at or near the level of best sensitivity (Finneran and Schlundt 2013). The onset of TTS — defined as a threshold shift of six dB measured approximately four minutes after exposure (i.e., clearly above the typical variation in threshold measurements) — also varies with exposure frequency. At low frequencies TTS onset exposure levels are higher compared to those in the region of best sensitivity. However, gradual increases of TTS may not be directly observable with increasing exposure levels before the onset of PTS, which can occur without measurable behavioral modifications (Reichmuth et al. 2019).
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al. 2010; Kastelein et al. 2015c; Kastelein et al. 2014b; Mooney et al. 2009b). This means that TTS predictions based on the total, cumulative SEL will likely overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., approximately 40 dB) may require several days or longer for recovery. Recovery times are consistent for similar-magnitude shifts, regardless of the type of fatiguing sound exposure (impulsive, continuous noise band, or sinusoidal) (Kastelein et al. 2019b). 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., six dB recovery per doubling of time), although this may not hold for all sound sources and species.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of man-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include some sonars and other transducers that would be used by the Navy within the TMAA, and impulsive sound sources such as airguns and impact pile driving that would not be used as part of the proposed action. Recent studies have begun to show that some cetaceans (odontocetes) may learn to reduce their hearing sensitivity (presumably to protect their hearing) when warned of an impending intense sound exposure (Finneran 2018; Nachtigall and Supin 2013; Nachtigall et al. 2016). The marine mammal criteria and thresholds for hearing impairment and non-auditory injury from sonars and other transducers used for the Navy's quantitative model were described in Section 2.2.2.1.

Southall et al. (2019d) updated scientific information after evaluating Southall et al. (2007a) to propose revised noise exposure criteria to predict onset of auditory effects in marine mammals (i.e., PTS and TTS onset). Southall et al. (2019d) note that the quantitative processes described and the resulting exposure criteria (i.e., thresholds and auditory weighting functions) are largely identical to those in Finneran (2015a) and NMFS (2016c); NMFS (2018b). However, they differ in that the Southall et al. (2019d) exposure criteria are more broadly applicable as they include all marine mammal species (rather than those only under NMFS jurisdiction) for all noise exposures (both in air and underwater for amphibious species), and that while the hearing group compositions are identical they renamed the hearing groups. The thresholds discussed in the paper (TTS/PTS only) are the same as the Navy's criteria and NMFS' criteria.

There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by airguns.

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

In addition to these studies, a number of impulsive noise exposure studies have been conducted without behaviorally measurable TTS of 6 dB or more. The results of these studies are either consistent with the Navy criteria and thresholds (e.g., exposure levels were below those predicted to cause TTS and TTS did not occur) used to support the analysis for the proposed action or suggest that the thresholds used to support the analysis for the proposed action overestimate the potential for impact (e.g., exposure levels were above thresholds used to support the analysis for the proposed action, but TTS did not occur).

Finneran et al. (2000) exposed dolphins and belugas to single impulses from an "explosion simulator" and Finneran et al. (2015) exposed three dolphins to sequences of 10 impulses from a seismic airgun (maximum cumulative SEL = 193 to 195 dB re 1 $\mu Pa^2 s$, peak SPL = 196 to 210 dB re 1 μPa) without measurable TTS. Finneran et al. (2003) exposed two sea lions to single impulses from an arc-gap transducer with no measurable TTS (maximum unweighted SEL = 163 dB re 1 $\mu Pa^2 s$, peak SPL = 183 dBre 1 μPa).

8.2.1.1.2 Physiological Stress

Marine mammals naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

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

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

Meissner et al. 2015; Rolland et al. 2012). Anthropogenic stressors potentially include fishery interactions, pollution, and ocean noise.

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

Rolland et al. (2017) studied glucocorticoid hormones in North Atlantic right whales, evaluating and comparing healthy whales with whales that were chronically entangled in fishing gear. The authors found that stress hormones in the entangled whales were elevated compared to those of healthy whales. The authors also cited several studies to conclude that stress responses over a short period of time (i.e., hours/days) can be beneficial and life-saving. However, chronic elevations of glucocorticoids (i.e., weeks/months) may result in decreased growth, depressed immune system function, and suppression of reproduction (e.g., Romero and Wikelski 2001; Sapolsky et al. 2000). If the magnitude and duration of the stress response is too great, too long, or occurs at a time when the animal is in a vulnerable state, it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction).

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

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al. 1990) but showed a small but statistically significant increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate a statistically significant elevation in aldosterone (Romano et al. 2004), albeit the increase was within the normal daily variation observed in this species (St. Aubin et al. 1996). Increases in heart rate were observed in bottlenose dolphins to which known calls of other dolphins were played, although no increase in heart rate was observed when background tank noise was played back (Miksis et al. 2001). Unfortunately, it cannot be determined from this study whether the increase in heart rate was due to stress or an anticipation of being reunited with the dolphin to which the vocalization belonged. Similarly, a young beluga's heart rate was observed to increase during exposure to noise, with increases dependent upon the frequency band of noise and duration of exposure, and with a sharp decrease to normal or below normal levels upon cessation of the exposure (Lyamin et al. 2011). However, this response may have been in part due to the conditions during testing. Kvadsheim et al. (2010) measured the heart rate of captive hooded seals during exposure to sonar signals, and found an increase in the heart rate of the seals during exposure periods versus control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, researchers observed a rapid but short-lived decrease in heart rates in harbor and gray seals exposed to seismic airguns (Gordon et al. 2003). Williams et al. (2017) found a non-linear increase in oxygen consumption with both stroke rate and heart rate in swimming and diving bottlenose dolphins, and found that the average energy expended per stroke increased from 2.81 Joules/kilogram/stroke during preferred swim speeds to a maximum expenditure of 6.41 Joules/kilogram/stroke when freely following a boat. Houser et al. (2020) measured cortisol and epinephrine levels in bottlenose dolphins and found no correlation between these stress hormone levels and received sound pressure levels from mid-frequency sonar signals. Houser et al. (2020) and Houser et al. (2013b) observed that the severity of bottlenose dolphin behavioral responses scaled with sound pressure level. Therefore, behavioral reactions to sonar signals may not be indicative of a hormonal stress response.

Similarly, a limited amount of work has addressed how chronic exposure to acoustic stressors affect stress hormones in cetaceans, particularly as it relates to survival or reproduction. Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al. 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (Bain 2002; Erbe 2002; Noren et al. 2009). Most of these efforts focused primarily on estimates of metabolic costs associated with altered behavior or inferred consequences of boat presence and noise, but did not directly measure stress hormones. Ayres et al. (2012) investigated Southern Resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone measurements that the lack of prey overshadowed any population-level physiological impacts on Southern Resident killer whales due to vessel traffic. Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise.

8.2.1.1.3 Masking

Clark et al. (2009) developed a method for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar Soto et al. (2006) found that a 15 dB increase in background noise due to vessels led to a communication range of only 18 percent of its normal value for foraging beaked whales. Their method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2016) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, and noise-source location, distance relative to each other, and received level of the call.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise and include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin and Parks 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (e.g., Holt 2008; Holt et al. 2011; Rolland et al. 2012) as well as changes in the natural acoustic environment (Dunlop et al. 2014). Vocal changes can be temporary, or can be permanent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen and Parks 2016). This shift in frequency was modeled, and it was found that it led to increased detection ranges between right whales. The frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than three kilometers to over nine kilometers (Tennessen and Parks 2016). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al. 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may also move beyond vocal modifications (Dunlop et al. 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a different location to improve binaural cues (time or intensity differences between the ears due to a sound source's location relative to the animal's head), or going still to reduce noise associated with hydrodynamic flow. The structure of some noises (e.g., amplitude modulation) may also provide some release from masking through comodulation masking release (the difference in masking when a noise is broadband versus having the same bandwidth as the signal; Branstetter and Finneran 2008). Signal characteristics (e.g., whether the signal has harmonics, or is frequency modulated) may further enhance the detectability of a signal in noise (Cunningham et al. 2014).

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators (Allen et al. 2014; Cummings and Thompson 1971a; Cure et al. 2015), which may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and identification of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, sperm whales (Isojunno et al. 2016), long-finned pilot whales (Visser et al. 2016), and humpback whales (Cure et al. 2015) changed their behavior in response to killer whale vocalization playbacks. These findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking 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., two to ten 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. With mid-frequency high duty cycle systems, 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 cetaceans, 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. 2003; Sivle et al. 2016). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al. 2004; Parks et al. 2007b), 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. 2003).

8.2.1.1.4 Behavioral Reactions

Acoustic stimuli in the marine environment can cause a behavioral response in marine mammals and can also influence how or if a marine mammal responds to a sound such as the presence of predators, prey, or conspecifics. The response of a marine mammal to 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. 2012). 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).

A review of marine mammal responses to anthropogenic sound was first conducted by Richardson et al. (1995c). Other reviews (Gomez et al. 2016; Nowacek et al. 2007; Southall et al. 2007) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed cetacean was known or could be estimated, and also examined the role of context. Southall et al. (2007) 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. 2007; Southall et al. 2016).

Ellison et al. (2012) 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 what activity the animal is engaged in, 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 note 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 suitability for foraging, resting, or socializing.

Sonar and other transducers can range in frequency (from less than 1 kHz to over 200 kHz) and duty cycles (from one ping per minute to an almost continuous sound). These acoustic sources can also be stationary or operated from a moving platform, and there can one or multiple sources present at a time. 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. For some ESA-listed marine mammal species little or no data exist on behavioral responses to any sound source, and so these species have been grouped into taxonomic groups (e.g., mysticetes, odontocetes, and pinnipeds) from which general response information can be inferred.

Cetacean behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, U.S. (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. 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 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 one to eight kilometers. 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., five minutes.) of ramp-up (von Benda-Beckmann et al. 2016; von Benda-Beckmann et al. 2014; Wensveen et al. 2017).

Passive acoustic monitoring and visual observational behavioral response studies have been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real 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). 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. During all of these monitoring efforts, only a few behavioral responses were observed, (discussed below in Mysticetes and Odontocetes – Behavioral Response) 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). It should be noted that passive acoustic studies are limited to observations of vocally-active cetaceans and visual studies are limited to what can be observed at the surface.

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 sound sources (smaller sized and deployed at closer proximity) and on wild animals with both scaled and real but directed sound sources. Captive studies on odontocete species can provide insight into how these animals may respond in the wild (see Odontocetes – Behavioral Response below for details). 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.

8.2.1.1.5 Mysticetes – Behavioral Response

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

Surface feeding blue whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 μPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior (DeRuiter et al. 2017; Goldbogen et al. 2013). 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. 2016b; Southall et al. 2019b). However, even when responses did occur, the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al. 2013).

A behavioral response study by Harris et al. (2019) looked at the exposure of lunge feeding rates blue, fin, and humpback whales to simulated naval sonar. Results of their study showed that regardless of exposure levels, blue and fin whale lunge rates remained similar to baseline. However, their study did demonstrate that humpback whales – which were exposed to the highest sound levels of controlled exposures of simulated sonar – did show a greater degree of feeding disruption than either of the other two species, both during and up to 15 minutes after sonar exposure. In another study, humpback whales exposed to a three kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 meters (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. 2004a). 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 two 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 (Sivle et al. 2015), and actually responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks. Several humpback whales have been observed during aerial or visual surveys during Navy training events involving sonar (Harris et al. 2019; Henderson et al. 2019; Sivle et al. 2016; Wensveen et al. 2017). No avoidance or other behavioral responses were ever noted, even when the whales were observed within five kilometers 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 aforementioned Norwegian behavioral response study, where the whale responded at 146 dB re 1 μPa by strongly avoiding the sound source (Harris et al. 2019; Kvadsheim et al. 2017; Sivle et al. 2015). Although the minke whale increased its swim speed, directional movement and respiration rate, none of these were greater than rates observed in baseline behavior, and its dive behavior remained similar to baseline dives. A minke whale tagged in a Southern California behavioral response study also responded by increasing its directional movement, but maintained its speed and dive patterns, so did not demonstrate as strong of a response (Kvadsheim et al. 2017). In addition, the 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 2013b; 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. 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 sound 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 two kilometers to avoid the sound, but when the source was outside their path, little response was observed (Clark and Fristrup 2001; Croll et al. 2001a; 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); (2014) concluded that reductions in humpback whale songs in the Stellwagen Bank National Marine Sanctuary were a result of an Ocean Acoustic Waveguide Remote Sensing experiment occurring about 200 kilometers away from the whales location. 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 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. 2004a), 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. 2012).

8.2.1.1.6 Odontocetes – Behavioral Response

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; Isojunno et al. 2020; McCarthy et al. 2011; Moretti et al. 2009; Southall et al. 2013; Southall et al. 2012; Southall et al. 2014; Wensveen et al. 2019). Though below we will discuss results of behavioral response studies on many odontocete species (e.g., beaked whales), sperm and killer whales are the only odontocetes 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). However, in response to seismic surveys and naval sonar, sperm whales have demonstrated avoidance, changes in locomotion/orientation, changes in dive profiles, cessation of foraging, cessation of resting, and changes in vocal behavior (Isojunno et al. 2016; Miller et al. 2009; Miller et al. 2012; Sivle et al. 2012). Sperm whales may be more sensitive to larger amounts of cumulative sound energy they receive, rather than higher sound amplitudes during sonar exercises. Sperm whales in and around the Norwegian Sea were found to halt foraging behavior for longer periods of time following exposure to continuous sonar than they were following exposure to pulsed sonar of similar amplitudes, although these behavioral changes became more pronounced with increasing pulsed sonar amplitudes (Isojunno et al. 2020).

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; Cholewiak et al. 2017; Deruiter et al. 2013a; Joyce et al. 2019; Miller et al. 2015; Southall et al. 2019b; 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, which are shorter duration and randomly located, are more difficult for beaked whales to predict or track and therefore potentially more likely to cause a response, especially when they occur at closer distances (six to 25 kilometers in this study).

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 seven hours (Miller et al. 2015). Responses occurred at received levels between 95 and 150 dB re 1 μPa. All of these exposures occurred within one to eight kilometers 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 kilometers 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. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other cetaceans 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 expended 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. (2017) was higher.

On Navy ranges, Blainville's beaked whales located on the range appeared to move off-range during sonar use and returned 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). Blainville's beaked whales remained on the Navy range to forage throughout the rest of the year (Henderson et al. 2016), and photo identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whales, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone and Schorr 2014; Falcone et al. 2009). These results suggest that the range areas studied represent preferred foraging habitat regardless of the effects of the noise, and that there may be no long term consequences of the sonar activity on beaked whales in these areas.

Tyack et al. (2011a) hypothesized that beaked whale responses to sonar may represent an anti-predator response. Such anti-predator responses in Blainville's beaked whales and Cuvier's beaked whales may include overlapping foraging times among group members and coordinated silent ascents in unpredictable directions (de Soto et al. 2020). To test the sonar/anti-predator hypothesis, 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 kilometers 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, changes in dive behavior, and reduced breathing rate (Antunes et al. 2014; Miller et al. 2011; Miller et al. 2014; Miller et al. 2012).

One study reported the temporary separation of a killer whale calf from its group during exposure to mid-frequency sonar playback (Miller et al. 2011). The separation event occurred during the third (of three) sonar exposures of a group of seven killer whales in a fjord surrounding the Lofoten Islands, Norway. During the first exposures, some calling was observed before the initial ping, and calling increased and continued throughout both the mid-frequency active and low-frequency active sonar exposures (Miller et al. 2011). A second mid-frequency active sonar exposure was conducted to try to achieve a closer approach to the whales after they had moved into a deeper part of the fjord. The whales made a strong change of direction during a long dive in the ramp-up phase of the second mid-frequency active sonar exposure and increased speed immediately after the dive (Miller et al. 2011). At the end of the second mid-frequency active sonar exposure, the smallest calf in the group was seen traveling alone, more than 1,000 meters behind the location of the group. The calf rejoined the group after traveling alone for at least 86 minutes (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 one to two kHz sonar (sweeping across frequencies), but did not change their dive behavior if they were deep diving during six to seven 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 six to seven kHz sonar, while during one to two kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al. 2012). In addition, pilot whales were more likely to respond to lower received levels when non-feeding than feeding during six to seven kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during one to two 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 six to seven 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. (2013) 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 and 94.4 km. However, one pilot whale did have reduced dive rates (from 2.6 dives per hour before to 1.6 dives per hour during) and deeper dives (from a mean of 124 meters to 268 meters) during a period of sonar exposure. Baird et al. (2016) also tagged four short-finned pilot whales from both the resident island-associated population and from the pelagic population. The core range for the pelagic population was over 20 times larger than for the island-associated population, leading the researchers to hypothesize 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 Resident killer whales 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 2014b). 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 (at the highest received levels animals were not present in the area at all) (Henderson et al. 2014). 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 et al. 1985). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bowride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (HDR 2011; Navy 2011a; Watwood et al. 2012). 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 seven days of mid-frequency sonar activity. It was not investigated if this change was due to the sonar activity or was a seasonal difference that 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 cetaceans from approaching fishing gear both to prevent entanglement and to reduce depredation (taking fish) (85 FR 53763). 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 ten 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 two to four exposures, longer term exposures (over 28 days) showed no evidence of additional habituation. Kindt-Larsen et al. (2018) also report on the effectiveness of pingers to deter harbor porpoise from depredating fishing nets and also indicate no evidence of habituation. Omeyer et al. (2020) found that a Banana Pinger (50 to 120 kHz, sound pressure level 145 dB re 1 μPa) was an effective harbor porpoise deterrent and there was no evidence of habituation over an eight-month period. 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 cetaceans 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 meters away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of cetacean 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 cetaceans 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 cetaceans 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; van Beest 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 three kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al. 2013a), and in other studies bottlenose dolphins and beluga whales were presented with one-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. 2002; Schlundt et al. 2000). In the behavioral response experiment, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over ten trials. In the TTS study bottlenose dolphins exposed to one-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa, and beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). Götz et al. (2020) found that magnitudes of startle responses in bottlenose dolphins increased exponentially with increasing sound received levels but decreased with increased rise times in the sound signals. 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 respond 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 one to two kHz and six to seven 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 one to two kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the six to seven 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 one to two kHz and six to seven kHz sweeps respectively when no harmonics were present, and decreased to 90 dB re 1 μPa for one to two kHz sweeps with harmonics present (Kastelein et al. 2014d). Harbor porpoises responded to 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 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. These "real-world" responses are more likely to be short-term, lasting the duration of the exposure.

