DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT / SUPPLEMENTAL OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL OPERATIONS

AUGUST 2018

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Abstract

Designation:	Draft Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement
Title of Proposed Action:	SURTASS LFA Sonar Training and Testing
Lead Agency:	Department of the Navy
Cooperating Agency:	National Marine Fisheries Service, Office of Protected Resources
Affected Region:	Western and Central North Pacific and Eastern Indian oceans
Action Proponent:	Chief of Naval Operations
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Date:	August 2018

The Department of the Navy has prepared this Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (SEIS/SOEIS) in accordance with the National Environmental Policy Act (NEPA), as implemented by the Council on Environmental Quality Regulations and Navy regulations for implementing NEPA. The proposed action is the continued use of SURTASS LFA sonar onboard U.S. Navy surveillance ships for training and testing in the western and central North Pacific and eastern Indian oceans, with certain geographic constraints and mitigation and monitoring protocols applied. This SEIS/SOEIS evaluates the potential environmental impacts associated with the two action alternatives, Alternatives 1 and 2, and the No-Action Alternative to the following resource areas: air quality, marine waters, biological, and economic resources.

Executive Summary

The United States (U.S.) Department of the Navy (Navy) has prepared this Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/SOEIS) as a comprehensive assessment of the environmental impacts associated with the use of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems. The Navy as the lead agency for the Proposed Action is responsible for the scope and content of this SEIS/SOEIS. In accordance with 40 Code of Federal Regulations (CFR) 1501.6, the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) is a cooperating agency, since the scope of the Proposed Action and alternatives involve activities that have the potential to impact protected marine resources under NMFS's jurisdiction, including marine mammals, threatened and endangered species, and essential fish habitat (EFH). In accordance with Council on Environmental Quality (CEQ) regulations, the Navy would issue a Record of Decision (ROD) that provides the rationale for choosing one of the alternatives. Since the issuance of an Incidental Take Authorization (ITA) is a major federal action under NEPA, NMFS, in accordance with 40 CFR 1506.3 and 1505.2, intends to adopt this SEIS/OSEIS and issue a separate ROD associated with its decision to grant or deny the Navy's request for an ITA.

On July 15, 2016, the U.S. Court of Appeals for the Ninth Circuit issued a decision in Natural Resources Defense Council (NRDC), et al. versus Pritzker, et al., which was an appeal of a challenge to NMFS's 2012 MMPA Final Rule for SURTASS LFA sonar. Both the Navy and NMFS have carefully and fully considered the Ninth Circuit's decision and have addressed it herein, as appropriate. The court ultimately dismissed the case in 2017 as a result of a settlement agreement.

On August 10, 2017, in consultation with the Secretary of Commerce and pursuant to Title 16, Section 1371(f) U.S. Code (U.S.C.), the Secretary of Defense determined that it was necessary for the national defense to exempt all military readiness activities that employ SURTASS LFA sonar from compliance with the requirements of the MMPA for two years from August 13, 2017 through August 12, 2019, or until such time when NMFS issues the required regulations and a Letter of Authorization (LOA) under Title 16, Section 1371, whichever is earlier. During the two-year exemption period, all military readiness activities that involve the use of SURTASS LFA sonar are required to comply with all mitigation, monitoring, and reporting measures set forth in the 2017 National Defense Exemption (NDE) for SURTASS LFA sonar.

Proposed Action

The Navy proposes to continue utilizing SURTASS LFA and compact LFA (CLFA) sonar systems onboard U.S. Navy surveillance ships for training and testing activities conducted under the authority of the Secretary of the Navy in the western and central North Pacific and eastern Indian oceans. In this SEIS/SOEIS, the terms "SURTASS LFA sonar" or "SURTASS LFA sonar systems" are inclusive of both the LFA and CLFA systems, each having similar acoustic operating characteristics. The Navy currently has four surveillance ships that utilize SURTASS LFA sonar systems but may develop and field additional SURTASS LFA sonar equipped vessels, either to replace or complement the Navy current SURTASS LFA sonar equipped fleet. Under the 2017 NDE, the Navy is currently allowed to transmit 255 hours of LFA sonar transmission hours per vessel per year or a total of 1,020 sonar transmission hours per year. Under Alternative 1 of this SEIS/SOEIS, the Navy would transmit 360 hours of LFA sonar transmissions per year pooled across all SURTASS LFA equipped vessels, while under Alternative 2, the Navy's Preferred Alternative, the Navy would transmit 496 total hours of LFA sonar transmissions per year across all SURTASS LFA sonar equipped vessels in the first four years, and would increase usage to 592 total hours of LFA sonar transmissions in year five and continuing into the foreseeable future, regardless of the number of vessels.

The geographic scope of the previous National Environmental Policy Act (NEPA) and Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions,* documents for SURTASS LFA sonar routine training, testing, and military operations was the non-polar areas of the Atlantic, Pacific, and Indian oceans and the Mediterranean Sea. The geographic scope of this SEIS/SOEIS and the Navy's Proposed Action is the western and central North Pacific and eastern Indian oceans. The Navy scoped the geographic extent of this document to better reflect the areas where the Navy anticipates conducting SURTASS LFA sonar training and testing activities now and into the foreseeable future.

Since acoustic stimuli from use of SURTASS LFA sonar during training and testing has the potential to cause harassment of marine mammals, the Navy submitted an application to NMFS requesting authorization for the taking of marine mammals pursuant to section 101(a)(5)(A) of the MMPA and 50 CFR 216 (NMFS's implementing regulations). Once NMFS determines an application is adequate and complete, NMFS has a corresponding duty to determine whether and how to authorize take of marine mammals incidental to the activities described in the application. To authorize the incidental take of marine mammals, NMFS evaluates the best available scientific information to determine whether the take would have a negligible impact on the affected marine mammal species or stocks and an unmitigable impact on their availability for taking for subsistence uses. NMFS also must prescribe the "means of effecting the least practicable adverse impact" on the affected species or stocks and their habitat, and on the availability of those species or stocks for subsistence uses, as well as monitoring and reporting requirements. NMFS cannot issue an ITA unless it can make the required findings. NMFS proposed action is a direct outcome of responding to the Navy's request for an ITA.

Purpose of and Need for the Proposed Action

The Navy's statutory mission is the maintenance, training, equipping, and operation of combat-ready naval forces capable of accomplishing America's strategic objectives, deterring maritime aggression, and maintaining freedom of navigation in ocean areas (10 U.S.C. Section 5062). By law, the Secretary of the Navy is responsible for functions such as training, supplying, equipping, and maintaining naval forces that are ready to achieve national security objectives as directed by the National Command Authorities. Preparing and maintaining forces skilled in anti-submarine warfare (ASW) is a critical part of the Navy's mission. The purpose of the proposed action is to ensure that the Navy remains proficient in the use of SURTASS LFA sonar in support of the Navy's mission. The need for the Proposed Action is to maintain a system capable of detecting at long ranges the increasingly technologically advanced foreign submarine presence that threatens our national security.

The purpose of NMFS's action—which is a direct outcome of the Navy's request for authorization to take marine mammals incidental to SURTASS LFA sonar training and testing activities -- is to evaluate Navy's application pursuant to section 101(a)(5)(A) of the MMPA and 50 CFR 216 and issue an incidental take authorization if appropriate. The need for NMFS's action is to consider the impacts of the Navy's activities on marine mammals and ultimately allow the Navy to conduct its activities in compliance with the MMPA if the requirements of section 101(a)(5)(A) are satisfied. In short, the Navy submitted an application demonstrating the need and potential eligibility for an ITA under the MMPA, thus NMFS has a corresponding duty to determine whether and how to authorize take of marine mammals incidental to the activities described in the application.

Alternatives Considered

Alternatives were developed for analysis based upon the following reasonable alternative screening factors that allow the Navy to: meet all training and testing requirements for SURTASS LFA sonar systems, vessels, and crews; and meet all requirements for scheduling of maintenance and repair as well as vessel crews for SURTASS LFA sonar vessels. After consideration of the screening factors, the Navy has carried forward two action alternatives for analysis that meet the purpose and need for the Proposed Action.

Under the No Action Alternative, the Proposed Action would not occur, and the SURTASS LFA sonar training and testing activities would not occur. Although the No Action Alternative does not meet the purpose and need for the Proposed Action, it was nonetheless carried forward to provide a baseline for environmental consequences. For NMFS, pursuant to its obligation to grant or deny permit applications under the MMPA, the No Action Alternative involves NMFS' denial of Navy's application for an incidental take authorization under Section 101(a)(5)(A) of the MMPA. If NMFS were to deny the Navy's applications based upon the assumption that the Navy's proposed action would not occur, the Navy would not be authorized to incidentally take marine mammals associated with covered SURTASS LFA sonar activities.