8.2.1.1.7 Impact Range to Effects from Sonar and Other Transducers

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 and other transducers to specific criteria determined using the NAEMO. Cetaceans within these ranges would be predicted to receive the associated effect. All information on range to effects, as presented below, is taken from the Navy's GOA Phase III

BA (Navy 2021). We use the Navy's calculated range to effects as the best available information for analyzing effects of sonar and on cetaceans.

The estimated ranges to the PTS threshold for an exposure of 30 seconds are shown in Table 46, and are relative to the cetacean's functional hearing group. 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. The 30-second exposure period was chosen based on examining the maximum amount of time a cetacean 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 meters per second. Estimated range to effects used for the NAEMO analysis are based on a number of factors including: 1) the assumed duty cycle for that bin (e.g., MF1 hull mounted sonar pings once every 50 seconds) relative to the durations over which SEL is accumulated in the range tables, 2) the source level of the bin, and 3) the susceptibility of the functional hearing group based on the source frequency.

Table 46. Range to permanent threshold shift for three representative sonar systems.

Hearing Group	*Approximate PTS (30 seconds) Ranges (meters)*[1]		
	Sonar bin MF1	*Sonar bin MF4*	*Sonar bin MF5*
Low-frequency cetaceans	65 (65–65)	13 (0–15)	0 (0–0)
Mid-frequency cetaceans	16 (16–16)	3 (3–3)	0 (0–0)

[1]PTS ranges extend from the sonar or other transducer sound source to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parenthesis.
Notes: MF = mid-frequency, PTS = permanent threshold shift

The tables below illustrate the range to TTS for 1, 30, 60, and 120 seconds from three representative sonar systems (Table 47 through Table 49). Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to be additive, further increasing the range to onset-TTS.

Table 47. Ranges to temporary threshold shift for sonar bin MF1 over a representative range of environments within the action area.

Hearing Group	Approximate TTS Ranges (meters)[1]			
	Sonar Bin MF1			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency cetaceans	920 (850–1,025)	920 (850–1,025)	1,415 (1,025–2,025)	2,394 (1,275–4,025)
Mid-frequency cetaceans	209 (200–210)	209 (200–210)	301 (300–310)	376 (370–390)
Otariids and Mustelids	65 (65–65)	65 (65–65)	100 (100–110)	132 (130–140)

[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 parenthesis.
Notes: HF = high frequency, TTS = temporary threshold shift

Table 48. Ranges to temporary threshold shift for sonar bin MF4 over a representative range of environments within the action area.

Hearing Group	Approximate TTS Ranges (meters)[1]			
	Sonar Bin MF4			
	1 second	30 seconds	60 seconds	120 seconds
Low-frequency cetaceans	77 (0–100)	175 (130–340)	299 (190–550)	497 (280–1,000)
Mid-frequency cetaceans	22 (22–22)	35 (35–35)	50 (50–50)	71 (70–75)
Otariids and Mustelids	8 (8–8)	15 (15–15)	19 (19–19)	25 (25–25)

[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 parenthesis.
Notes: HF = high frequency, TTS = temporary threshold shift

Table 49. Ranges to temporary threshold shift for sonar bin MF5 over a representative range of environments within the action area.

Hearing Group	*Approximate TTS Ranges (meters)[1]*			
	Sonar Bin MF5			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
Low-frequency cetaceans	9 (0–12)	9 (0–12)	13 (0–17)	19 (0–24)
Mid-frequency cetaceans	5 (0–9)	5 (0–9)	12 (11–13)	18 (17–18)
Otariids and Mustelids	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 parenthesis.

Notes: HF = high frequency, TTS = temporary threshold shift

The range to received sound levels in 6 dB steps from five representative sonar bins and the percentage of animals that may exhibit a significant behavioral response under each behavioral response function are shown in Table 50 through Table 52, respectively.

Table 50. Ranges to a potentially significant behavioral response for sonar bin MF1 over a representative range of environments within the action area.

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF1*		
		Mysticetes	*Odontocetes*	*Pinnipeds*
196	105 (100–110)	100%	100%	100%
190	240 (240–240)	98%	100%	100%
184	498 (490–525)	88%	99%	98%
178	1,029 (950–1,275)	59%	97%	92%
172	3,798 (1,525–7,025)	30%	91%	76%
166	8,632 (2,775–14,775)	20%	78%	48%
160	15,000 (3,025–26,525)	18%	58%	27%
154	23,025 (3,275–47,775)	17%	40%	18%
148	47,693 (10,275–54,025)	16%	29%	16%
142	53,834 (12,025–72,025)	13%	25%	15%
136	60,035 (13,275–74,525)	9%	23%	15%
130	72,207 (14,025–75,025)	5%	20%	15%

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF1		
		Mysticetes	Odontocetes	Pinnipeds
124	73,169 (17,025–75,025)	2%	17%	14%
118	72,993 (25,025–75,025)	1%	12%	13%
112	72,940 (27,525–75,025)	0%	6%	9%
106	73,016 (28,525–75,025)	0%	3%	5%
100	73,320 (30,025–75,025)	0%	1%	2%

Notes: (1) Cells are shaded if the mean range value for the specified received level exceeds the distance cut-off range for a particular hearing group. Any impacts within the cut-off range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels or multiple platforms.
(2) dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 51. Ranges to a potentially significant behavioral response for sonar bin MF4 over a representative range of environments within the action area.

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF4		
		Mysticetes	Odontocetes	Pinnipeds
196	8 (0–8)	100%	100%	100%
190	17 (0–17)	98%	100%	100%
184	34 (0–35)	88%	99%	98%
178	69 (0–75)	59%	97%	92%
172	156 (120–190)	30%	91%	76%
166	536 (280–1,000)	20%	78%	48%
160	1,063 (470–1,775)	18%	58%	27%
154	2,063 (675–4,275)	17%	40%	18%
148	5,969 (1,025–9,275)	16%	29%	16%
142	12,319 (1,275–26,025)	13%	25%	15%
136	26,176 (1,775–40,025)	9%	23%	15%
130	42,963 (2,275–54,775)	5%	20%	15%
124	53,669 (2,525–65,775)	2%	17%	14%
118	63,387 (2,775–75,025)	1%	12%	13%
112	71,709 (3,025–75,025)	0%	6%	9%
106	73,922 (22,775–75,025)	0%	3%	5%
100	73,923 (25,525–75,025)	0%	1%	2%

Notes: (1) Cells are shaded if the mean range value for the specified received level exceeds the distance cut-off range for a particular hearing group. Any impacts within the cut-off range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels or multiple platforms. (2) dB re 1 μPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 52. Ranges to a potentially significant behavioral response for sonar bin MF5 over a representative range of environments within the action area.

Received Level (dB re 1 μPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF5*		
		Mysticetes	*Odontocetes*	*Pinnipeds*
196	0 (0–0)	100%	100%	100%
190	1 (0–3)	98%	100%	100%
184	4 (0–7)	88%	99%	98%
178	14 (0–15)	59%	97%	92%
172	29 (0–30)	30%	91%	76%
166	59 (0–65)	20%	78%	48%
160	130 (0–170)	18%	58%	27%
154	349 (0–1,025)	17%	40%	18%
148	849 (410–2,275)	16%	29%	16%
142	1,539 (625–3,775)	13%	25%	15%
136	2,934 (950–8,525)	9%	23%	15%
130	6,115 (1,275–10,275)	5%	20%	15%
124	9,764 (1,525–16,025)	2%	17%	14%
118	13,830 (1,775–24,775)	1%	12%	13%
112	18,970 (2,275–30,775)	0%	6%	9%
106	25,790 (2,525–38,525)	0%	3%	5%
100	36,122 (2,775–46,775)	0%	1%	2%

Notes: (1) Cells are shaded if the mean range value for the specified received level exceeds the distance cut-off range for a particular hearing group. Any impacts within the cut-off range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels or multiple platforms.
(2) dB re 1 μPa = decibels referenced to 1 micropascal, MF = mid-frequency

8.2.1.1.8 Cetacean Exposure and Response Analysis –Sonar and Other Transducers

In this section we discuss the estimated number of exposures of ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, and sperm whale to sonar and other transducers, the expected magnitude of effect from those exposures, and the responses to those types and levels of exposure. The exposure estimates used for our effects analysis were produced by the Navy based on NAEMO output and post-processing techniques, and are based on the typical number of activities every seven years of the proposed action, and the maximum number of activities in a given year under the proposed action. NAEMO modeled-estimated exposures resulting in injury and mortality are further analyzed to account for mitigation proposed by the Navy to avoid or reduce impacts to cetaceans and for consideration of avoidance of multiple exposures that would be expected from individual animals once they sense the presence of Navy acoustic stressors. For GOA Phase III, NAEMO modeled-estimated impacts for ESA-listed species were reduced (from PTS to TTS) in only one instance: 1.6 fin whales PTS per year from NAEMO results were reduced to 0 PTS (after rounding) per year after accounting for mitigation and avoidance (Navy 2022d). While results from Oedekoven and Thomas (2022) raise questions about the application of a mitigation effectiveness factor, in this instance the reduction from PTS to TTS was largely driven by the application of an avoidance factor. See Section 2.2.1 above for a discussion of mitigation and avoidance factors in the Navy's quantitative acoustic effects analysis. For details, see the technical report Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training (Navy 2018c).

As previously mentioned above in Section 2.2.1, the model estimates the annual number of exposures that may result in different effects but does not estimate the number of individual marine mammals that may be affected. Some individuals may be exposed more than once per year but the model does not estimate whether a single individual is exposed multiple times.

Blue Whale

Blue whales are present in the GOA TMAA year-round and may be exposed to sounds from sonar and other transducers associated with training activities from April through October. The Navy's quantitative analysis estimates three behavioral harassments and 35 exposures resulting in TTS every year from maximum activity of the proposed action. The Navy's quantitative analysis estimates there would be 21 behavioral harassments and 245 exposures resulting in TTS every seven years from the proposed activities, and would be inclusive of male or female whales of any life stage present (Table 53).

Table 53. Estimated impacts on blue whales over a seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using sonar and other transducers in the GOA TMAA.

Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***
Seven-year Period	21	245	0
One-year Maximum	3	35	0

Fin Whale

Fin whales could be present year-round in the GOA TMAA but are expected in greatest abundance from June through August. Fin whales may be exposed to sounds from sonar and other transducers associated with training activities from April through October. The Navy's analysis estimates 104 exposures resulting in behavioral harassment and 1,125 exposures resulting in TTS per year of maximum activity as a result of the proposed action. The Navy's quantitative analysis estimates 728 exposures resulting in behavioral harassment and 7,785 exposures resulting in TTS every seven years of the proposed action (Table 54). Male and/or female whales of any life stage may be affected from the proposed action.

Table 54. Estimated impacts on fin whales over a seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using sonar and other transducers in the GOA TMAA.

Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***
Seven-year Period	728	7,875	0
One-year Maximum	104	1,125	0

Humpback Whale – Mexico DPS

Humpback whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although the timing of humpback whale migrations may change year to year, they are most likely to be present in the Action Area June through September. Impacts have been modeled for the Mexico DPS (California, Oregon, and Washington stock) humpback whales and the Navy's quantitative analysis estimates 7 exposures to result in behavioral harassment and 56 TTS every seven years of the proposed action. Both male and female humpback whales of all life stages may be exposed (Table 55).

Based on the results of the Navy's quantitative analysis, the likelihood of Western North Pacific DPS humpback whales being exposed to sonar and other transducers in the action area is extremely unlikely, and thus considered discountable.

Table 55. Estimated impacts on Mexico DPS humpback whales by over a seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using sonar and other transducers in the GOA TMAA.

Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***
Seven-year Period	7	56	0
One-year Maximum	1	8	0

North Pacific Right Whale

North Pacific right whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although North Pacific right whales are considered rare in the Action Area due to their low abundance, their occurrence in the Action Area is year round, and they are most likely to be present June through September. The Navy's quantitative analysis estimates 14 exposures resulting in behavioral harassment and 168 exposures resulting in TTS every seven years of the proposed action (Table 56). Both male and female right whales of all life stages may be exposed.

Table 56. Estimated impacts on North Pacific right whales over a seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using sonar and other transducers in the GOA TMAA.

Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***
Seven-year Period	0	14	0
One-year Maximum	0	2	0

Sei Whale

Sei whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although sei whales' occurrence in the Action Area is year round, they are considered rare, even during the summer time period. The Navy's quantitative analysis estimates 14 exposures resulting in behavioral harassment and 238 exposures resulting in TTS every seven years of the proposed action (Table 57). Both male and female sei whales of all life stages may be exposed.

Table 57. Estimated impacts on sei whales over a seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using sonar and other transducers in the GOA TMAA.

Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***
Seven-year Period	14	238	0
One-year Maximum	2	34	0

Sperm Whale

Sperm whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although sperm whales' occurrence in the TMAA is year round, they are most likely to be present June through September. The Navy's quantitative analysis estimates 749 exposures resulting in behavioral harassment and 35 exposures resulting in TTS every seven years of the proposed action (Table 58). Both male and female sperm whales of all life stages to be exposed to the proposed activities.

Table 58. Estimated impacts on sperm whales over a seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using sonar and other transducers in the GOA TMAA.

Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***
Seven-year Period	749	35	0
One-year Maximum	107	5	0

Above we described the anticipated number and types of exposures of ESA-listed marine mammals to sonar and other transducers associated with the proposed action. Given the above estimated exposures of ESA-listed marine mammals to sonar and other transducers associated with the proposed action, here we describe the likely responses of these species to these exposure types and levels. This includes behavioral responses and sound-induced hearing loss (i.e., TTS), as well as other possible responses (e.g., stress) that marine mammals may exhibit to exposure to sound fields from sonar and other transducers.

Hearing Threshold Shifts

The hearing effectiveness of an individual animal can vary depending on the duration, frequency, and magnitude of the shift. Hearing loss will vary depending on the frequency of the fatiguing noise, with diminished hearing abilities within those frequencies at and above the noise frequency which was affected. Recent literature on harbor porpoises showed that at higher sound pressure levels, hearing was most affected at frequencies half an octave above the center frequency of the fatiguing sound, while hearing was most affected at the center frequency of the fatiguing sound when the animals were exposed to lower sound pressure levels (Kastelein et al. 2020; Kastelein et al. 2019a; Kastelein et al. 2019c). 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), although most sources individually operate over a relatively narrow frequency band. Marine mammals 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. Pinnipeds probably use sound and vibrations to find and capture prey underwater. 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 use sound to find and capture prey underwater. Therefore, it could be more difficult for pinnipeds (e.g. Guadalupe fur seals) and odontocetes (e.g., sperm whales) to locate prey for a short period before their hearing recovers, assuming the TTS is within a frequency range used by these species for hunting.

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 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 2015b). 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. Because TTS would likely be minor to moderate (less than 20 dB of TTS) and last for a short period of time (minutes to hours), costs would likely not be consequential to the animal long term. Behavioral research 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 blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, or sperm whale would experience TTS as the result of being exposed to sonar and other transducers from Navy training activities (see Table 53 through Table 58 for estimates). 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.

There is also the potential for repeated 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. Because we don't know what the condition of the animal's hearing is at the time of first exposure, it is possible that in some instances a minor TTS could exacerbate an already sensitive or vulnerable animal, thus increasing the risk of more severe effects. Given the relatively low usage of Navy sonar in the action area, and low predicted instances of TTS per individual in each ESA-listed population, the likelihood of repeat instances of TTS in a given day is very low.

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. While the risk functions were developed by identifying significant behavioral responses in the data sets (i.e., those that were moderate or high severity based on the Southall et al. (2007) severity scale), the estimates calculated using the behavioral response functions (as shown in Table 50 through Table 52) 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 was presented earlier in this section. 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 a marine mammals 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. (2013) 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. (2013) 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." Additional controlled exposure experiments with mid-frequency sonar elicited behavioral responses from more than half of tagged blue whales feeding at depth, while no behavioral responses from blue whales feeding near the surface (Southall et al. 2019a). Friedlaender et al. (2016a) reported that deep-feeding blue whales responded more strongly to mid-frequency sonar than whales in other behavioral states. If individual ESA-listed cetaceans briefly respond to underwater sound from Navy training (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 cetaceans 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. (2013) 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 (Southall et al. 2007)., we do not anticipate this movement to be consequential to the animal over the long-term

While the Navy implements a series of mitigation measures to minimize high level sonar exposures during training 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. 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. While some Navy activities involve the use of sonar from multiple platforms over days or weeks, the proposed activities within the GOA TMAA do not include any major training events, and most activities only involve unit level training with a small number of assets involved. 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 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 training activity and associated sources to assess behavioral responses (Deakos and Richlen 2015; Henderson et al. 2019; 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 cetaceans 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 cetaceans 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 for cetaceans, 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 responses to sonar in the wild.

Masking (auditory interference)

The potential effects of masking were described earlier in this section. 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 2022a). This indicates biologically-relevant sounds for individuals in close proximity would be masked intermittently for only a short time.

Newer high duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for sperm whales but, as explained above, 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. 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 earlier in this section. Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). 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.

8.2.1.2 Explosives

As described in Section 5.1.2, explosives include, but are not limited to, bombs, missiles, rockets, and naval gun shells. Explosive detonations involving these high-explosive munitions, could occur in the air or near the water's surface.

Assessing whether an explosive detonation may disturb or injure a marine mammal involves understanding the characteristics of the explosive sources, the marine mammals that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on marine mammal hearing and behavior. Many other factors besides just the received level or pressure wave of an explosion such as the animal's physical condition and size; prior experience with the explosive sound; and proximity to the explosion may influence physiological effects and behavioral reactions.

The potential range of effects from explosions include death, physical injury or trauma, observable behavioral response, and stress response that may not be detectable. Injury can occur to organs or tissues of an animal. Permanent or temporary hearing loss may occur as well. Stress can help an animal cope with changing conditions, but too much stress can result in negative physiological effects. Behavioral responses range from brief distractions to avoidance of a sound source to prolonged flight. The sections below provide additional background on the potential effects of explosives on marine mammals. In our exposure and response analyses below, we use this information to discuss the likely effects of Navy GOA TMAA explosive use on ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, or sperm whale.

8.2.1.2.1 Non-Auditory Injury

Explosive injury to marine mammals would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Corey et al. 1943; General 1991; Richmond et al. 1973). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities such as in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (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 B (Acoustic and Explosive Concepts) in the 2022 Navy GOA Final SEIS/SOEIS for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

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 kilogram explosive used off Newfoundland during demolition of an offshore oil rig platform (Ketten et al. 1993), but the proximity of the whales to the detonation was unknown. Eardrum rupture was examined in submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973). However, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects.

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

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and size of an animal's gas-containing cavities was thought to play a role in blast injury susceptibility. The lungs of most cetaceans are similar in proportion to overall body size as those of terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to cetaceans when scaled for body size. Within the marine mammals, mysticetes and deeper divers (e.g., Kogiidae, Physeteridae, Ziphiidae) tend to have lung to body size ratios that are smaller and more similar to terrestrial animal ratios than the shallow diving odontocetes (e.g., Phocoenidae, Delphinidae) and pinnipeds (Fahlman et al. 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 kilograms) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than six pounds per square inch per millisecond [psi-ms; 40 Pascals per second (Pa-s)], no instances of slight lung hemorrhage occurred below 20 psi-ms (140 Pa-s), and instances of no lung damage were observed in some exposures at higher levels up to 40 psi-ms (280 Pa-s). An impulse of 34 psi-ms (230 Pa -s) resulted in about 50 percent incidence of slight lung hemorrhage. About half of the animals had gastrointestinal tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25-27 psi-ms (170-190 Pa-s). Lung injuries were found to be slightly more prevalent than gastrointestinal tract injuries for the same exposure.

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

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

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

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

8.2.1.2.2 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 hearing frequencies resulting in 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 airguns and during impact pile driving. General research findings regarding TTS and PTS in marine mammals are discussed in Section 8.2.1.1.1.

8.2.1.2.3 Physiological Stress

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 8.2.1.1.2. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

8.2.1.2.4 Masking

Masking can also result from exposure to sound from Navy explosives. There are no direct observations of masking in marine mammals due to exposure to explosive sources. General research findings regarding masking in marine mammals due to exposure to sound and other stressors are discussed in Section 8.2.1.1.3. Due to the short duration of sound from explosives, the potential for explosives to result in masking that would be biologically significant is limited.

8.2.1.2.5 Behavioral Reactions

Impulsive signals such as explosives, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. In fact, any stimuli in the environment can cause a behavioral response in marine mammals, including noise from explosions. There are few direct observations of behavioral reactions from cetaceans due to exposure to explosive sounds. Lammers et al. (2017) recorded dolphin detections near naval mine neutralization exercises and found that although the immediate response (within 30 seconds of the explosion) was an increase in whistles relative to the 30 seconds before the explosion, there was a reduction in daytime acoustic activity during the day of and the day after the exercise within 6 km. However, the nighttime activity did not seem to be different than that prior to the exercise, and two days after there appeared to be an increase in daytime acoustic activity, indicating a rapid return to the area by the dolphins (Lammers et al. 2017). Vallejo et al. (2017) report on boat-based line-transect surveys which were run over ten years in an area where an offshore wind farm was built; these surveys included the periods of preconstruction, construction, and post-construction. Harbor porpoise were observed throughout the area during all three phases, but were not detected within the footprint of the wind farm during the construction phase, and were overall less frequent throughout the action area. They returned after the construction was completed at a slightly higher level than in the preconstruction phase. Furthermore, there was no large-scale displacement of harbor porpoises during construction, and in fact their avoidance behavior only occurred out to about 18 km, in contrast to the approximately 25 kilometers avoidance distance found in other wind farm construction and pile driving monitoring efforts.

At long distances the rise time increases as the signal duration lengthens (similar to a "ringing" sound), making the impulsive signal more similar to a non-impulsive signal. Data on behavioral responses to impulsive sound sources are limited across all cetacean groups, with only a few studies available for mysticetes and odontocetes. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-airgun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by cetaceans, it is likely that these responses represent a worst-case scenario as compared to responses to Navy impulsive sources such as explosives. Navy explosive activities typically consist of a single or multiple explosions occurring over a short period of time in a relatively small area whereas seismic surveys input impulsive sound from airguns into the water column over a long period of time and over a large area (e.g., following a transect).

For their quantitative effects analysis, the Navy assumes that significant behavioral responses to solitary explosions are not anticipated due to the short duration of acoustic exposure from such explosions, but this does not preclude the potential for responses within the range to TTS. There has been very little research conducted on this topic. Depending on numerous factors (e.g., proximity, attentional focus, charge weight of blast, and experience of the animal) the responses of individuals may vary and we would assume some animals would exhibit more of a reaction than others. The mitigation measures that would be implemented (such as exclusion zones) are expected to reduce the potential for significant behavioral responses to occur from exposure to solitary explosions.

8.2.1.2.6 Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, attraction to the source, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al. 2003; McCauley et al. 2000; Richardson et al. 1985;

Southall et al. 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin, and bowhead whales. For the purposes of this analysis, due to the limited amount of data available, it is assumed that these responses are representative of all baleen whale species. As was discussed for responses to sonar, the behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond to impulsive sources, as does the location and movement of the sound source, more than the received level of the sound.

Migratory behavior seems to lead to a higher likelihood of response, with some species demonstrating more sensitivity than others do. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 μPa (Malme et al. 1986; Malme et al. 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of five to eight kilometers from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et al. 1998) and up to three kilometers from a source vessel moving directly across their migratory path (Dunlop et al. 2017), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al. 2015). When comparing received levels and behavioral responses when using ramp-up versus a constant noise level of airguns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decreased their swim speeds (Dunlop 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials. In either case there was no dose-response relationship with the received level of the airgun 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 airguns 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 three kilometers or above 140 dB re 1 μPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al. 2017). McDonald et al. (1995b) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 kilometers 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 eight kilometers of seismic vessels (Richardson et al. 1995c), some whales avoided vessels by more than 20 kilometers 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 kilometers 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 six to eight kilometers (Gordon et al. 2003) out to 20 or 30 kilometers (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 from a sparker at average received peak-to-peak measurements of 131 dB re 1 $\mu Pa^2 s$ (Di Lorio and Clark 2010), a potentially compensatory response to increased noise level. Responses by fin whales to a 10-day seismic survey in the Mediterranean Sea included possible decreased 20-Hz call production and movement of animals from the area based on lower received levels and changes in bearings (Castellote et al. 2012). However, similarly distant seismic surveys elicited no apparent vocal response from fin whales in the mid-Atlantic Ocean; instead, Nieukirk et al. (2012) hypothesized that 20-Hz calls may have been masked from the receiver by distant seismic noise. Models of humpback whale song off Angola showed significant seasonal and diel variation, but also showed a decrease in the number of singers with increasing received levels of airgun 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 μPa^{2}s cumulative SEL (Blackwell et al. 2015).

Mysticetes seem to be the most sensitive taxonomic group of cetaceans to impulsive sound sources, with possible avoidance responses occurring out to 30 kilometers and vocal changes occurring in response to sounds over 100 kilometers away. Responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior. These response patterns are likely to hold true for Navy impulsive sources. However, Navy impulsive sources would largely be stationary and short-term (i.e., instantaneous for explosives) as compared to sources in these studies, and so responses would likely occur in closer proximity or not at all.

8.2.1.2.7 Odontocetes

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

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nautical miles 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 airguns ceased firing (Miller et al. 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al. 2009). Similarly, Weir (2008) observed that seismic airgun 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 airgun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to airgun impulses within approximately one kilometer of the source (Weir 2008). The dolphins were observed at greater distances from the vessel when the airgun was in use, and when the airgun was not in use they readily approached the vessel to bow ride.

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

A study was conducted on the response of harbor porpoises to a seismic survey using aerial surveys and C-PODs (an autonomous recording device that counts odontocete clicks); the animals appeared to have left the area of the survey, and decreased their foraging activity within 5 to 10 km, as evidenced by both a decrease in vocalizations near the survey and an increase in vocalizations at a distance (Pirotta et al. 2014; Thompson et al. 2013). The animals returned within a day after the airgun 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 kilometers 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. Received levels in this area were lower due to propagation effects than in the other areas described above, which may have led to the lack of or reduced response.

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

8.2.1.2.8 Impact Range to Effects from Explosives

Section 2.2.2 presented information on the criteria and thresholds used to estimate impacts to marine mammals from explosives. Additional information on these criteria is described in the technical report Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine

Mammals and Sea Turtles (Navy 2017a). In this section we present information on calculated range to effects for various explosive sources used by the Navy as part of the proposed action.

The tables below (Table 59 through Table 64) provide range to effects for explosives sources to the criteria and thresholds described in Section 2.2.2 as they were used as inputs into NAEMO. The range to effects are shown for a range of explosive bins from E5, E9, E10, and E12. Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause a non-auditory injury, PTS, TTS, and significant behavioral disruption. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure based ranges are estimated using the best available science; however, data on peak pressure at far distances from explosions are very limited. For additional information on how ranges to impacts from explosions were estimated, see the technical report Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training Ranges (Navy 2018c).

Ranges to mortality, based on animal mass, are shown in Table 59. Table 60 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. Ranges to gastrointestinal tract injury typically exceed ranges to slight lung injury; therefore, the maximum range to effect is not mass dependent. Animals within these water volumes would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point. SEL-based and peak based range to effects (PTS, TTS, and behavioral for SEL only) for low-frequency cetaceans are shown by bin and cluster size in Table 61 and Table 62, respectively. For mid-frequency cetaceans, SEL-based and peak based range to effects are shown in Table 63 and Table 64, respectively.

Table 59. Ranges to mortality (in meters) for all marine mammal hearing groups as a function of animal mass.

Bin[1]	*Animal Mass Intervals (kg)*[2]					
	10	*250*	*1,000*	*5,000*	*25,000*	*72,000*
E5	13 (12–14)	7 (4–11)	3 (3–4)	2 (1–3)	1 (1–1)	1 (0–1)
E9	35 (30–40)	20 (13–30)	10 (9–13)	7 (6–9)	4 (3–4)	3 (2–3)
E10	43 (40–50)	25 (16–40)	13 (11–16)	9 (7–11)	5 (4–5)	4 (3–4)
E12	55 (50–60)	30 (20–50)	17 (14–20)	11 (9–14)	6 (5–7)	5 (4–6)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
[2]Average distance to mortality (meters) is depicted above the minimum and maximum distances, which are in parentheses for each animal mass interval. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely over-estimating ranges to effect.

Table 60. Ranges to non-auditory Injury (in meters) for all marine mammal hearing groups.

Bin[1]	*Range to Non-Auditory Injury (meters)*[2]
E5	40 (40–40)
E9	121 (90–130)
E10	152 (100–160)
E12	190 (110–200)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
[2]Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely over-estimating ranges to effect.
Notes: All ranges to non-auditory injury within this table are driven by gastrointestinal tract injury thresholds regardless of animal mass.

Table 61. Sound exposure level (SEL)-based ranges to onset PTS, onset TTS, and behavioral reaction (in meters) for low-frequency cetaceans.

Range to Effects for Explosives: Low-frequency cetaceans[1]					
Bin[2]	*Modeled Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*	*Behavioral*
E5	0.1	1	171 (100–190)	633 (230–825)	934 (310–1,525)
		7	382 (170–450)	1,552 (380–5,775)	3,712 (600–13,025)
E9	0.1	1	453 (180–550)	3,119 (550–9,025)	6,462 (1,275–19,275)
E10	0.1	1	554 (210–700)	4,213 (600–13,025)	9,472 (1,775–27,275)
E12	0.1	1	643 (230–825)	6,402 (1,275–19,775)	13,562 (2,025–34,775)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely over-estimating ranges to effect.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 62. Peak pressure based ranges to onset PTS and onset TTS (in meters) for low frequency cetaceans.

Range to Effects for Explosives: Low-frequency cetaceans[1]				
Bin[2]	*Modeled Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*
E5	0.1	1	419 (170–500)	690 (210–875)
		7	419 (170–500)	690 (210–875)
E9	0.1	1	855 (270–1,275)	1,269 (400–1,775)
E10	0.1	1	953 (300–1,525)	1,500 (450–2,525)
E12	0.1	1	1,135 (360–1,525)	1,928 (525–4,775)

[1]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely over-estimating ranges to effect.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 63. Sound exposure level (SEL)-based ranges to onset PTS, onset TTS, and behavioral reaction (in meters) for mid-frequency cetaceans.

Range to Effects for Explosives: Mid-frequency cetaceans[1]					
Bin[2]	*Modeled Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*	*Behavioral*
E5	0.1	1	79 (75–80)	363 (360–370)	581 (550–600)
		7	185 (180–190)	777 (650–825)	1,157 (800–1,275)
E9	0.1	1	215 (210–220)	890 (700–950)	1,190 (825–1,525)

E10	0.1	1	275 (270–280)	974 (750–1,025)	1,455 (875–1,775)
E12	0.1	1	340 (340–340)	1,164 (825–1,275)	1,746 (925–2,025)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely over-estimating ranges to effect.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 64. Peak pressure based ranges to onset PTS and onset TTS (in meters) for mid-frequency cetaceans.

Range to Effects for Explosives: Mid-frequency cetaceans[1]				
Bin[2]	***Modeled Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E5	0.1	1	158 (150–160)	295 (290–300)
		7	158 (150–160)	295 (290–300)
E9	0.1	1	463 (430–470)	771 (575–850)
E10	0.1	1	558 (490–575)	919 (625–1,025)
E12	0.1	1	679 (550–725)	1,110 (675–1,275)

[1]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely over-estimating ranges to effect.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

8.2.1.2.9 Cetacean Exposure and Response Analysis – Explosives

The numbers of potential impacts from the quantitative analysis estimated for individual species of cetaceans from exposure to explosive energy and sound for training activities are presented below for each species. Results are presented for a maximum explosive use year. The Navy has proposed to conduct all explosive activities in the TMAA off the continental shelf and beyond the 4,000 meter isobath. No explosives would be detonated within the proposed Continental Shelf and Slope Mitigation Area (Section 4.6.2) or within the WMA. This new mitigation measure for Phase III may further reduce impacts to ESA-listed marine mammals, especially those that have a higher density on the shelf and slope habitats (e.g. blue whale, fin whale, humpback whale, North Pacific right whale, and sei whale).

Blue Whales

The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates one behavioral response of blue whales from training activities. The analysis estimates seven behavioral responses are predicted for blue whales every seven years of the proposed action (Table 65). Both male and female blue whales of all life stages may be exposed.

Table 65. Estimated impacts on blue whales every seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using explosives in the GOA TMAA.

Estimated Impacts by Effect				
Timeframe	***Behavioral***	***TTS***	***PTS***	***Injury***
Seven-year Period	7	0	0	0
One-year Maximum	1	0	0	0

Fin Whales

The quantitative analysis, using the maximum number of explosions per year under the proposed action, estimates 11 exposures resulting in behavioral responses, two exposures resulting in TTS, and two exposures resulting in PTS for fin whales. This translates into 77, 14, and 14 exposures respectively (behavioral, TTS, and PTS) every seven years of the proposed action (Table 66). Both male and female fin whales of all life stages may be exposed.

Table 66. Estimated impacts on fin whales every seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using explosives in the GOA TMAA.

Estimated Impacts by Effect				
Timeline	***Behavioral***	***TTS***	***PTS***	***Injury***
Seven-year Period	77	14	14	0
One-year Maximum	11	2	2	0

Humpback Whale – Mexico DPS

The quantitative analysis, using the maximum number of explosions per year under the proposed action, estimates a single behavioral harassment of the Mexico DPS of humpback whales per year for a total of seven behavioral responses (Table 67). Both male and female humpback whales of all life stages may be exposed.

Table 67. Estimated impacts on the humpback whale Mexico DPS every seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using explosives in the GOA TMAA.

	Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***	***Injury***
Seven-year Period	7	0	0	0
One-year Maximum	1	0	0	0

North Pacific Right Whale

The quantitative analysis, using the maximum number of explosions per year under the proposed action, estimates a single behavioral harassment of the North Pacific right whale per year for a total of seven behavioral responses (Table 68). Even if an individual right whale experiences a behavioral response a few times over the course of a year, the responses are unlikely to have any significant costs or long-term consequences for that individual. In addition to implementing procedural mitigation for explosives, from June through September (i.e., the months when North Pacific right whales are most likely to be present in the action area) the Navy will not use explosives within the North Pacific Right Whale Mitigation Area or within the large Continental Shelf Mitigation Area year-round. The North Pacific Right Whale Mitigation Area encompasses the portion of the biologically important habitat identified by Ferguson et al. (2015a) for North Pacific right whale feeding that overlaps the action area. Both male and female right whales of all life stages may be exposed.

Table 68. Estimated impacts on North Pacific right whale every seven-year period and over a year of maximum activity as a result of the proposed Navy training using explosives in the GOA TMAA.

	Estimated Impacts by Effect			
Timeframe	***Behavioral***	***TTS***	***PTS***	***Injury***
Seven-year Period	7	0	0	0

Estimated Impacts by Effect				
Timeframe	*Behavioral*	*TTS*	*PTS*	*Injury*
One-year Maximum	1	0	0	0

Sei Whales

The quantitative analysis, using the maximum number of explosives per year under the proposed action, estimates one behavioral response for sei whales from training activities annually. The analysis estimates seven behavioral responses for sei whales every seven years of the proposed action (Table 69). Both male and female sei whales of all life stages may be exposed.

Table 69. Estimated impacts on sei whales every seven-year period and over a year of maximum activity as a result of the proposed Navy training activities using explosives in the GOA TMAA.

Estimated Impacts by Effect				
Timeframe	*Behavioral*	*TTS*	*PTS*	*Injury*
Seven-year Period	7	0	0	0
One-year Maximum	1	0	0	0

Sperm Whales

The quantitative analysis, using the maximum number of explosions per year under the proposed action, estimates no impacts to sperm whales due to training activities using explosives. Based on the results of the Navy's quantitative analysis, the likelihood of sperm whales being exposed to explosive sound and energy in the offshore portion of the action area is extremely unlikely, and thus considered discountable. Therefore, we conclude the impacts of explosives from activities associated with the proposed action may affect, but is not likely to adversely affect sperm whale.

Summary

Above, we described the types and numbers of exposures of ESA-listed cetaceans to explosives associated with the proposed action. Given the above estimated types and numbers of exposures of ESA-listed cetaceans to explosives, here we describe in more detail the likely responses of these species to this exposure. This includes behavioral response, sound-induced hearing loss (i.e., TTS), as well as other possible responses (e.g., stress) that cetaceans may exhibit as a result of exposure to Navy explosives.