Both action alternatives include the use of SURTASS LFA sonar systems, with geographical restrictions to include maintaining SURTASS LFA sonar received levels (RLs) below 180 decibels (dB) re 1 microPascal (µPa) (root-mean-square [rms]) (sound pressure level [SPL]) within 12 nautical miles (nmi) (22 kilometers [km]) of any emergent land and within the boundary of a designated offshore biologically important area (OBIA) during their respective effective periods when significant biological activity occurs. Additionally, the SURTASS LFA sonar RLs would not exceed 145 dB re 1 µPa (rms) within known recreational and commercial dive sites. Under Alternative 1, the maximum number of pooled LFA sonar transmission hours would not exceed 360 hours across all SURTASS LFA sonar-equipped vessels per year. Under Alternative 2 (Preferred Alternative), the annual pooled LFA sonar transmission hours are increased to 496 hours total per year across all SURTASS LFA sonar-equipped vessels in the first four years of the effective period, with the number of transmission hours increasing to 592 hours across all vessels during year 5 and continuing into the foreseeable future, regardless of the number of SURTASS LFA sonar-equipped vessels.

Summary of Environmental Resources Evaluated in the SEIS/SOEIS

CEQ regulations, NEPA, and Navy instructions for implementing NEPA and Executive Order 12114 specify that a SEIS/SOEIS should address those resource areas potentially subject to impacts. In addition, the level of analysis should be commensurate with the anticipated level of environmental impact. The following resource areas have been addressed in this SEIS/SOEIS: air quality, marine water, biological, and economic resources. Since potential impacts were considered to be negligible or nonexistent for the following resources, they were not evaluated in this SEIS/SOEIS: airspace, geological resources, cultural resources, land use, infrastructure, transportation, public health and safety, hazardous materials and wastes, sociologic, and environmental justice.

Air quality may be affected as SURTASS LFA sonar vessels training and testing activities, with a nominal schedule of 54 days of transit, 240 at-sea activities, and 71 days in port, per vessel. The use of the SURTASS LFA sonar vessels does not vary between the two action alternatives (the difference between the two alternatives is the number of LFA sonar transmission hours); the air quality analysis compared both action alternatives against the No Action Alternative of the existing air quality within the western and central North Pacific and eastern Indian oceans.

The only potential impact on marine water resources associated with SURTASS LFA sonar activities is the addition of underwater sound to the ambient noise environment during use of both the SURTASS LFA sonar and the associated high frequency/marine mammal monitoring (HF/M3) sonar system. The parameters at which the HF/M3 sonar operates and the high transmission loss of its HF signals reduce the possibility for HF/M3 sonar to contribute to the ambient noise environment or affect marine animals. Therefore, the focus of the SEIS/SOEIS's analysis was on the intermittent increase in the ambient noise level in the frequency band (100 to 500 Hz) in which LFA sonar operates.

Biological resources that may be impacted by the proposed action are marine habitats and marine species, including marine and anadromous fishes, sea turtles, and marine mammals. The marine species that were evaluated must: 1) occur within the same ocean region as SURTASS LFA sonar use, and 2) possess some sensory mechanism that allows them to perceive low-frequency (LF) sound, and/or 3) possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. Fishes are able to detect sound, although there is remarkable variation in hearing capabilities amongst species. While it is not easy to generalize about hearing capabilities due to this diversity, most fishes known to detect sound can at least hear frequencies from below 50 Hertz (Hz) up to 800 Hz, while a large subset of fishes can detect sounds to approximately 4,000 Hz and another, very small subset can detect sounds up to about 110,000 Hz. Thus, many species of fishes can potentially hear SURTASS LFA sonar transmissions and were considered for potential impacts. It is also likely that all potentially occurring species of sea turtles hear LF sound, at least as adults, and so were considered for potential impacts. Marine mammals are highly adapted marine animals, able to detect underwater sound. Marine mammal species that may occur in areas in which SURTASS LFA sonar might operate were included in the impact analysis. Four types of marine habitat areas, critical habitat, EFH, marine protected areas, and national marine sanctuaries, which are all protected under U.S. legislation, were considered in the impact analysis.