Hearing Threshold Shifts

The response of ESA-listed cetaceans from exposure to explosives resulting in TTS and PTS is expected to be similar to the response of ESA-listed cetaceans experiencing hearing loss due to sonar or other transducers. The exception is that because active sonar is transmitted at a specified frequency, animals 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 an increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. Based on information regarding sound levels and hearing thresholds for these animals, our response analysis indicates that annually, exposures to explosives are expected to result in two exposures resulting in TTS and two exposures resulting in PTS for fin whales each year. No other ESA-listed cetaceans are expected to experience TTS or PTS from Navy explosives in the action area.

Behavioral response

The exposure analysis indicates that several cetacean species could experience behavioral disruptions as a result of exposures to explosives. These include 11 fin whale exposures and one exposure each to blue whale, humpback whale (Mexico DPS), North Pacific right whale, and sei whale that are expected to result in significant behavioral disruptions as a result of exposures to explosives.

General research findings regarding potential behavioral reactions from marine mammals due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail earlier in this section. Behavioral reactions from explosive sounds could be similar to reactions studied for other impulsive sounds such as those produced by seismic airguns (e.g., startle reactions, avoidance of the sound source), but there are important differences in how seismic surveys using airguns are conducted compared with explosive use by the Navy. Seismic surveys using airguns are typically conducted over transects and successive airgun blasts occurring over a sustained period of time. In contrast, Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time. The available information on the response of humpback and sei whales to explosives indicates animals may alert to the sound source, may alter foraging behavior, or exhibit avoidance behavior. These responses are expected to be similar in the other cetaceans and are expected to be temporary with behavior returning to a baseline state shortly after the activity using explosives ends. The exposure analysis indicates that exposures to explosives are expected to result in significant behavioral disruptions of ESA-listed cetaceans each year as a result of GOA TMAA activities. The only species not expected to experience significant behavioral disruptions from Navy explosives in the action area is the sperm whale.

Non-auditory Physical or Physiological responses

The available research on the potential for explosives or other sources of anthropogenic noise to result in physiological responses (e.g., stress) is described earlier in this section. Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). However, increased stress has been documented as a result of both acute (e.g., Romano et al. 2004) and chronic (e.g., Rolland et al. 2012) anthropogenic noise. As described previously, though there are unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Masking

Some limited masking could occur due to the Navy's use of explosives when animals are in close enough proximity. That is, if an animal is close enough to the source to experience TTS or a significant behavioral disruption, we anticipate some masking could occur. Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Given that Navy explosive use typically involves a single detonation or series of detonations conducted over a short period of time, if masking occurs it would likely be a very short-term effect.

8.2.1.3 Anticipated Consequences of Sonar and Explosive Stressors on Individual Cetaceans Exposed

In the exposure and response analyses above, we established that a range of impacts including PTS, TTS, behavioral response, and physiological stress are likely to occur due to exposure to Navy sonar and explosives during GOA TMAA activities. In this, section we assess the likely consequences of the responses to the individual ESA-listed marine mammals 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, the transient nature of sonar use, and the short duration of explosive sound effects. As such, we have concluded that there is little to no risk to marine mammals associated with exposure and response to the effects of masking.

Efforts have been made to link short-term effects to individuals due to anthropogenic stressors with long-term consequences to marine mammal populations using population models. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. Unfortunately, for acoustic and explosive impacts on cetacean populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The Population Consequences of Acoustic Disturbance model (NRC 2005) proposes a conceptual framework for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population.

In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al. 2016a; Costa et al. 2016b; Harwood et al. 2014; Hatch et al. 2012; New et al. 2014; New et al. 2013a; New et al. 2013b; Pirotta et al. 2018). However, the Population Consequences of Disturbance model is still in the preliminary stages of development. Costa et al. (2016b) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions.

The long-term consequences due to individual behavioral reactions and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like cetaceans. Of critical importance in discussions of the potential consequences of such effects is the health of the individual animals disturbed, and the trajectory of the population those individuals comprise. The consequences of disturbance, particularly repeated effects, would be more significant if the affected animal were already in poor condition. As such, animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. Short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences to individuals exposed to the effects of Navy sonars and other transducers as part of the proposed action.

To consider the potential consequences of PTS, TTS, and behavioral response and stress to affected animals, we also consider the context of the exposure and response scenario including the following: 1) the duration of the exposure and associated response, 2) whether or not repeated exposures would be expected, 3) the behavioral state of the animal at the time of the response, and 4) the health of the animal at the time of the response.

As described previously, cetaceans 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. A hearing threshold shift of limited duration and occurring in a frequency range that does not coincide with that used for vocalization or recognition of important acoustic cues would likely have no effect on an animal's fitness.

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. Navy proposed mitigation measures (i.e., not deploying an explosive when a marine mammal is in the mitigation zone) may further reduce 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. All explosives used in the GOA TMAA are in-air or near the water surface and NAEMO modeled explosive effects to a depth of 0.1 m, which is more conservative and likely overestimates the potential impacts from explosives to ESA-listed cetaceans. Additionally, the Navy's proposed mitigation measures (i.e., not deploying an explosive when a marine mammal is in the mitigation zone) may further reduce the likelihood that cetaceans will be close to the impact area at the time of detonation. This reduces the potential for more severe instances of PTS from explosives to ESA-listed cetaceans.

In most cases, TTS is expected to be of short duration. Longer duration TTS is expected to last hours or at most a few days (Finneran 2015b). Unlike TTS, PTS is permanent, meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of an animal's life functions, including those that do not overlap in time and space with the proposed action. While hearing loss in marine mammals resulting from temporary exposure to PTS-causing sound levels is not expected to deafen the animals, we expect it would have some effect on the hearing ability of the animals in the frequencies of the sound that caused the damage. For the purposes of this assessment, we assume that the PTS-causing frequencies overlap with those utilized by animals for acoustic cues. Therefore, PTS from explosives may interfere with the ability of fin whales (the only species expected to experience PTS as a result of the proposed action) to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. The ability to detect anthropogenic sounds may be important to provide information on the location and direction of human activities, and may provide a warning regarding nearby activities that may be hazardous. The ability to detect conspecifics is also important for mating and mother-calf communication.

Our exposure and response analyses indicate that fin whales would experience PTS, but this PTS is expected to be minor due to the conservative methods used to calculate impacts and the Navy's proposed mitigation. With this minor degree of PTS, a few individual fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances.

The duration and magnitude of the proposed activity is important to consider in determining the likely severity, duration, and potential consequences of exposure and associated response to Navy explosives. As noted in Southall et al. (2007), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. However, 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). Therefore, there is a low likelihood that animals and Navy activities would co-occur for extended periods of time or repetitively over the duration of an activity. Proposed mitigation measures may further reduce the likelihood of this occurring.

Analysis predicts that exposure to explosive acoustic sources would result in two PTS exposures annually, and 14 PTS exposures every seven years of the proposed action for fin whales. For the GOA TMAA, explosives training activities would result in an estimated 0.0006 PTS exposures annually per fin whale.

Based on our review of the available literature (discussed above), 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. Because active sonar is transmitted at a specified frequency, animals experiencing TTS from sonar would only experience threshold shifts around that particular frequency. In contrast, explosives are a broadband source, so if an animal experiences TTS from explosives, a greater frequency band would be affected. Because a greater frequency band would be affected due to explosives, there is increased chance that the hearing impairment will affect frequencies utilized by animals for acoustic cues. The exposure analysis estimates two annual exposures to explosives resulting in TTS and two annual exposures resulting in PTS of fin whales. Exposures resulting in TTS and PTS in fin whales are both estimated to be 0.0006 individual animals annually, with potential occurrence in the GOA TMAA. These numbers represent the estimated TTS and PTS exposures during a maximum year (21 consecutive days) of GOA TMAA explosive activity levels, and estimates in some years would be lower. No other ESA-listed cetacean are expected to experience TTS or PTS from Navy explosives in the action area. Given these low exposure numbers, it is unlikely that an individual whale would experience TTS from Navy explosives more than once per year, or possibly per lifetime. Thus, adverse effects on acoustic cues resulting from exposure to TTS from explosives would likely be limited in scope and duration for individual whales. The two PTS exposures that may occur annually to fin whales are expected to be minor due to the conservative methods used to calculate impacts and the Navy’s mitigation. With this minor degree of PTS, even though an individual fin whale is expected to experience a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance), we would not expect such impacts to have meaningful effects at the population level.

The available literature on cetacean behavioral responses indicate that most 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 cetacean 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 and explosives. As noted in Southall et al. (2007), 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. Several categories of training exercises are expected to result in hundreds of hours of sonar activity involving multiple platforms (i.e., surface vessels, submarines, and aircraft) utilizing sonar, as well as the use of explosives. 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, 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 would co-occur for extended periods of time or repetitively over the duration of an activity.

While it is difficult to predict exactly what a marine mammal may be doing at the time of exposure, we can make some predictions based on time of year and the location of the animal at the time of exposure, where such information is available. Humpback whales are known to feed in and around waters near the action area (Bettridge et al. 2015b). Anthropogenic noise can have negative impacts on marine mammals if they result in the animals leaving the area, potentially away from a food source.

Also important to consider is an animal's prior experience with a sound source. The majority of ESA-listed marine mammals exposed to sound from GOA TMAA 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. (2017) found no large-scale avoidance by false killer whales of areas with 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.

Quantifying the fitness consequences of sub-lethal behavioral impacts and effects on hearing is exceedingly difficult for marine mammals because of the limitations of studying these species (e.g., due to the costs and logistical challenges of studying animals that spend the majority of time underwater). Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try and quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). A key limitation in these models is that we often do not have empirical data to link sub-lethal behavioral responses to effects on animal vital rates.

Behavioral responses may impact health through a variety of different mechanisms, but most Population Consequences of Disturbance models focus on how such responses affect an animal's energy budget (Farmer et al. 2018; King et al. 2015; NAS 2017; New et al. 2014; Villegas-Amtmann et al. 2017). Responses that relate to foraging behavior, such as those that may indicate reduced foraging efficiency or involve the complete cessation of foraging, may result in an energetic loss to animals (Miller et al. 2009). Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (Bejder et al. 2019; NAS 2017). Important in considering whether or not energetic losses, whether due to reduced foraging or increased traveling, will affect an individual's fitness is considering the duration of exposure and associated response. Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts on an animal (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007; 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 or an explosion 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 due to the low densities of the ESA-listed cetaceans in the action area and the size and relative ease of detection of these species by shipboard observers. Therefore, we focus our risk analysis on the energetic costs associated with a behavioral response.

We would expect many of the anticipated exposures and potential responses of ESA-listed cetaceans to sonar and explosives to have little effect on the exposed animals. Based on the controlled exposure experiments and opportunistic research presented above, responses are expected to be short term, with the animal returning to normal behavioral patterns shortly after the exposure is over. However, there is some uncertainty due to the limitations of the controlled exposure experiments and observational studies used to inform our analysis. Additionally, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. Quantifying the fitness consequences of sub-lethal impacts from acoustic stressors is exceedingly difficult for cetaceans and we do not currently have data to conduct a quantitative analysis on the likely consequences of such sub-lethal impacts. While we are unable to conduct a quantitative analysis on how sub-lethal behavioral effects and temporary hearing impacts may impact animal vital rates (and therefore fitness), based on the best available information, we expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

During exposure, affected animals may be engaged in any number of activities including, but not limited to, migration, foraging, nursing, or resting. If marine mammals exhibited a behavioral response to Navy explosives, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, behavioral responses to Navy explosives are anticipated to be short-term. Based on best available information that indicates marine mammals resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013; Melcon et al. 2012), we anticipate that exposed animals will be able to return normal behavioral patterns after this short duration activity ceases. Goldbogen et al. (2013) suggested that if the documented temporary behavioral responses interrupted behavior, this could have impacts on individual fitness and eventually, population health. For this to be true, we would have to assume that an individual animal could not compensate for this lost resting/nursing or feeding opportunity by either moving to another location, by stopping the activity until shortly after cessation of acoustic exposure, or by resting/nursing or feeding at a later time. There is no indication this is the case. There would likely be an energetic cost associated with any temporary disruption of cetacean feeding activities to find alternative locations for these to occur. However, unless such disruptions occur over long durations or over subsequent days, we do not anticipate these movement to be consequential to the animal's fitness over the long-term (Southall et al.

2007). While activities could be conducted for up to 21 days, there is no Navy activity in the proposed action that is both long in duration (more than a day) and concentrated in the same location.

Based on the estimated abundance of the ESA-listed cetaceans that are expected to occur in the action area, and the estimated maximum annual number of instances of behavioral disruption (i.e., TTS or significant behavioral response) expected from sonar and explosives (i.e., estimates based on Navy modeling using maximum annual activity level), most individual blue whales, fin whales, humpback whales, North Pacific right whales, sei whales, sperm whales would likely experience no more than one behavioral disruption in any given year as a result of GOA training (Table 70). For most species, the likelihood that an individual ESA-listed cetacean would experience multiple exposures annually is extremely low, and most individuals within the population would not experience a single behavioral disruption per year due to Navy sonar or explosives in the GOA TMAA. For fin whales and sperm whales, the average annual disruptions per animal is greater than other species due to the relatively higher densities of these species in the action area. This also suggests a greater likelihood that multiple exposures of the same individual could occur annually for these two species, particularly considering that all estimated exposures would occur within the three-week GOA timeframe. However, available information does not allow us to estimate the frequency of this occurring (i.e., multiple exposures of one individual) or the maximum number of exposures one whale could experience in a given year.

Table 70. Estimated average behavioral disruptions (i.e., TTS or significant behavioral response) from Navy sonar (and other transducers) and explosives per animal of each species/stock/DPS in the action area. These estimates are based on a year of estimated maximum behavioral disruptions during a year of maximum sonar and explosive activity levels.

Species	Size of Listing Unit Likely to be Found in Action Area	Annual Behavioral Disruptions from Active Sonar and Explosives	Average Annual Disruptions per Animal
Blue Whale	1,496	39	0.026
Fin Whale	3,168	1,244	0.393
Humpback Whale –Mexico DPS	2,900	10	0.003
North Pacific Right Whale	31	3	0.096
Sei Whale	29,632	37	0.001
Sperm Whale	345	112	0.325

We recognize that the calculation of the number of disruptions per animal is based on Navy modeling and is a rough approximation of what will occur during Navy training activities in the action area. Therefore, some individuals from each species could experience a few more or less disruptions annually than what is presented. This is especially relevant given the fact that all of the estimated exposures would occur in a three week period, therefore, increasing the likelihood that individual whales (e.g., fin or sperm whales) could experience multiple exposures. 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 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 and explosives annually. The estimates presented in Table 70 are based on conservative assumptions, and are provided to indicate the relative magnitude of likely exposures on an annual basis.

In summary, we anticipate some animals in the action area could experience more than one behavioral disruption per year, but animals would be exposed periodically and based on the available literature that indicates infrequent exposures are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015; NAS 2017; New et al. 2014; Southall et al. 2007; Villegas-Amtmann et al. 2015), we do not expect this level of exposure to impact the long-term fitness of exposed animals. These sub-lethal effects would be short-term and temporary, and are expected to result in only minor changes in energy expenditure for the individual whale affected. 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 in TTS, recovery occurs quickly (Finneran 2015b). The brief amount of time cetaceans are expected to experience TTS may temporarily impair their ability to communicate, forage, or breed, but the effects would not be permanent, and are not expected to result in long-term fitness consequences for the individuals affected. Additionally, we do not anticipate these species will experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history and that 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. Although there is an increased chance that TTS resulting from explosives would affect frequencies utilized by animals for acoustic cues (as compared to TTS from sonar), the Navy's quantitative model predicts very few instances of TTS from explosives. Since it is unlikely that an individual marine mammal would experience TTS from Navy explosives on multiple occasions within a given year, adverse effects on acoustic cues resulting from such exposures would likely be limited in scope and duration for individual whales.

For the reasons above, we do not anticipate that instances of TTS or behavioral response from Navy activities involving sonar (and other transducers) and explosives would result in long-term fitness consequences to individual ESA-listed blue whale, fin whale, Mexico DPS humpback whale, North Pacific right whale, sei whale, or sperm whale in the action area.

We anticipate that instances of fin whale PTS could result in fitness consequences to the individual. 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. With this PTS exposure, those individual fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances. PTS from explosives may interfere with the ability of individual fin whales to hear sounds produced by ships, construction activities, seismic surveys, or communication signals of conspecifics. Our exposure and response analyses indicate that two fin whales would experience PTS annually as a result of explosives during the proposed activity. However, these individuals (i.e., two annually) would represent a very small portion of the fin whale population. 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 (Nadeem et al. 2016). Although we cannot quantify the magnitude of PTS, given the Navy's proposed procedural mitigation measures for active sonar, the conservative methods used to calculate impacts, the short PTS range to effects for low-frequency cetaceans from MF1 sonar (Navy 2018c), and the anticipated vessel speed, incidents of PTS are expected to be of relatively low magnitude. With this minor degree of PTS, even though an individual fin whale is expected to experience a 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.

8.2.2 Fishes – Effects of Explosive Stressors

Of all the potential stressors resulting from the proposed GOA TMAA activities (see Section 5 Potential Stressors), we determined that only stressors associated with the use of explosives would likely result in adverse effects to ESA-listed salmonids. Previously, in Section 8.1.2, we discussed those stressors associated with the proposed action that we determined were not likely to adversely affect ESA-listed salmonids. The effects of explosions on fish have been studied and reviewed by numerous authors (Hawkins and Johnstone 1978; Popper 2008; Popper et al. 2007a; Popper et al. 2014b; Tavolga and Wodinsky 1963). This section discusses the effects of explosive stressors from the proposed action on ESA-listed chum salmon (Columbia River and Hood Canal Summer-Run ESUs), sockeye salmon (Ozette Lake and Snake River ESUs), and steelhead (all six DPSs listed in Section 6.2) (see Section 5.1.2 for a general discussion of explosives as a potential stressor).

Training activities using explosive ordnances that could affect ESA-listed salmonids will occur in the GOA TMAA. The general categories, explosive weights, and numbers of the explosives that are likely to adversely affect ESA-listed salmonids in the proposed action area are presented in Table 71. As a mitigation measure, the Navy has proposed to conduct all training activities using explosive ordnance off the Alaskan continental shelf and beyond the 4,000 meter depth contour on the slope. A more thorough description of Navy GOA activities involving the use of explosives is provided in the Description of the Action (Section 0) and the Navy's FSEIS/OEIS (Navy 2022a).

Table 71. Explosive ordnances used during Navy training activities in the GOA TMAA.

Source Class: Net Explosive Weight (pounds)	Representative munition	Ordnance per year (annual)
E5: 5-10	5" projectile	56
E9: 100-250	500 lb. bomb	64
E10: 250-500	1,000 lb. bomb	6
E12: 650-1,000	2,000 lb. bomb	2

8.2.2.1 Ranges to Effects

Using the explosives exposure criteria described for fish in Section 2.3.2, the Navy developed ranges to effects for fish mortality, injury, and TTS (See Table 72 and 73 below). Fishes within these ranges could be exposed above the effect threshold levels and a portion may experience those effects. Ranges may vary greatly depending on factors such as the cluster size, location, depth, and season of the event, all of which are accounted for in NAEMO. The NAEMO model which predicted these ranges cannot account for the highly non-linear effects of cavitation and surface blowoff; therefore, some estimated ranges may be overly conservative. Also, the ranges are the distance where the threshold is not exceeded at any depth where animals could be present (the entire water column for fishes). Thus, portions of the water column within the ranges shown would not exceed mortality, injury, or TTS thresholds (i.e., the range does not represent a cylinder of effect in the water column).

As noted previously (Section 2.3.2), our range to effects for fish injury are based on the more conservative acoustic injury criterion of > 207 dB peak re 1 μPa for fishes with a swim bladder (versus the Navy's proposed 220 dB peak re 1 μPa). The ranges to effects used in our analysis (i.e., based on 207 dB peak re 1 μPa) are also a conservative approach since the criterion they are based on is expressed in Popper et al. (2014a) as "greater than" the 207 dB threshold. In combination, these factors likely result in conservatively high estimates of salmonid fish injury from Navy explosives. In addition, the range to effects for in air and near surface explosions (Table 72 nd 73) are calculated within the model as if they occur in water (at 0.1 meter depth), therefore these ranges likely overestimate the area impacted since they don't account for the air-water interface.

Table 72. Ranges to mortality and injury from explosives for fishes with and without a swim bladder.

Bin[1]	*Range to Effects (meters)*	
	Onset of Mortality	*Onset of Injury*
	229 SPL_{peak} (all fishes)	***> 207 SPL_{peak}*** (fishes with a swim bladder)
E5	175 (170–180)	< 1,525 (1,525—1,525)
E9	500 (500–500)	< 3,775 (3,775—3,775)
E10	638 (625–650)	< 4,706 (4,525—5,275)
E12	800 (800–800)	< 5,553 (5,275—6,275)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: (1) SPL_{peak} = Peak sound pressure level, < indicates that the given range would be less than the estimated range provided. (2) Range to effects for in-air and near surface explosions are calculated within the model as if they occur in water (at 0.1m depth), therefore these ranges likely overestimate the actual area of effect. Ranges 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.

Table 73. Range to TTS for fishes with a swim bladder from explosives.

Bin[1]	Cluster Size	Range to Effects (meters)
		TTS
		SEL_{cum}
E5	1	< 155 (150–160)
	7	< 365 (360–370)
E9	1	< 450 (440–460)
E10	1	< 563 (550–575)
E12	1	< 711 (700–750)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650– 1,000)
Notes: (1) SELcum = Cumulative sound exposure level, TTS = Temporary Threshold Shift, < indicates that the given range would be less than the estimated range provided. (2) Range to effects for in-air and near surface explosions are calculated within the model as if they occur in water (at 0.1m depth), therefore these ranges likely overestimate the actual area of effect. Ranges 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.

8.2.2.2 Exposure Analysis

In Section 6.1 above, we determined that the proposed action may affect but would not likely adversely affect ESA-listed Chinook salmon ESUs from Oregon, Washington, and Idaho (Section 6.1.6), ESA-listed salmonid ESU/DPSs from California (Section 6.1.7), and two ESUs of ESA-listed coho salmon (Section 6.1.8). In this section, we provide our exposure analysis for the following ESA-listed salmonids that we determined are likely to be adversely affected from the use of Navy explosives in the action area: chum salmon Columbia River and Hood Canal summer-run ESUs; sockeye salmon Ozette Lake and Snake River ESUs; and steelhead Lower Columbia River, Middle Columbia River, Upper Columbia River, Puget Sound, Snake River Basin, and Upper Willamette River DPSs.

It is difficult to accurately estimate the number of individuals from each ESU/DPS that will experience adverse effects from elevated underwater noise and sound pressures in the marine environment because fish distribution is influenced by numerous environmental factors. When ESA-listed salmonid ESU/DPSs from the U.S. West Coast migrate into the GOA they are mixed with hundreds to thousands of other stocks (Bellinger et al. 2015) originating from British Columbia, Alaska, Asia, as well as non-listed populations from the West Coast. Available information for estimating the stock origins of salmonids in the GOA is limited, particularly for the offshore portion of the GOA where Navy explosives would occur (i.e., beyond 4,000 meter depth contour). This lack of information makes it difficult to accurately estimate how many individuals from each ESA-listed ESU/DPS may be exposed to explosive stressors. Other unknowns, including the specific locations where explosives would be detonated within the vast TMAA or the time of year (within the proposed April to October timeframe) the Navy's GOA three-week training window would occur, add to the difficulty of quantifying exposures.

Chum Salmon

Echave et al. (2012) found that within the Gulf of Alaska, juvenile chum salmon are distributed throughout the inner and middle shelf along the Gulf coastline from Dixon entrance to the eastern Aleutian Islands. While juvenile chum salmon appear to have a thorough distribution in the western half of the GOA, these are mostly low abundance areas. Based on the information available, we find it extremely unlikely (i.e., discountable) that juvenile chum from ESA-listed ESUs would be exposed to Navy explosives occurring off the shelf and beyond the 4,000 meter depth contour (i.e., outside of the Continental Shelf and Slope Mitigation Area) within the TMAA. Immature and mature adult chum salmon and sockeye salmon are distributed widely throughout the outer portion of the continental shelf and over oceanic waters as far offshore as the U.S. EEZ boundary (Echave et al. 2012; Myers et al. 1996b). We have no additional information on the distribution, abundance or density of specific ESA-listed chum or sockeye salmon ESUs within the action area.

In their GOA Phase II analysis, NMFS (2017c) estimated densities for ESA-listed salmonids in the action area based on information regarding the geographic distribution and abundance of each ESU or DPS. This approach was based on the assumption of even distribution of fish throughout the geographic range of each ESU or DPS. In reality, densities of ESA-listed salmonids in the action area would likely be lower than the NMFS (2017c) estimates because the action area represents the northern edge of these species' ranges. Higher densities would be expected much closer to each ESU's or DPS's natal watershed. Based on information presented above from coded-wire tag recoveries, many of the salmon migrating from Oregon and Washington natal streams do not go farther north than Vancouver Island or Southeast Alaska. NMFS (2017c) estimated densities are also likely conservatively high for the offshore portion of the action area (greater than 4,000 meters) where explosives would be used, because, based on their coastal migratory behavior, higher densities for many salmon populations would be expected in nearshore areas and on the shelf during much of the year.

NMFS (2017c) combined these conservatively high ESA-listed salmonid density estimates with the ranges to effects estimates provided by the Navy for Phase II to quantify the number of fish within each ESU that would be exposed to explosives at threshold levels resulting in injury or mortality. The range to effects estimates used in NMFS (2017c) for the Phase II fish exposure analysis are generally smaller than those presented above for Phase III in Table 72 and Table 73, particularly for onset of injury. The larger Phase III ranges to effects would result in a larger area affected by explosions and, thus, a greater number of fish exposed. However, as discussed above, since the Navy's Phase III ranges to effects were calculated based on in-water explosive detonations (i.e., just below the surface) they are considered conservatively large for estimating exposures to the in-air explosives used by the Navy in GOA (i.e., will result in a conservatively high estimate of fish injured or killed). Therefore, the smaller ranges to effects used for the Phase II exposure analysis may have been offset to some extent by modeling explosive impacts based on in-water detonations, which would be expected to have considerably larger ranges to effects as compared to in air detonations.

NMFS (2017c) estimated the following number of injuries and mortalities of adult (immature and mature) chum salmon (by ESU) per year from the GOA Phase II action: Hood Canal chum - 0.16 killed, 0.28 injured; Columbia River chum - 0.09 killed, 0.17 injured. Thus, NMFS (2017c) estimated impacts on ESA-listed chum salmon from GOA Phase II explosives are extremely small. While the larger ranges to effects calculated for Phase III would have resulted in a greater number of estimated exposures for Phase II, this would likely be offset by the highly conservative assumptions regarding the density of ESA-listed ESUs in the action area and the use of in-water explosives models as a surrogate for the estimating the effects of in air explosives. In addition, whereas GOA Phase II included six E5 detonations on the shelf, the proposed Navy mitigation measure for Phase III to move all explosives off the continental shelf and beyond 4,000 meters should further reduce impacts to ESA-listed chum salmon. Therefore, we expect the impacts to ESA-listed chum from the proposed action to be similar to those estimated by NMFS (2017c) for GOA Phase II. Although we do not quantify the number of fish exposed in this analysis, we anticipate the number of adult Hood Canal and Columbia River chum killed and injured by explosive use as a result of the proposed action to be extremely small (i.e., likely less than one injury or mortality per year from each ESU). Some proportion of exposures resulting in injury would likely also produce TTS. Although we cannot quantify, we also anticipate additional adult Hood Canal and Columbia River chum would be exposed to explosives at levels resulting in a short-term behavioral response or physiological stress response.

Sockeye Salmon

While NMFS (2017c) did not estimate any ESA-listed sockeye salmon exposures to the effects of GOA Phase II explosives, based on the available information regarding their distribution throughout the GOA, we anticipate adult sockeye from the Ozette Lake and Snake River ESUs could be exposed. Echave et al. (2012) documented that the distribution of juvenile sockeye salmon in the Gulf of Alaska is generally contained to the continental shelf. Tucker et al. (2009) studied the migratory patterns of juvenile sockeye salmon and found that the majority were caught from central British Columbia to Southeast Alaska. They did not observe juvenile sockeye originating from the Columbia River or the Washington coast (inclusive of Lake Ozette sockeye) north of southeast Alaska during any time of the year. Thus, based on the information available, we find it extremely unlikely (i.e., discountable) that juvenile sockeye from ESA-listed ESUs would be exposed to Navy explosives occurring off the shelf and beyond the 4,000 meter depth contour (i.e., outside the Continental Shelf and Slope Mitigation Area) within the TMAA. Distribution of adult sockeye salmon within the GOA is widespread and sparse, consisting of low relative abundance extending from coastal waters to the U.S. EEZ boundary(Echave et al. 2012). Estimated adult population abundances (natural and hatchery fish combined) for Ozette Lake (5,036 adults) and Snake River sockeye (4,550) ESUs are relatively small compared to other ESA-listed salmonids, including Hood Canal and Columbia River chum (NMFS 2019b; NMFS 2019c; NMFS 2020b; Zabel 2015; Zabel 2017a; Zabel 2017b; Zabel 2018; Zabel 2020).

Based on the likelihood that ESA-listed sockeye densities in the offshore portion of the action area are very low, we anticipate the number of exposures to explosives to be as small or smaller as those anticipated for ESA-listed chum, as described above. Although we do not quantify the number of exposures in this analysis, we expect the number of adult Ozette Lake and Snake River ESU sockeye killed and injured by explosive use as a result of the proposed action to be extremely small (i.e., likely less than one injury or mortality per year from each ESU). Some proportion of exposures resulting in injury would likely also produce TTS. Although we cannot quantify, we also anticipate additional adult Ozette Lake and Snake River ESU sockeye salmon would be exposed to explosives at levels resulting in a short-term behavioral response or physiological stress response.

Steelhead

Steelhead are thought to rely heavily on offshore marine waters for feeding. ESA-listed steelhead originating from freshwater streams in the Pacific Northwest are known to occur in the offshore portion of the GOA during both their juvenile or adult life stages (NMFS 2015a). Thus, both life stages are expected to occur in portions of the action area where they could be exposed to the effects of Navy explosives. Steelhead capture data indicate a more offshore distribution for this species as compared to the other salmonid species considered in this opinion (i.e., Chinook, coho, chum and sockeye salmon). Studies by Daly et al. (2014) and Pearcy and Fisher (1990) suggest a rapid offshore migration by juvenile steelhead after leaving the freshwater environment. Light et al. (1989) reported that both juvenile and adult steelhead were distributed across the North Pacific throughout the year at distances greater than 50 nautical miles from shore.

Recoveries of coded-wire tagged steelhead in the North Pacific Ocean from high seas commercial fishery and research catches from 1981-2008 are shown in Figure 61. The ocean distribution of coded-wire tag recoveries of steelhead originating from Oregon rivers from 1956-2004 is shown in Figure 62. These data suggest a fairly wide distribution throughout the northern GOA, including the offshore portions of the action area where explosives would be used.

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 one meter of the water column, with few movements below seven meters. A preferred use of the upper portion of the water column would likely result in steelhead being in closer proximity and, therefore, more susceptible to the impacts of explosives detonated at (or near) the water's surface (as compared to species that occupy deeper water habitat).

As part of the effects analysis conducted for the Navy Northwest Training (NWTT) biological opinion, NMFS (2020c) estimated densities of each ESA-listed steelhead DPS based on information regarding the geographic distribution and abundance of each population. We have no new information regarding steelhead geographic distributions or abundances since the NMFS (2020c) opinion was issued that would change these estimated densities. Therefore, for purposes of our fish exposure analysis for this opinion we apply the NMFS (2020c) estimated densities for each ESA-listed steelhead DPS (Table 74). While this approach was used to estimate densities within the NWTT action area, the approach used assumed a uniform density distribution across the entire range of each DPS, including the GOA action area. Given the distance from their natal streams in Washington and Oregon to the GOA, we would expect steelhead densities would be relatively higher in offshore areas closer to their natal streams than in the GOA TMAA. Therefore, these density estimates are likely conservatively high for the action area. However, based on the available information on steelhead migratory patterns and abundance and their generally widespread distribution in offshore areas, we believe these still represent the best available estimates of steelhead densities for the offshore portion of the TMAA where explosives would be used.

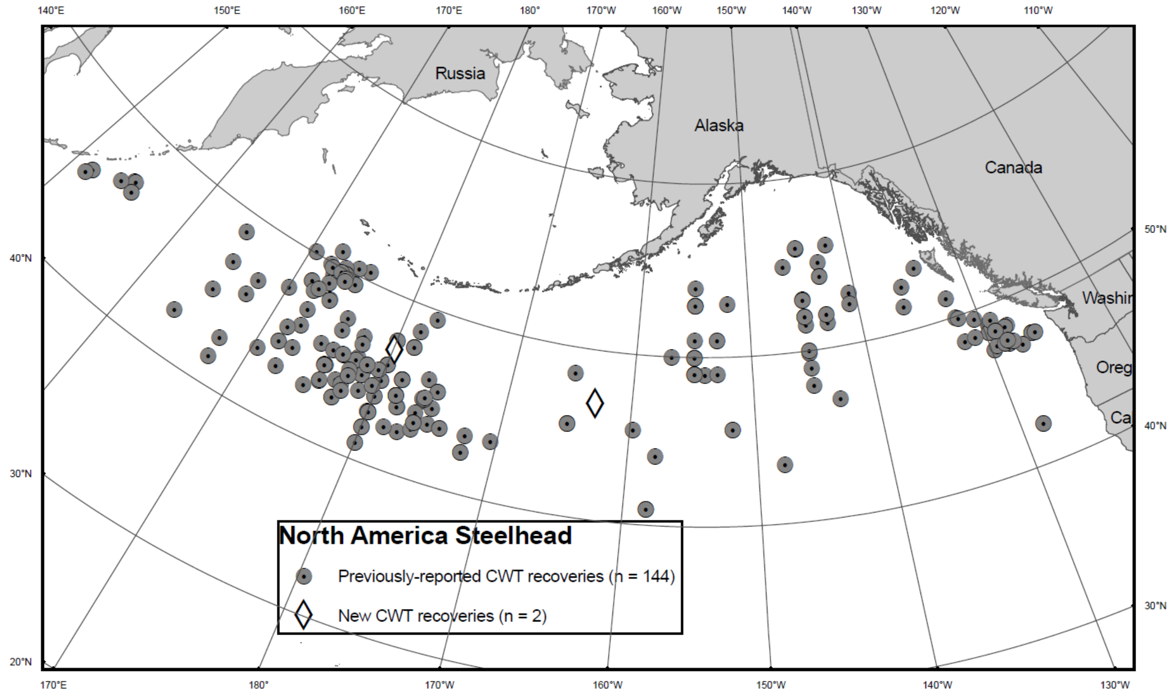

Figure 61. Ocean distribution of North America steelhead from coded-wire tag recoveries, 1981-2008 (Celewycz et al. 2008).

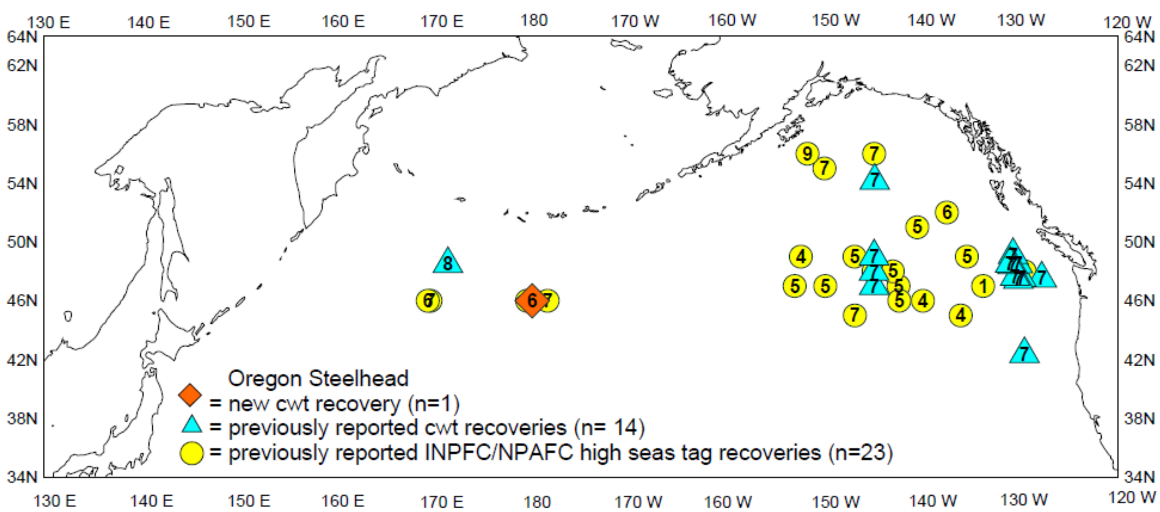

Figure 62. Ocean distribution of Oregon steelhead trout, from coded-wire tag recoveries, 1956-2004 (Myers et al. 2004).