Summary of Potential Environmental Consequences of the Action Alternatives and Major Mitigating Actions

Air Quality: Effects on air quality are based on estimated direct and indirect emissions associated with the action alternatives. Under both action alternatives, SURTASS LFA sonar vessels would conduct training and testing activities at sea, both potentially in the territorials seas (waters between 3 and 12 nmi [5.6 to 22 km] from shore) of the U.S. in Hawaii, Guam, and CNMI as well as in the global commons (i.e., beyond the territorial seas of any nation). During the execution of their training and testing missions, SURTASS LFA sonar vessels would emit HAPs as the result of the combustion of marine diesel fuel necessary to operate the vessels. Estimated air emissions of six criteria air pollutants generated by the existing four SURTASS LFA sonar vessels under Alternatives 1 and 2 resulted in values ranging from 0.24 to 14.87 metric tons and 0.39 to 24.44 metric tons, respectively. Estimates of the greenhouse gas emissions under Alternative 1 and Alternative 2 were estimated as 532.9 metric tons and 876.3 metric tons per year CO_2 equivalency, respectively. To put these emission values into a more understandable perspective, the annual average CO_2 equivalency emissions from international shipping for the period 2007 to 2012 was 846,000,000 metric tons. Based on the small quantities of expected air emissions resulting from Alternatives 1 or 2, the meteorology of the study area, and the frequency and isolation of the proposed training and testing activities, the incremental contribution of air emissions resulting from the execution of the Proposed Action would not result in measurable additional impacts on air quality in the study area or beyond. Thus, the execution of the Proposed Action would not result in significant impacts to Air Quality.

Marine Water Resources: When deployed and transmitting, sound generated by SURTASS LFA sonar would temporarily add to the ambient noise level in the frequency band (100 to 500 Hz) in which SURTASS LFA sonar operates, but the impact on the overall noise level in the ocean would be minimal. SURTASS LFA sonar produces a coherent LF signal with a duty cycle of less than 20 percent and an average pulse length of 60 seconds (sec). In most oceans, the LF (10 to 500 Hz) portion of the ambient noise level is dominated by anthropogenic noise sources, particularly shipping and seismic airguns. The total energy output of individual sources was considered in calculating an annual noise energy budget (Hildebrand, 2005). The percentage of the total anthropogenic acoustic energy budget added by LFA source transmissions is estimated to be 0.21 percent under Alternative 1 and 0.29 and 0.34 percent, respectively for years 1 to 4 and year 5 and beyond, under Alternative 2 when commercial supertankers, seismic airguns, mid-frequency military sonar, and SURTASS LFA sonar were considered. Implementation of either action alternative would not result in significant impacts to marine water resources.

Biological Resources: Of the potential biological stressors associated with the Navy's proposed action, the only stressor that is likely to affect marine species or critical habitat is the transmission of LFA sonar signals. The potential for acoustic impacts to marine animals is assessed in the context of how impacts on individual animals affect the fitness or survivorship of the population or stock that comprise those individuals. Individual marine animals may experience behavioral responses that are not likely to result in fitness consequences for individuals or adverse population level impacts that exceed the least practicable adverse impact standard. Potential impacts on marine animals from transmission of SURTASS LFA sonar include:

- Non-auditory impacts: direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas;
- Auditory impacts: permanent threshold shift (PTS), which is a permanent loss of hearing sensitivity over the frequency band of the exposure, or temporary threshold shift (TTS), in which an animal's hearing sensitivity over the frequency band of exposure is impaired for a period of time (minutes to days);
- Behavioral change: for military readiness activities such as the use of SURTASS LFA sonar, Level B incidental "harassment" under the MMPA is defined as any act that disturbs or is likely to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or significantly altered;
- Masking: when sounds in the environment interfere with an animal's ability to hear sounds of interest; and
- Physiological stress: a response in a physiological mediator (e.g., glucocorticoids, cytokines, or thyroid hormones).

Given the studies of sound exposure to fishes, the potential for impacts is restricted to within close proximity of SURTASS LFA sonar while it is transmitting sound. A summary of the thresholds defined by Popper et al. (2014), and modified by DoN (2017c) to account for the signal duration of exposure and add fishes with high-frequency hearing sensitivity, shows the probability of an impact is low to moderate and would require fishes to be within close proximity (<0.54 nmi [<1 km]) of the SURTASS LFA sonar while it was transmitting sound. The potential is minimal to negligible for an individual fish to experience non-auditory impacts, auditory impacts, or a stress response. A low potential for minor, temporary behavioral responses or masking of an individual fish may occur when SURTASS LFA sonar is transmitting sound, but there is no potential for fitness level consequences. Since a minimal to negligible portion of any fish stock would need to be in sufficient proximity during SURTASS LFA sonar transmissions to experience such impacts, the potential is minimal for SURTASS LFA sonar to affect fish stocks.

The paucity of data on underwater hearing sensitivities of sea turtles, whether sea turtles use underwater sound, or the responses of sea turtles to sound exposures make a quantitative analysis of the potential impacts from SURTASS LFA sonar signals difficult (NMFS, 2012), but available information suggests that there is a low to moderate potential for impacts to occur. DoN (2017) developed an auditory weighting function and an exposure function to estimate onset TTS and PTS for sea turtles. Given the frequency at which SURTASS LFA sonar transmits sound, the most protective calculations would use the threshold for onset TTS as 200 dB re 1 μPa^2-sec and onset PTS as 220 dB re 1 μPa^2-sec and would be weighted by 0 dB (DoN, 2017). Given the 60-sec duration of the typical SURTASS LFA transmission, the SPL thresholds for onset TTS and onset PTS are 182 dB re 1 µPa and 202 dB re 1 µPa, respectively. Based on simple spherical spreading (i.e., transmission loss based on 20 x $\log_{10}$[range{m}]), sea turtles would need to remain within 143 ft (44 m) or 14 ft (4 m), respectively, for the duration of an entire 60-sec LFA sonar transmission to experience onset of TTS or PTS. This would require them to swim at approximately 3 knots (5.6 kilometers per hour) for the 60-sec signal, which is faster than their average swim speeds, without being detected by the HF/M3 active sonar mitigation measure. The best estimate of a threshold for behavioral response in sea turtles is 175 dB re 1 µPa SPL (rms); this RL could occur at a distance of approximately 1 nmi (2 km) from the SURTASS LFA sonar. Given these thresholds for sea turtles, the probability of TTS is low and PTS is extremely low. No evidence exists on how sea turtles use sound to communicate or capture prey, so if any hearing loss were to occur, the potential for impact on important biological functions is likely limited.

In addition, given the lack of data on the distribution and abundance of sea turtles in the open ocean, it is not feasible to estimate the percentage of a sea turtle population that could be located in a SURTASS LFA sonar model area. Given that the majority of sea turtles encountered in oceanic areas in which SURTASS LFA sonar is proposed to operate would in high likelihood be transiting through the area and not lingering, the possibility of significant behavior changes, especially from displacement, are unlikely and there is no potential for fitness level consequences. The geographical restrictions imposed on SURTASS LFA sonar use would greatly limit the potential for exposure to occur in nearshore areas such as nesting beaches where sea turtles would be aggregated, potentially in large numbers. While it is possible that a sea turtle could hear LFA sonar transmissions if the animal were in close proximity to the transmitting SURTASS LFA sonar source, when this is combined with the low probability of sea turtles potentially being near the LFA sound source while it is transmitting, the potential for impacts from exposure to SURTASS LFA sonar is considered negligible.