Table 74. Offshore density estimates for ESA-listed steelhead by DPS and life stage [derived from (NMFS 2020c)].

Life stage	DPS	Density (# fish/km^2)
Adult	Upper Columbia River	0.0041439
Juvenile		0.168581385
Adult	Snake River basin	0.05236907
Juvenile		0.789687182
Adult	Lower Columbia River	0.017367097
Juvenile		0.25617911
Adult	Upper Willamette River	0.001436039
Juvenile		0.023078542
Adult	Middle Columbia River	0.002767531
Juvenile		0.158322484
Adult	Puget Sound	0.009524115
Juvenile		0.397705395

8.2.2.3 Response Analysis

We combined the offshore densities (Table 74), the mean range to effects values (Table 72), and the annual number of explosives proposed for each bin type (Table 71), to estimate the annual number of steelhead mortalities and injuries resulting from Navy explosives by DPS and life stage. Range to effects was used to calculate a cylindrical area around each detonation that would result in mortality and injury. Using the range to effects to estimate a cylinder of the affected area is a conservative approach since the actual volume of water affected may be less depending on the location of the explosive in the water column and other environmental factors. We multiplied this area of injury or mortality by the density of each species to determine the number of individual fish from each DPS that would be expected to be killed or be injured from each detonation (in order to estimate the number of fish injured, the area of mortality was subtracted from the area of injury estimate; this ensured we did not double count). We then multiplied this result by the number of detonations expected for each explosive bin to get a total number of fish (juvenile or adult) that would be expected to die or be injured annually from each explosive bin. We then summed the number of injuries and mortalities across all explosives bins and multiplied that number by the total proportion of hatchery fish with clipped fins, hatchery fish with unclipped fins, and natural (wild) born fish (Table 75). The total estimated annual number of ESA-listed steelhead mortalities and injuries resulting from Navy explosives in the GOA action area by DPS, life stage, and natal origin type (natural, hatchery intact adipose fin, and hatchery adipose fin clipped) are shown in Table 76 and Table 77, respectively.

Table 75. Summary of estimated annual abundance of ESA-listed steelhead. Abundance estimates for each DPS are divided into natural, listed hatchery intact adipose, and listed hatchery adipose clip (NMFS 2019b; NMFS 2019c; NMFS 2020b; Zabel 2015; Zabel 2017a; Zabel 2017b; Zabel 2018; Zabel 2020).

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
Upper Columbia River steelhead	Adult	1,931	1,163	5,309
	Juvenile	199,380	138,601	687,567
Snake River Basin steelhead	Adult	10,547	16,137	79,510
	Juvenile	798,341	705,490	3,300,152
Lower Columbia River steelhead	Adult	12,920	22,297[1]	-
	Juvenile	352,146	9138	1,197,156
Upper Willamette River steelhead	Adult	2,912	-	-
	Juvenile	140,396	-	-
Middle Columbia River steelhead	Adult	5,052	112	448
	Juvenile	407,697	110,469	444,973
Puget Sound steelhead	Adult	19,313[2]	-	-
	Juvenile	2,196,901	112,500	110,000

[1] We do not have separate estimates for fin-clipped and intact adipose fin hatchery fish for the life stage of this DPS.
[2] Includes estimates for natural and hatchery fish (intact and clipped numbers)

Table 76. Estimated annual number of ESA-listed steelhead mortalities resulting from Navy explosives in the GOA action area by DPS, life stage, and natal origin.

DPS	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
Upper Columbia River steelhead	Adult	0.06	0.04	0.18
	Juvenile	2.21	1.53	7.61
Snake River Basin steelhead	Adult	0.35	0.54	2.64
	Juvenile	8.83	7.81	36.52
Lower Columbia River steelhead	Adult	0.06	1.11	0.00
	Juvenile	3.90	0.10	13.25
Upper Willamette River steelhead	Adult	0.10	0.00	0.00
	Juvenile	1.55	0.00	0.00
Middle Columbia River steelhead	Adult	0.17	0.00	0.01
	Juvenile	4.51	1.22	4.92
Puget Sound steelhead	Adult	0.64	0.00	0.00
	Juvenile	24.31	1.24	1.22

Table 77. Estimated annual number of ESA-listed steelhead injuries resulting from Navy explosives in the GOA action area by DPS, life stage, and natal origin type (natural, hatchery intact adipose fin, and hatchery adipose fin clipped).

DPS	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
Upper Columbia River steelhead	Adult	3.63	2.19	9.99
	Juvenile	125.08	86.95	431.33
Snake River Basin steelhead	Adult	19.85	30.37	149.64
	Juvenile	500.83	442.58	2,070.29
Lower Columbia River steelhead	Adult	3.63	62.65	0.00
	Juvenile	220.91	5.73	751.02
Upper Willamette River steelhead	Adult	5.48	0.00	0.00
	Juvenile	88.08	0.00	0.00
Middle Columbia River steelhead	Adult	9.51	0.21	0.84
	Juvenile	255.76	69.30	279.15
Puget Sound steelhead	Adult	36.35	0.00	0.00
	Juvenile	1,378.19	70.57	69.01

8.2.2.3.1 Injury and Mortality

As described previously, NMFS considers the potential effects from explosive 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.

Injury refers to the direct effects on the tissues or organs of a fish. We expect the majority of fish injuries to be minor and recoverable although some injuries may lead to internal bleeding, barotrauma, and death. The blast wave from an in-water explosion is lethal to fishes at close range, causing massive organ and tissue damage (Keevin and Hempen 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors including fish size, body shape, depth, physical condition of the fish, and perhaps most importantly, the presence of a swim bladder (Keevin and Hempen 1997; Wright 1982; Yelverton and Richmond 1981; Yelverton et al. 1975). At the same distance from the source, larger fishes are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fishes oriented sideways to the blast suffer the greatest impact (Edds-Walton and Finneran 2006; O'Keeffe 1984; O'Keeffe and Young 1984; Wiley et al. 1981; Yelverton et al. 1975). Species with a swim bladder, including all of the salmonids considered in this opinion, are much more susceptible to blast injury from explosives than fishes without them (Gaspin 1975; Gaspin et al. 1976; Goertner et al. 1994).

Fish that are near the range to mortality may be more likely to incur a more severe injury that could lead to mortality with time (e.g., internal bleeding, barotrauma, higher susceptibility to predation). For example, if a fish is close to an explosive detonation, the exposure to rapidly changing high pressure levels can cause barotrauma. Barotrauma is injury due to a sudden difference in pressure between an air space inside the body and the surrounding water and tissues. Rapid compression followed by rapid expansion of airspaces, such as the swim bladder, can damage surrounding tissues and result in the rupture of the airspace itself. The swim bladder is the primary site of damage from explosives (Wright 1982; Yelverton et al. 1975). Gas-filled swim bladders resonate at different frequencies than surrounding tissue and can be torn by rapid oscillation between high- and low-pressure waves (Goertner 1978). Small airspaces, such as micro-bubbles that may be present in gill structures, could also be susceptible to oscillation when exposed to the rapid pressure increases caused by an explosion. This may have caused the bleeding observed on gill structures of some fish exposed to explosions (Goertner et al. 1994). Sudden very high pressures can also cause damage at tissue interfaces due to the way pressure waves travel differently through tissues with different densities. Rapidly oscillating pressure waves might rupture the kidney, liver, spleen, and sinus and cause venous hemorrhaging (Keevin and Hempen 1997).

Several studies have exposed fish to explosives and examined various metrics in relation to injury susceptibility. Sverdrup (1994) exposed Atlantic salmon (1 to 1.5 kilograms [2 to 3 pounds]) in a laboratory setting to repeated shock pressures of around 300 psi without any immediate or delayed mortality after a week. Hubbs and Rechnitzer (1952) showed that fish with swim bladders exposed to explosive shock fronts (the near-instantaneous rise to peak pressure) were more susceptible to injury when several feet below the water surface than near the bottom. When near the surface, the fish began to exhibit injuries around peak pressure exposures of 40 to 70 psi. However, near the bottom (all water depths were less than 100 feet) fish exposed to pressures over twice as high exhibited no sign of injury. Yelverton et al. (1975) similarly found that peak pressure was not correlated to injury susceptibility; instead, injury susceptibility of swim bladder fish at shallow depths (10 feet or less) was correlated to the metric of positive impulse (Pa-s), which takes into account both the positive peak pressure, the duration of the positive pressure exposure, and the fish mass, with smaller fish being more susceptible.

Dahl et al. (2020) reported the effects of underwater explosions on one species of clupeiform fish, Pacific sardines (*Sardinops sagax*), with a physostomous swim bladder (an open swim bladder with direct connection to the gut via pneumatic duct). Fish were stationed at various distances prior to each explosion, in addition to a control group that was not exposed. Necropsies following explosions observed significant injuries, including fat hematoma, kidney rupture, swim bladder rupture, and reproductive blood vessel rupture. While most significant injuries were consistently present at close range (<50 meters), there were inconsistent findings at the 50 to 154 meter range. For example, higher rates of injury were shown at a distance of 154 meters compared to 68 meters. The acoustic analysis led to the suggestion that, at a range of 154 meters, the greater rate of pressure change and deeper low-pressure point during the decompression phase were linked to swim bladder expansion damage and rupture. This includes damage to immediately neighboring organs as manifested by kidney data that are highly correlated with swim bladder data. This is the proposed cause of the observed higher injury rate at 154 meters despite the higher peak pressures observed at 68 meters, and has been suggested by earlier models of swim bladder related injury (Goertner, 1978 and Wiley et al., 1981 as cited in Dahl et al. 2020).

Gaspin et al. (1976) exposed multiple species of fish with a swim bladder, placed at varying depths, to explosive blasts of varying size and depth. Goertner (1978) and Wiley (1981) developed a swim bladder oscillation model, which showed that the severity of injury observed in those tests could be correlated to the extent of swim bladder expansion and contraction predicted to have been induced by exposure to the explosive blasts. Per this model, the degree of swim bladder oscillation is affected by ambient pressure (i.e., depth of fish), peak pressure of the explosive, duration of the pressure exposure, and exposure to surface rarefaction (negative pressure) waves. The maximum potential for injury is predicted to occur where the surface reflected rarefaction (negative) pressure wave arrives coincident with the moment of maximum compression of the swim bladder caused by exposure to the direct positive blast pressure wave, resulting in a subsequent maximum expansion of the swim bladder. Goertner (1978) and Wiley et al. (1981) found that their swim bladder oscillation model explained the injury data in the Yelverton et al. (1975) exposure study and their impulse parameter was applicable only to fishes at shallow enough depths to experience less than one swim bladder oscillation before being exposed to the following surface rarefaction wave.

O’Keeffe (1984) provides calculations and contour plots that allow estimation of the range to potential effects of in-water explosions on fish possessing swim bladders using the damage prediction model developed by Goertner (1978). O’Keeffe’s (1984) parameters include the charge weight, depth of burst, and the size and depth of the fish, but the estimated ranges do not take into account unique propagation environments that could reduce or increase the range to effect. The 10 percent mortality range represents the maximum horizontal range predicted by O'Keeffe (1984) for 10 percent of fish suffering injuries that are expected to not be survivable (e.g., damaged swim bladder or severe hemorrhaging). Fish at greater depths and near the surface are predicted to be less likely to be injured because geometries of the exposures would limit the amplitude of swim bladder oscillations. In contrast, detonations at or near the surface (i.e., similar to most Navy activities that utilize bombs and missiles) would result in energy loss at the water air interface resulting in lower overall ranges to effect than those predicted here.

Studies that have documented caged fishes killed during planned underwater explosions indicate that most fish that die do so within one to four hours, and almost all die within a day (Yelverton et al. 1975). Mortality in free-swimming (uncaged) fishes may be higher due to increased susceptibility to predation. Fitch and Young (1948) found that the type of free-swimming fish killed changed when blasting was repeated at the same location within 24 hours of previous blasting. They observed that most fish killed on the second day were scavengers, presumably attracted by the victims of the previous day's blasts.

In summary, while we would expect many salmonids to recover from sub-lethal injuries from explosives with little or no long-term effect on their survival or future reproductive potential, some proportion of sub-lethal injuries from GOA explosives would likely result in more serious fitness consequences for individual chum salmon, sockeye salmon and steelhead. Juvenile steelhead may be more susceptible to sub-lethal injuries resulting in long-term fitness consequences due to their smaller size as compared to adult steelhead, chum or sockeye salmon (we do not anticipate adverse effects to juvenile chum or sockeye).

8.2.2.3.2 Hearing Impairment (TTS)

ESA-listed salmonids may experience TTS as a result of explosives in the action area. We are unaware of any research demonstrating TTS in these species (or other fish species 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. The criteria used for TTS was based upon a conservative value for more sensitive fish species and life stages with swim bladders. If TTS does occur, it would likely co-occur with barotraumas (i.e., non-auditory injury), and therefore would be within the range of other injuries these fishes are likely to experience from blast exposures. None of the ESA-listed salmonids considered in this opinion have a hearing specialization or a swim bladder involved in hearing, thus, minimizing the likelihood of each instance of TTS affecting an individual's fitness. Most fish 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. 2014a). Additionally, hearing is not thought to play a role in salmonid migration (e.g., Putnam et al. 2013). 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). 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).

In summary, because the ESA-listed salmonid species considered in this opinion are not known to rely on hearing for essential life functions, and any effects from TTS would be short-term and temporary, instances of TTS would not likely result in measurable effects on any individual's fitness.

8.2.2.3.3 Physiological Stress and Behavioral Responses

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 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 occur if multiple detonations occurred (within a few seconds apart). If multiple exposures occurred within a short period of time, 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 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.

In summary, for ESA-listed salmonid species, behavioral effects resulting from reactions to sound created by Navy 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.

9 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, we searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area. We conducted electronic searches of business journals, trade journals, and newspapers using First Search, Google, and other electronic search engines. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline (Section 7), most of which we expect would continue in the future. In particular, we are reasonably certain that threats associated with climate change, marine debris, fisheries bycatch, vessel strike, and anthropogenic ocean noise will continue in the future. An increase in these activities could similarly increase the magnitude of their effects on ESA-listed species and for some stressors, including climate change and anthropogenic ocean noise, an increase in the future is considered likely to occur. For many of the activities and associated threats identified in the environmental baseline, and other unforeseen threats, the magnitude of increase and the significance of any anticipated effects remain unknown. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on populations of ESA-listed species. Thus, this opinion assumes effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the Species and Designated Critical that May be Affected (Section 0) and Environmental Baseline (Section 7).

Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities occurring in action area are primarily those conducted under state, tribal or federal government management. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, and designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. As a result any analysis of cumulative effects is difficult, particularly when taking into account the geographic scope of the action area, the various authorities involved in the action, and the changing economies of the region. Although state, tribal and local governments have developed plans and initiatives to benefit ESA-listed species, they must be applied and sustained in a comprehensive way before we can consider them "reasonably certain to occur" in its analysis of cumulative effects.

10 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the Effects of the Action (Section 0) to the Environmental Baseline (Section 7) and the Cumulative Effects (Section 9) to formulate the agency's biological opinion as to whether the proposed action is likely to 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. This assessment is made in full consideration of the Status of the Species Likely to be Adversely Affected (Section 6.2). The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the activities considered further in this opinion, specifically the use of Navy sonar and explosives.

10.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is to 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 the survival and recovery of the species.

Based on our effects analysis, adverse effects to ESA-listed species are likely to result from the proposed action. The following discussions summarize the probable risks that activities involving the use of sonar and explosives pose to threatened and endangered species over the 7-year lifetime of the MMPA authorization (for ESA-listed marine mammals) and into the reasonably foreseeable future (for all ESA-listed species considered in this opinion). These summaries integrate our exposure and response analyses from Section 8.2.

10.1.1 Blue Whale

Blue whales are present in the action area and all life stages may be exposed to acoustic stressors (sonar and explosives) associated with training activities each year from April through October. Blue whales found in the GOA action area are recognized as part of the Eastern North Pacific stock. The minimum population size for Eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta et al. 2020b) and is considered in this consultation as representative of the blue whale abundance expected to occur in the GOA action area. Current estimates indicate a growth rate of just under three percent per year for the Eastern North Pacific stock. 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.

The acoustic effects analysis predicts that blue whales may be exposed to sonar and other active acoustic sources associated with training activities in the action area that may result in 35 TTS and 3 behavioral disruptions annually and 245 TTS and 21 behavioral disruptions of blue whales (all life stages) over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Acoustic modeling predicts that blue whales exposed to impulses from explosive sources associated with training activities in the GOA TMAA would result in one behavioral reaction annually and seven behavioral reactions over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Overall, GOA TMAA training activities would result in an estimated 0.026 behavioral disruptions annually per blue whale (see Table 70). This anticipated level of take would not be expected to lead to a measureable loss of reproduction at an individual level, and therefore would not result in a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of blue whales and no reduction in the distribution or numbers of this species is expected as a result of the action. Anthropogenic noise associated with GOA TMAA/WMA activities is not expected to permanently impact the fitness of any individuals of this species. No mortality or serious injury of blue whales is expected to occur from GOA TMAA/WMA activities. Thus, we do not expect the non-lethal take of individuals to result in population-level consequences to blue whales.

The 1998 blue whale recovery plan does not outline downlisting or delisting criteria. The recovery plan does list several stressors potentially affecting the status of blue whales in the North Pacific Ocean that are relevant to GOA TMAA/WMA activities including vessel strike, vessel disturbance, and military operations (including sonar). At the time the recovery plan was published, the effects of these stressors on blue whales in the Pacific Ocean were not well documented, their impact on recovery was not understood, and no attempt was made to prioritize the importance of these stressors on recovery.

Take resulting from stressors associated with the use of sonar and explosives during the proposed Navy training activities in the GOA proposed action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from December 2022 through December 2029, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of blue whales in the wild by reducing the reproduction, numbers, or distribution of the species. Similarly, the effects from ongoing Navy training activities and related incidental take specified in the proposed MMPA rule continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of blue whales in the wild. Therefore, we conclude that the proposed action will not jeopardize the continued existence of blue whales.

10.1.2 Fin Whale

Fin whales are present in the action area and all life stages may be exposed to acoustic stressors (sonar and explosives) associated with training activities each year from April through October. The current minimum abundance estimate for fin whales is based on the Northeast Pacific stock within the GOA is 3,168 (CV=0.36) (Carretta et al. 2020b; Nadeem et al. 2016); the minimum population estimate is 2,554 individuals (Carretta et al. 2020b). The minimum population estimate provided above represents the best estimate for ESA-listed fin whales in the GOA action area. Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent, and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016).

The acoustic effects analysis predicts that fin whales within the GOA TMAA would be exposed to sonar and other active acoustic sources associated with training activities that would result in 1,125 TTS and 104 behavioral reactions annually, and 7,875 TTS and 728 behavioral reactions over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Acoustic modeling predicts that fin whales exposed to impulses from explosive sources associated with training activities in the GOA TMAA area would result in two PTS, two TTS, and 11 behavioral reactions annually, and 14 PTS, 14 TTS and 77 behavioral reactions over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Overall, GOA training activities would result in an estimated 0.393 behavioral disruptions annually per fin whale in the GOA (see Table 70). This anticipated level of non-lethal take would not be expected to lead to a measureable loss of reproduction at an individual level, and therefore would not result in a measurable effect on reproduction at the population level.

Anthropogenic noise associated with GOA TMAA activities is expected to impact the fitness of two individuals (annually) of this species as a result of harm incurred from explosives in the form of PTS. Although we cannot quantify the magnitude of PTS, given the Navy's proposed procedural mitigation measures for explosives use and the relatively short PTS range to effects, incidents of PTS are expected to be of relatively low magnitude. No mortality of fin whales is expected to occur from GOA TMAA activities. While PTS is permanent, we would not expect impacts to two individual whales annually to have meaningful effects at the population level. The current minimum abundance estimate for fin whales belonging to the Northeast Pacific stock within the GOA is 3,168 (CV=0.36) (Carretta et al. 2020b; Nadeem et al. 2016) and best represents the potential abundance of fin whales that may occur in the GOA action area. Based on our analysis, we expect that the number of fin whales that experience fitness consequences annually as a result of the proposed action would be an extremely small proportion estimated population within the action area, and an even smaller proportion of the U.S. Pacific Ocean population. Thus, we do not anticipate that instances of PTS will result in appreciable changes in the number, distribution, or reproductive potential of fin whales in the Pacific Ocean or rangewide.

The 2010 fin whale recovery plan defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to GOA TMAA activities. Downlisting criteria for fin whales includes the maintenance of at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years. To our knowledge a population viability analysis has not been conducted on fin whale recovery populations.

Take resulting from stressors associated with the use of sonar and explosives during the proposed Navy training activities in the GOA action area on an annual basis, cumulatively over the seven year period of the MMPA Rule from December 2022 through December 2029, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of fin whales in the wild by reducing the reproduction, numbers, or distribution of the species. Similarly, the effects from ongoing Navy training activities and related incidental take specified in the proposed MMPA rule continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of fin whales in the wild. Therefore, we conclude that the proposed action will not jeopardize the continued existence of fin whales.

10.1.3 Humpback Whale – Mexico DPS

Based on surveys from 2004 to 2006, the Mexico DPS is estimated to have just below 3,000 individuals (Wade 2017). However, sightings of humpbacks off the U.S. West Coast have been increasing in more recent years, and these DPS numbers are likely underestimates. Population growth rates are currently unavailable for the Mexico DPS of humpback whales (Calambokidis 2017).

Humpback whales that are part of the threatened Mexico DPS could be in all portions of the action area. All life stages may be exposed to sonar and other active acoustic sources associated with training activities April through October and are expected to feed seasonally in the action area. The acoustic effects analysis predicts that humpback whales of the Mexico DPS would be exposed to sonar and other active acoustic sources associated with training activities throughout the action area, resulting in 8 TTS and 1 behavioral reactions annually from December 2022 through December 2029, and 56 TTS and 7 behavioral reactions over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Acoustic modeling predicts that humpback whales exposed to impulses from explosive sources associated with training activities in the GOA TMAA area would result in one behavioral reactions annually, and seven behavioral reactions over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Overall, GOA TMAA training activities would result in an estimated 0.003 behavioral disruptions annually per humpback whale from the Mexico DPS (see Table 70). This anticipated level of take would not be expected to lead to a measureable loss of reproduction at an individual level, and therefore would not result in a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of Mexico DPSs of humpback whales and no reduction in the distribution or numbers of this DPS is expected as a result of the action. As described previously, anthropogenic noise associated with GOA TMAA/WMA activities will not permanently impact the fitness of any individuals of this species. No mortality or serious injury of Mexico DPS humpback whales is expected to occur from GOA TMAA/WMA activities. For this reason, we do not expect the non-lethal take of individuals to result in population-level consequences to the Mexico DPS of humpback whales.

The 1991 humpback whale recovery plan does not outline specific downlisting and delisting criteria. The recovery plan does list several threats known or suspected of impacting humpback whale recovery including subsistence hunting, commercial fishing stressors, habitat degradation, loss of prey species, ship collision, and acoustic disturbance. Of these, acoustic disturbance is relevant to GOA TMAA/WMA activities.

Take resulting from stressors associated with the use of sonar and explosives during the proposed Navy training activities in the GOA TMAA on an annual basis, cumulatively over the seven year period of the MMPA Rule from December 2022 through December 2029, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of Mexico DPS humpback whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training activities and related incidental take specified in the MMPA Rule continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of Mexico DPS humpback whales in the wild. Therefore, we conclude that the proposed action will not jeopardize the continued existence of Mexico DPS humpback whales.

10.1.4 North Pacific Right Whale

North Pacific right whales are present in the action area and all life stages may be exposed to acoustic stressors (sonar and explosives) associated with training activities each year from April through October. The recent estimate of North Pacific right whale abundance comes from mark-recapture analyses of photo-identification and genetic data. Photographic (18 identified individuals) and genotype (21 identified individuals) data through 2008 were used to calculate the first mark-recapture estimates of abundance for right whales in the Bering Sea and Aleutian

Islands, resulting in separate estimates of 31 (95 percent CL: 23-54; CV = 0.22) and 28 (95 percent CL: 24-42), respectively (Wade et al. 2011). The abundance estimates are for the last year of each study, corresponding to 2008 for the photo-identification estimate and 2004 for the genetic identification estimate. The minimum estimate of abundance of Eastern North Pacific right whales is 26 whales based on the 20th percentile of the photo-identification estimate of 31 whales (CV = 0.226: Wade et al. 2011). The larger estimate of 31 animals is considered in this consultation as representative of the North Pacific right whale abundance expected to occur in the GOA action area.

The acoustic effects analysis predicts that North Pacific right whales may be exposed to sonar and other active acoustic sources associated with training activities in the action area, resulting in two TTS annually from December 2022 through December 2029 and 14 TTS over the seven years of the Permits Division’s proposed action, and every seven years of the Navy’s proposed action into the reasonably foreseeable future. Overall, GOA TMAA training activities would result in an estimated 0.096 behavioral disruptions annually per North Pacific right whale (see Table 70). This anticipated level of North Pacific right whale (any life stage) take would not be expected to lead to a measureable loss of reproduction at an individual level, and therefore would not result in a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of North Pacific right whales and no reduction in the distribution or numbers of this species is expected as a result of the action. Anthropogenic noise associated with GOA TMAA/WMA activities is not expected to permanently impact the fitness of any individuals of this species. No mortality or serious injury of North Pacific right whales is expected to occur from GOA TMAA/WMA activities. For this reason, we do not expect the non-lethal take of individuals to result in population-level consequences to North Pacific right whales.

The 2013 Final Recovery Plan for the North Pacific right whale lists recovery objectives for the species. The recovery plan does list several stressors potentially affecting the status of North Pacific right whales in the North Pacific Ocean that are relevant to GOA TMAA/WMA activities including vessel strike and vessel disturbance (National Marine Fisheries Service 2013).

Take resulting from stressors associated with the use of sonar and explosives during the proposed Navy training activities in the GOA TMAA on an annual basis, cumulatively over the seven year period of the MMPA Rule from December 2022 through December 2029, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of North Pacific right whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training activities and related incidental take specified in the proposed MMPA rule continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of Mexico DPS humpback whales in the wild. Therefore, we conclude that the proposed action will not jeopardize the continued existence of North Pacific right whales.

10.1.5 Sei Whale

Sei whales are present in the action area and all life stages may be exposed to acoustic stressors (sonar and explosives) associated with training activities each year from April through October. The best abundance estimate for sei whales for the waters of the U.S. West Coast is 519 (CV=0.40) (Carretta et al. 2020b). 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.

Sei whales found in the action area are recognized as part of the Eastern North Pacific stock. Sei whales may also be exposed to sonar and other active acoustic sources associated with training activities in the TMAA from April through October. The acoustic effects analysis predicts that sei whales from the Eastern North Pacific stock would be exposed to sonar and other active acoustic sources associated with training activities in the offshore area that would result in 2 behavioral reactions and 34 TTS exposures annually, and 14 behavioral reactions and 238 TTS exposures over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Acoustic modeling predicts that sei whales would be exposed to impulses from explosive sources associated with training activities in the offshore area that would result in one behavioral reaction annually, and seven behavioral reactions every seven years of the proposed action. Overall, GOA TMAA training activities would result in an estimated 0.001 behavioral disruptions annually per sei whale (see Table 70). This anticipated level of sei whale (any life stage) take would not be expected to lead to a measureable loss of reproduction at an individual level, and therefore would not result in a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of sei whales and no reduction in the distribution or numbers of this species is expected as a result of the action. Anthropogenic noise associated with GOA TMAA/WMA activities is not expected to permanently impact the fitness of any individuals of this species. No mortality or serious injury of sei whales is expected to occur from GOA TMAA/WMA activities. For this reason, we do not expect the non-lethal take of individuals to result in population-level consequences to sei whales.

The 2011 sei whale recovery plan defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to GOA TMAA/WMA activities. Downlisting criteria for fin whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years. To our knowledge a population viability analysis has not been conducted on sei whale recovery populations.

Take resulting from stressors associated with the use of sonar and explosives during the proposed Navy training activities in the GOA TMAA on an annual basis, cumulatively over the seven year period of the MMPA Rule from December 2022 through December 2029, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of sei whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training activities and related incidental take specified in the proposed MMPA rule continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of sei whales in the wild. Therefore, we conclude that the proposed action will not jeopardize the continued existence of sei whales.

10.1.6 Sperm Whale

Sperm whales are present in the action area and all life stages may be exposed to acoustic stressors (sonar and explosives) associated with training activities each year from April through October. There are no reliable abundance estimates for sperm whales that occur in the GOA specifically. However, recent work based on surveys in 2009 and 2015 (Rone et al. 2017) estimated 129 (CV = 0.44) and 345 sperm whales (CV = 0.43) in each year, respectively. These estimates are for a small area that was unlikely to include females and juveniles and do not account for animals missed on the trackline; therefore, they are not considered reliable estimates. But, lacking any other current abundance estimates for the GOA action area these data serve as the best estimate for sperm whale abundance for this consultation.

The acoustic effects analysis predicts that sperm whales (all life stages) would be exposed to sonar and other active acoustic sources associated with training activities in the GOA TMAA, resulting in 107 behavioral reactions and five TTS exposures annually from April through October, and 749 behavioral reactions and 107 TTS exposures over the seven years of the Permits Division's proposed action, and every seven years of the Navy's proposed action into the reasonably foreseeable future. Overall, GOA TMAA training activities may result in an estimated 0.325 behavioral disruptions annually per sperm whale (see Table 70). The acoustic effects analysis also predicted there would no exposures to sperm whales resulting in any behavioral disruptions from explosive stressors. This anticipated level of sperm whale (any life stage) take would not be expected to lead to a measureable loss of reproduction at an individual level, and therefore would not result in a measurable effect on reproduction at the population level.

The action will not affect the current geographic range of sperm whales and no reduction in the distribution or numbers of this species is expected as a result of the action. Anthropogenic noise associated with GOA TMAA/WMA activities is not expected to permanently impact the fitness of any individuals of this species. No mortality or serious injury of sperm whales is expected to occur from GOA TMAA/WMA activities. For this reason, we do not expect the non-lethal take of individuals to result in population-level consequences to sperm whales.

The 2010 sperm whale recovery plan defines three recovery populations by ocean basin (the Atlantic Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with fisheries, climate change, direct harvest, oil spills, anthropogenic noise, and ship collision. Of these, anthropogenic noise and ship collision are relevant to GOA TMAA/WMA activities. Downlisting criteria for sperm whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population. To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years. To our knowledge a population viability analysis has not been conducted on sperm whale recovery populations.

Take resulting from stressors associated with the use of sonar and explosives during the proposed Navy training activities in the GOA TMAA on an annual basis, cumulatively over the seven year period of the MMPA Rule from December 2022 through December 2029, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of sperm whales in the wild by reducing the reproduction, numbers, or distribution of that species. Similarly, the effects from ongoing Navy training activities and related incidental take specified in the proposed MMPA rule continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of sperm whales in the wild. Therefore, we conclude that the proposed action will not jeopardize the continued existence of sperm whales.

10.1.7 Chum Salmon

Based on our effects analysis (Section 0), we determined that two ESUs of ESA-listed chum salmon were likely to be adversely affected by the proposed action. These are the threatened Columbia River ESU and the threatened Hood Canal summer-run ESU.

Of all the potential stressors resulting from Navy activities in the action area, we determined that only stressors associated with the use of explosives would likely result in adverse effects to ESA-listed salmonids. Any salmon located within the blast radius of an explosion could be injured or killed, and sustain some degree of TTS or exhibit behavioral disruptions. Although we did not conduct a quantitative analysis to estimate the number of fish exposed, we anticipate the number of adult Hood Canal and Columbia River chum killed or injured by explosives as a result of the proposed action to be extremely small (i.e., likely less than one killed or injured per year from each ESU). Thus, we anticipate an extremely small percentage of each chum salmon ESU would be killed or injured from the proposed action during a maximum year of explosives activity (i.e., less than 0.004 percent of the Hood Canal ESU and less than 0.01 percent of the Columbia River ESU adult populations).

Some proportion of the exposures resulting in injury would likely also produce TTS. However, chum salmon lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness.

Although we cannot quantify, we also anticipate additional adult Hood Canal and Columbia River chum would be exposed to explosives at levels resulting in a short-term behavioral response or physiological stress response. Behavioral effects on chum salmon 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 measurable effects on an individual's fitness.

The loss of an individual fish represents the loss of future reproductive potential and temporary effects to an individual's fitness due to TTS or behavioral responses may represent temporary effects to reproduction. Given the extremely small anticipated mortality rate and the temporary nature of TTS and behavioral effects, it is unlikely that salmon mortality from GOA explosives and TTS and behavioral responses would have an appreciable impact on overall population trends.

Chum salmon have large ranges over which they disperse so no reduction in the distribution or current geographic range of these ESUs is expected as a result of the proposed action. Because we do not anticipate a significant reduction in numbers, reproduction, or distribution of this species as a result of the action, a reduction in the likelihood of survival for chum salmon is not expected.

The recovery strategy for Columbia River ESU chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated (NMFS 2013a). The primary goal is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence, and the persistence probability of the two Gorge populations improves. The recovery strategy for Hood Canal Summer-run chum salmon focuses on habitat protection and restoration throughout the geographic range of the ESU, including both freshwater habitat and nearshore marine areas within a one-mile radius of the watersheds' estuaries (NMFS 2007a). The recovery plan includes an ongoing harvest management program to reduce exploitation rates, a hatchery supplementation program, and the reintroduction of naturally spawning summer chum salmon aggregations to several streams where they were historically present. Thus, the proposed action is not likely to impede the recovery objectives for either ESU.

Based on the evidence available, effects resulting from stressors caused by training activities the Navy will conduct in the GOA action area on an annual basis, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of either the Hood Canal summer-run ESU or Columbia River ESU of chum salmon in the wild by reducing the reproduction, numbers, or distribution of the species or ESUs. We also conclude that effects from ongoing Navy training activities continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of either the Hood Canal summer-run ESU or Columbia River ESU of chum salmon. We do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Hood Canal summer-run ESU or Columbia River ESU of chum salmon as a result of the proposed action. Therefore, we conclude the proposed action will not jeopardize the continued existence of Hood Canal summer-run ESU or Columbia River ESU of chum salmon.

10.1.8 Sockeye Salmon

Based on our effects analysis (Section 0), we determined that two ESUs of ESA-listed sockeye salmon were likely to be adversely affected by the proposed action. These are the threatened Ozette Lake ESU and the endangered Snake River ESU.

Of all the potential stressors resulting from Navy activities in the action area, we determined that only stressors associated with the use of explosives would likely result in adverse effects to ESA-listed fishes. Any salmon located within the blast radius of an explosion could be injured or killed, and sustain some degree of TTS or exhibit behavioral disruptions. Although we did not conduct a quantitative analysis to estimate the number of fish exposed, we anticipate the number of adult Ozette Lake and Snake River sockeye salmon killed or injured by explosives as a result of the proposed action to be extremely small (i.e., likely less than one killed or injured per year from each ESU). Thus, we anticipate an extremely small percentage of each sockeye salmon ESU would be killed or injured from the Navy's GOA explosive activities during a maximum year of explosives activity (i.e., less than 0.02 percent of the Ozette Lake ESU and less than 0.03 percent of the Snake River ESU adult populations).

Some proportion of the exposures resulting in injury would likely also produce TTS. Although we cannot quantify, we also anticipate additional adult Ozette Lake and Snake River sockeye would be exposed to explosives at levels resulting in a short-term behavioral response or physiological stress response.

The loss of an individual fish represents the loss of future reproductive potential and temporary effects to an individual's fitness due to TTS or behavioral responses may represent temporary effects to reproduction. Given the extremely small anticipated mortality rate and the temporary nature of TTS and behavioral effects, it is unlikely that salmon mortality from GOA TMAA explosives and TTS and behavioral responses would have an appreciable impact on overall population trends.