When exposed to SURTASS LFA sonar, marine mammals have the potential to experience auditory impacts (i.e., PTS and TTS), behavioral change, acoustic masking, or physiological stress (Atkinson et al., 2015; Clark et al., 2009; Nowacek et al., 2007; Southall et al., 2007; NMFS, 2018). However, SURTASS LFA sonar transmissions are not expected to cause non-auditory impacts, such as gas bubble formation or strandings, particularly in beaked whales. One potential impact from exposure to high-intensity sound in marine mammals is auditory impacts, specifically TTS. Several studies by a number of investigators have been conducted, focusing on the relationships among the amount of TTS and the level, duration, and frequency of the stimulus (Finneran, 2017; NMFS, 2018). None of these studies on marine mammals have resulted in direct data on the potential for PTS, empirical measurements of hearing, or the impacts of noise on hearing for baleen whales (mysticetes), which are believed to be most sensitive to SURTASS LFA sonar. In preceding SURTASS LFA sonar documentation (DoN, 2001, 2007, 2012, 2015, 2017), the potential for PTS and TTS was evaluated as MMPA Level A harassment for all marine mammals at RLs greater than or equal to 180 dB re 1 µPa (rms) (SPL), even though NMFS stated that TTS is not a physical injury in MMPA rulemaking for SURTASS LFA sonar (NOAA, 2002, 2007, 2012). Since the 2012 SEIS/SOEIS was released, NMFS published acoustic guidance that incorporates new data and summarizes the best available information. The NMFS acoustic guidance defines hearing groups, develops auditory weighting functions, and identifies acoustic threshold levels at which PTS and TTS occur (NMFS, 2018). The Navy used this methodology for estimating the potential for PTS and TTS for SURTASS LFA sonar.

The potential impact on marine mammals from exposure to SURTASS LFA sonar is change in a biologically significant behavior. The Low Frequency Sound Scientific Research Program (LFS SRP) in 1997 to 1998 provided important results on, and insights into, the types of responses by baleen whales (mysticetes) to SURTASS LFA sonar signals and how those responses scaled relative to RL and context. These experiments still represent the most relevant predictions of the potential for behavioral changes from exposure to SURTASS LFA sonar. The results of the LFS SRP confirmed that some portion of the total number of baleen whales exposed to SURTASS LFA sonar responded behaviorally by changing their vocal activity, moving away from the source vessel, or both; but the responses were short-lived and animals returned to their normal activities within tens of minutes after initial exposure (Clark and Fristrup, 2001). The fact that none of the LFS SRP observations revealed a significant change in a biologically important behavior helped determine an upper bound for exposure risk. However, the LFS SRP results cannot be used to prove that there is zero risk at these levels. These LFS SRP results were used to derive the risk continuum function for SURTASS LFA sonar, from which the potential for biologically significant behavioral response was calculated. The SRP-based data on baleen whale responses to LFA sonar are realistic contextually and remain the best available data for the purpose of predicting potential impacts on LF-sensitive marine mammals from exposure to SURTASS LFA sonar.

The potential for masking and physiological stress to marine mammals was assessed with the best available data. The potential for masking from SURTASS LFA sonar signals is limited because no single frequency is transmitted for longer than 10 sec, and signals that consist of many frequencies do not span more than 30 Hz (i.e., they have limited bandwidths). Furthermore, when SURTASS LFA sonar is being used, the source is active only 7.5 to 10 percent of the time, with a maximum 20 percent duty cycle, which means that for 80 to 92.5 percent of the time, there is no potential for masking. More research is needed to understand the potential for physiological stress in marine mammals during noise exposure scenarios. The existing data suggest a variable response that depends on the characteristics of the received signal and an animal's prior experience with the received signal.

A quantitative impact analysis was conducted for marine mammals to assess their potential for PTS, TTS, and behavioral change. Fifteen representative modeling areas in the western and central North Pacific and eastern Indian oceans that represent the acoustic regimes and marine mammal species that may be encountered during LFA sonar activities were analyzed. To predict acoustic exposure, the SURTASS LFA sonar ship was simulated traveling in a triangular pattern at a speed of 4 knots (kt) (7.4 km per hour [kph]) for a 24-hr period, with a signal duration of 60 sec and a duty cycle of 10 percent (i.e., the source transmitted for 60 sec every 10 min for 24 hr). The acoustic field around the LFA sonar source was predicted with the Navy standard parabolic equation propagation model using the defined LFA sonar operating parameters.

Each marine mammal species potentially occurring in a model area in each of the four seasons was simulated by creating animats (model simulated animals) programmed with behavioral values describing their dive and movement patterns, including dive depth, dive duration, surfacing time, swimming speed, and direction change. The Acoustic Integration Model© (AIM) integrated the acoustic field created from the underwater transmissions of SURTASS LFA sonar with the three-dimensional movement of marine mammals to estimate their potential sonar exposure at each 30-sec timestep within the 24-hour (hr) modeling period. The sound energy received by each individual animat over the 24-hr modeled period was calculated as sound exposure level (SEL), and the potential for PTS and TTS was considered using the NMFS (2018) guidance. The sound energy received by each individual animat over the 24-hr modeled period was also calculated as dB single ping equivalent (SPE)[1] and used as input to the LFA risk continuum function to assess the potential risk of a behavioral reaction.