Sockeye salmon have large ranges over which they disperse so no reduction in the distribution or current geographic range of these ESUs is expected as a result of the proposed action. Because we do not anticipate a significant reduction in numbers, reproduction, or distribution of this species as a result of the action, a reduction in the likelihood of survival for sockeye salmon is not expected.

Recovery criteria for Ozette Lake sockeye include: 1) Multiple, spatially distinct and persistent spawning aggregations throughout the historical range of the population (i.e., along the lake beaches and in one or more tributaries); 2) One or more persistent spawning aggregations from each major genetic and life history group historically present; and 3) Abundance between 31,250 and 121,000 adult spawners, over a number of years. The Snake River ESU-level recovery objectives include: 1) Population-level persistence in the face of year-to-year variations in environmental influences; 2) Combination of abundance and productivity sufficient to sustain a population (in the absence of hatchery supplementation) at levels that will maintain genetic and spatial diversity; 3) Resilience to the potential impact of catastrophic events; 4) Populations distributed in a manner that insulates against loss from a local catastrophic event and provides for recolonization of a population that is affected by such an event; 5) Maintaining long-term evolutionary potential; and 6) Sustaining natural production across a range of conditions, allowing for adaptation to changing environmental conditions. Since we anticipate an extremely small percentage of each sockeye salmon ESU would be killed or injured from the Navy's GOA activities, the proposed action is not likely to impede the recovery objectives for either ESU.

Based on the evidence available, effects resulting from stressors caused by training activities the Navy will conduct in the GOA action area on an annual basis, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of either the Lake Ozette ESU or Snake River ESU of sockeye salmon in the wild by reducing the reproduction, numbers, or distribution of the species or ESUs. We also conclude that effects from ongoing Navy training activities continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of either the Lake Ozette ESU or Snake River ESU of sockeye salmon. We do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Lake Ozette ESU or Snake River ESU of sockeye salmon as a result of the proposed action. Therefore, we conclude the proposed action will not jeopardize the continued existence of the Lake Ozette ESU or Snake River ESU of sockeye salmon.

10.1.9 Steelhead

Based on our effects analysis (Section 8), we determined that six DPSs of ESA-listed steelhead were likely to be adversely affected by the proposed action. These are the Lower Columbia River DPS, Middle Columbia River DPS, Upper Columbia DPS, Snake River Basin DPS, Upper Willamette River DPS, and Puget Sound DPS. All six DPSs are listed under the ESA and threatened.

Of all the potential stressors resulting from Navy activities in the action area, we determined that only stressors associated with the use of explosives would likely result in adverse effects to ESA-listed fishes. Any steelhead located within the blast radius of an explosion could be injured or killed, and sustain some degree of TTS or exhibit behavioral disruptions. We conducted a quantitative analysis to estimate the number of steelhead exposed to explosive stressors at levels that would result in injury or mortality. The estimated annual numbers of steelhead mortalities and injuries resulting from the proposed action are presented in Section 8.2.2.2 (Table 76 and Table 77) by DPS, life stage, and natal origin type (natural, hatchery intact adipose fin, and hatchery adipose fin clipped). Expressed as a proportion of the DPS as a whole, the expected number of steelhead killed as a result of the proposed action does not exceed 0.004 percent of the population abundance for any DPS. While a larger number of steelhead are expected to be injured than killed, the expected number of steelhead injured as a result of the proposed action does not exceed 0.20 percent of the population abundance for any DPS. It is worth noting that, as described in Section 8.2.2, the methodology used to quantify fish injury and mortality from explosives was conservative. As a result, estimated impacts from Navy GOA explosives from our quantitative analysis may also be conservatively high due to several conservative assumptions in our approach.

Thus, we anticipate a very small percentage of each steelhead DPS would be injured, and an even smaller percent would be killed by the Navy's use of explosive during a maximum year of GOA explosives activity. While we would expect many steelhead to recover from sub-lethal injuries from explosives with little or no long-term effect on their survival or future reproductive potential, some proportion of sub-lethal injuries from GOA explosives would likely result in fitness consequences for individual steelhead.

Some proportion of the exposures resulting in injury would likely also produce TTS. Although we cannot quantify, we also anticipate additional steelhead from each DPS would be exposed to explosives at levels resulting in a short-term behavioral response or physiological stress response.

Both long-term fitness consequences and mortality represent the loss of future reproductive potential and temporary effects to an individual's fitness due to TTS or behavioral responses may represent temporary effects to reproduction. Given the extremely small anticipated mortality and injury rate (relative to each DPS size) and the temporary nature of TTS and behavioral effects, it is unlikely that impacts to steelhead resulting from GOA explosives and TTS and behavioral responses would have an appreciable impact on overall population trends.

Given that steelhead DPSs have large ranges over which they disperse, no reduction in the distribution or current geographic range of these DPSs is expected as a result of the proposed action. Because we do not anticipate a significant reduction in numbers, reproduction, or distribution of this species as a result of the action, a reduction in the likelihood of survival for any steelhead DPS is not expected.

The proposed action is also not likely to impede the recovery objectives for any steelhead DPS and will not result in an appreciable reduction in the likelihood of recovery of any steelhead DPS in the wild.

Based on the evidence available, effects resulting from stressors caused by training activities the Navy will conduct in the GOA action area on an annual basis, or cumulatively for the reasonably foreseeable future, would not be expected to appreciably reduce the likelihood of the survival of the following steelhead DPSs in the wild by reducing the reproduction, numbers, or distribution of these populations: Lower Columbia River DPS, Middle Columbia River DPS, Upper Columbia DPS, Snake River Basin DPS, Upper Willamette River DPS, and Puget Sound DPS. We also find that effects from ongoing Navy training activities continuing into the reasonably foreseeable future would not be expected to appreciably reduce the likelihood of recovery of any of these DPSs in the wild by reducing the reproduction, numbers, or distribution of these species. We do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Lower Columbia River DPS, Middle Columbia River DPS, Upper Columbia DPS, Snake River Basin DPS, Upper Willamette River DPS, and Puget Sound DPS of steelhead as a result of the proposed action. Therefore, we conclude the proposed action will not jeopardize the continued existence of the Lower Columbia River DPS, Middle Columbia River DPS, Upper Columbia DPS, Snake River Basin DPS, Upper Willamette River DPS, and Puget Sound DPS of steelhead.

11 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the: blue whale, fin whale, humpback whale (Mexico and Western North Pacific DPSs), North Pacific right whale, sei whale, sperm whale, chum salmon (Hood Canal summer-run ESU and Columbia River ESU), sockeye salmon (Snake River ESU and Ozette Lake ESU), and steelhead (Lower Columbia River DPS, Middle Columbia River DPS, Upper Columbia DPS, Snake River Basin DPS, Upper Willamette River DPS, and Puget Sound DPS).

It is also NMFS' biological opinion that the proposed action is not likely to adversely affect the following ESA-listed species and designated critical habitat: humpback whale (Mexico and Western North Pacific DPSs) gray whale (Western North Pacific DPS), Steller sea lion (Western DPS), leatherback sea turtle, green sturgeon (Southern DPS), Chinook salmon (Upper Columbia River spring-run ESU, Snake River spring/summer-run ESU, Snake River fall-run ESU, Puget Sound ESU, Lower Columbia River ESU, and Upper Willamette River ESU, Central Valley spring-run ESU, California Coastal ESU, and Sacramento River winter-run ESU), coho salmon (Southern Oregon Northern California Coast ESU, Central California Coast ESU, Oregon Coast ESU, and Lower Columbia River ESU), steelhead (Northern California DPS, Central California Coast DPS, California Central Valley DPS, South-Central California Coast DPS, and Southern California DPS), and humpback whale (Mexico DPS) critical habitat.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption.

"Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS 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" (NMFS 2016b).

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. When an action will result in incidental take of ESA-listed marine mammals, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS, including those specified as necessary to comply with the MMPA, Section 101(a)(5). Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA for ESA-listed marine mammals become effective only upon the issuance of MMPA authorization to take the marine mammals identified here.

12.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by the proposed action while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

The amount of take that would result from the proposed Navy GOA Phase III activities was estimated based on the best information available. Table 78 shows the estimated total number of behavioral, TTS, and PTS takes of threatened and endangered cetaceans reasonably certain to occur over a seven-year period and annually (in parentheses) as a result of the proposed Navy training activities in the GOA. Table 79 shows the estimated total number of ESA-listed steelhead mortalities and non-lethal takes (injuries), by DPS and life stage, reasonably certain to occur annually as a result of the proposed Navy training activities in the GOA based on the proposed maximum explosive activity levels.

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 in Section 8.2.2, due to the lack of available density or abundance information for ESA-listed chum and sockeye salmon ESUs in the portion of the action area where Navy explosives would be used, we cannot quantify the total number of individual fish from each ESU that would be exposed to acoustic stressors from explosives. As such, 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 the number of fish suffering mortality, injury, TTS, and behavioral disruption) of chum salmon (Columbia River ESU and Hood Canal ESU) or sockeye salmon (Ozette Lake ESU and Snake River ESU) or to monitor take-related impacts in terms of individuals of these ESUs. Because it is not practical to express the amount of anticipated take of ESA-listed chum or sockeye ESUs, we instead use a surrogate measure to express the amount or

Table 78. The estimated total number of behavioral, TTS, and PTS takes of threatened and endangered cetaceans reasonably certain to occur over a seven-year period and annually (in parentheses) as a result of the proposed Navy GOA Phase III activities.

ESA-Listed Cetaceans	Impulsive and Non-Impulsive Acoustic Stressors		
	Harassment (Behavioral)	Harassment (TTS)	Harm (PTS)
Blue Whale	28 (4)	245 (35)	-
Fin Whale	805 (115)	7 ,889 (1,129)	14 (2)
Humpback Whale (Mexico DPS)	14 (2)	56 (8)	-
North Pacific Right Whale	7 (1)	14 (2)	-
Sei Whale	21 (3)	238 (34)	-
Sperm Whale	749 (107)	35 (5)	-

Table 79. The estimated total number of ESA-listed steelhead mortalities and non-lethal takes (injuries), by DPS and life stage, reasonably certain to occur annually as a result of the proposed Navy GOA Phase III activities based on the proposed maximum explosive activity levels.

DPS	Life Stage	Injury	Mortality
Upper Columbia River steelhead	Adult	16	1
	Juvenile	644	12
Snake River Basin steelhead	Adult	200	4
	Juvenile	3,014	54
Lower Columbia River steelhead	Adult	67	2
	Juvenile	978	18
Upper Willamette River steelhead	Adult	6	1
	Juvenile	89	2
Middle Columbia River steelhead	Adult	11	1
	Juvenile	605	11
Puget Sound steelhead	Adult	37	1
	Juvenile	1,518	27

extent of incidental take. The surrogate for the incidental take of Columbia River ESU and Hood Canal ESU of chum salmon and Ozette Lake ESU and Snake River ESU of sockeye salmon is based on: 1) the ranges to effects, which are the distances in the water column that correlate with each of the predicted effects (e.g., mortality, injury, TTS) from explosives in those areas occupied by adult salmon from these ESUs, and 2) explosive activity level, which is the total number of explosives (by bin type) that would be detonated in the action area as part of the Navy's proposed action (see Section 8.2.2 for details on range to effects and activity levels).

Predicted ranges to effects for ESA-listed fish species are calculated with NAEMO based upon sound exposure criteria which are used to predict the onset of mortality, injury, or TTS within fishes within the GOA TMAA. Ranges may vary greatly depending on factors such as the cluster size, location, depth, and season of the event, all of which are accounted for in NAEMO. Fishes within these ranges could be exposed above the effect threshold levels and a portion may experience those effects. Ranges to effects, in combination with explosive activity levels (i.e., the number of explosives used, by bin type, in portions of the action area), can be used to estimate the area within the water column within which fish would be exposed to an impulsive sound source at levels resulting in the anticipated effects (i.e., mortality, injury, TTS). Thus, there is a causal link between the surrogate factors above (i.e., range to effects and activity level) and take of ESA-listed chum and sockeye salmon as a result of the proposed action.

NAEMO predicted ranges to effects could change based on new model inputs, including changes in environmental data, new findings on the responses of fish to impulsive sound sources, or updated sound exposure criteria levels based on new information. Any increase in the predicted ranges to effects on fish from explosives used in the action area would result in a larger area within the water column within which ESA-listed salmon would be exposed, and therefore, exceedance of the surrogate used to measure take of these species. Exceedance of an activity level as a trigger for consultation reinitiation is discussed below for any activity associated with take of an ESA-listed species.

Activity Levels as Indicators of Take for Cetaceans and Fishes

As discussed in this opinion, the estimated take of ESA-listed cetaceans and fish[5] 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 take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take at the scale of GOA TMAA 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 levels specified in the preceding opinion and in the final MMPA rule before the exceedance occurs if operational security considerations allow, or as soon as operational security considerations allow after the relevant activity is conducted. Exceedance of an activity level for any activity associated with take of an ESA-listed species will require the Navy to reinitiate consultation.

12.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that NMFS has determined are necessary or appropriate to minimize the impact of the amount or extent of incidental take." (50 CFR 402.02). The reasonable and prudent measures (RPMs) described below must be undertaken by the Navy and/or NMFS Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, RPMs and Terms and Conditions to implement the measures, must be provided. Only incidental takes resulting from the agency actions and any specified RPMS and Terms and

[5] For estimating take of fish, NMFS only used the ranges to effects modeled by the Navy's NAEMO model.

Conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

NMFS has determined the following RPMs described below are necessary and appropriate to minimize the impacts of incidental take on blue whale, fin whale, humpback whale (Mexico DPS), North Pacific right whale, sei whale, sperm whale, chum salmon (Columbia River and Hood Canal ESUs), sockeye salmon (Ozette Lake and Snake River ESUs), and steelhead (Northern California DPS, Central California Coast DPS, California Central Valley DPS, South-Central California Coast DPS, and Southern California DPS:

1. The Navy and NMFS Permits Division shall minimize effects to ESA-listed marine mammals and fishes from the use of active sonar, explosives, and vessels during training activities. This includes adherence to the mitigation measures specified in the final MMPA rule and LOA.

2. The Navy and NMFS Permits Division shall monitor and report to NMFS' Office of Protected Resources ESA Interagency Cooperation Division on impacts to ESA-listed marine mammals and fishes from the use of sonar and other transducers, explosives, and vessels during training activities. This includes adherence to the monitoring and reporting measures specified in the final MMPA rule and LOA.

12.3 Terms and Conditions

In order 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 RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If the Navy or NMFS Permits Division fail to ensure compliance with these Terms and Conditions to implement the associated RPMs applicable to the authorities of each agency, the protective coverage of section 7(o)(2) may lapse. The Terms and Conditions detailed below for each of the RPMs include monitoring and minimization measures where needed.

1) The following terms and conditions implement RPM 1:

   a) The Navy shall implement all mitigation measures as specified in the final MMPA rule and LOA.

   b) NMFS Permits Division shall ensure that all mitigation measures as prescribed in the final rule and LOA are implemented by the Navy.

   c) The Navy shall continue technical assistance/adaptive management efforts with NMFS to help inform future consultations on Navy training in the action area. Adaptive management discussions should include review of Navy's exercise and monitoring reports, review of ESA section 7 reinitiation triggers (described in Section 14 below), and potential new measures to increase mitigation effectiveness.

2) The following terms and conditions implement RPM 2:

   a) The Navy shall monitor training 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 analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs, and any new information regarding the ranges to effects used in our analysis of the effects of acoustic stressors (sonar and explosives) on ESA-listed species.

   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 analyzed in this opinion annually and over the seven-year period of the MMPA regulations and LOAs.

   c) The Navy shall report to the NMFS ESA Interagency Cooperation Division all observed injury or mortality of any ESA-listed species resulting from the proposed training 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 one or more of the activities included in the proposed action.

   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, the Navy shall comply with the stranding Notification and Reporting Plan.

   e) If NMFS personnel determine that the circumstances of any of the strandings reported in 2(f) suggest investigation of the associated Navy activities is warranted (see stranding Notification and Reporting Plan), 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 kilometers (27 nautical miles) of the discovery/notification of the stranding by NMFS, or estimated time of stranding. Navy will submit this information as soon as possible, but no later than seven business days after the request.

13 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

The following conservation recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the Navy:

1. As practicable, the Navy should develop procedures to aid any individual ESA-listed marine mammal that has been impacted by GOA TMAA/WMA activities and is in a condition requiring assistance to increase likelihood of survival.

2. The Navy should continue to model potential impacts to ESA-listed marine mammals using NAEMO and other relevant models. The Navy should validate assumptions used in risk analyses and seek new information and higher quality data for use in such efforts.

3. The Navy should work towards developing a model-based approach for quantitatively analyzing the effects of acoustic stressors (i.e., sonar and explosives) on ESA-listed fishes. The Navy should coordinate with NMFS' regional science centers or other entities to collect additional information on the density and distribution of ESA-listed fishes within the GOA TMAA in order to incorporate into density models in the future.

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 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 activities.

6. Based on information provided in the Oedekoven and Thomas (2022) report titled *Effectiveness of Navy Lookout Teams in Detecting Cetaceans*, and additional data available from that study, the Navy should: 1) Reevaluate how mitigation effectiveness is accounted for when updating its acoustic effects model, and 2) continue to coordinate with NMFS in evaluating and/or developing new (or modified) mitigation procedures to improve on the effectiveness of current procedural mitigation measures involving Navy lookouts via the adaptive management process.

7. As practicable, the Navy should supplement the proposed visual monitoring mitigation measures described in Section 4.6.1 with passive and active acoustic monitoring for activities that could cause marine mammal injury or mortality.

8. We recommend the Navy consider using the potential standards for towed array passive acoustic monitoring in the Towed Array Passive Acoustic Operations for Bioacoustic

Applications: ASA/JNCC Workshop Summary March 14-18, 2016 Scripps Institution of Oceanography, La Jolla, California, USA (Thode 2017).

9. The Navy should continue to conduct research on thermal detection monitoring systems, as a supplement to visual monitoring, to further minimize the impacts of Navy acoustic stressors on ESA-listed marine mammals.

In order for NMFS' Office of Protected Resources ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Navy should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 Reinitiation Notice

This concludes formal consultation on the Navy's proposed GOA Phase III activities and NMFS' promulgation of regulations and issuance of an MMPA LOA. Consistent with 50 C.F.R. §402.16(a), reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

(1) The amount or extent of taking specified in the ITS is exceeded, including exceedance of an activity level for any activity associated with take of an ESA-listed species.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to the listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed, or critical habitat designated under the ESA that may be affected by the action.

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