The results of these 24-hr sonar use simulations were scaled to calculate the potential annual impacts per activity, which were then summed across the stocks for a total potential impact for all activities. The scaling included determining the number of LFA sonar transmission hours that might occur in each model area, for each activity, and multiplying by the maximum 24-hr impact level for each stock that might occur in that model area. The end result was the number of individuals and the percentage of the stock or population that may experience TTS or behavioral changes from SURTASS LFA sonar exposures on an annual basis. When mitigation is applied in the modeling-analysis environment, estimations of PTS effects were 0 for all species. Therefore, no PTS (MMPA Level A incidental harassment) is expected with the implementation of mitigation measures. As the result, no MMPA Level A incidental harassment takes have been requested from NMFS.

Thus, the anticipated impact associated with use of SURTASS LFA sonar during training and testing activities is MMPA Level B harassment of marine mammals. For most stocks of marine mammal species, the maximum annual percent of the stock or population that may experience Level B incidental harassment is less than 15 percent. This means that during one 24-hr period during the year, less than 15 percent of the population may react to SURTASS LFA sonar by changing behavior or moving a small distance, or may experience TTS. Of the 139 stocks within the SURTASS LFA sonar study area, eight stocks under Alternative 1 and eleven stocks in years 1 to 4 and fifteen stocks in years 5 and beyond under Alternative 2 have the potential for MMPA Level B incidental harassment greater than 15 percent. The highest percentage of a population that may experience Level B harassment is the WNP stock and DPS of humpback whales at 157.68 percent under Alternative 1 and 233.84 percent and 321.49 percent in years 1 to 4 and years 5 and beyond, respectively, under Alternative 2. This means that each individual in the population may react behaviorally or have TTS one to three times during one year. The percentage of the WNP stock and DPS of humpback whales that may experience Level B harassment is influenced by the size of the population, which is small (1,328 individuals). The next highest stock is the WNP stock of killer whales, with 53.41 percent potentially experiencing Level B harassment under Alternative 1 and 85.37 percent and 117.31 percent in years 1 to 4 and years 5 and beyond, respectively, under Alternative 2.

1 The term "Single Ping Equivalent" (SPE) used herein is an intermediate calculation for input to the behavioral risk continuum used in the acoustic impact analysis for SURTASS LFA sonar. SPE accounts for the energy of all SURTASS LFA sonar transmissions that a modeled animal ("animat") receives during a 24-hr period of a SURTASS LFA sonar use as well as an approximation of the manner in which the effect of repeated exposures accumulate. As such, the SPE metric incorporates both physics and biology. Calculating the potential behavioral risk from exposure to SURTASS LFA sonar is a complex process and the reader is referred to Appendix B for details. As discussed in Appendix B, SPE is a function of SPL, not SEL. SPE levels will be expressed as "dB SPE" in this document, as they have been presented in preceding environmental compliance documentation for SURTASS LFA sonar: FOEIS/FEIS (DoN, 2001); FSEIS (DoN, 2007); FSEIS/SOEIS (DoN, 2012); FSEIS/SOEIS (DoN, 2015); and FSEIS/SOEIS (DoN, 2017).

The potential for impacts to marine habitats, including critical habitat, EFH, marine protected areas, and national marine sanctuaries, was considered within the context of the addition of sound energy to the marine environment while SURTASS LFA sonar is transmitting. SURTASS LFA sonar transmissions represent a vanishingly small percentage of the overall annual underwater acoustic energy budget, and the proposed LFA sonar transmissions would not only intermittently add sound to the ambient noise environment and only to a limited ocean area. As such, SURTASS LFA sonar activities would not significantly affect the ambient noise environment of marine habitats.

The objective of mitigation for SURTASS LFA sonar training and testing activities is the reduction or avoidance of potential effects to marine animals and marine habitat. This mitigation objective is met by ensuring that the activities under the Proposed Action:

- Do not expose coastal waters within 12 nmi (22 km) of emergent land to SURTASS LFA sonar signal RLs ≥180 dB re 1 µPa (rms)(SPL);
- Preclude OBIAs from being exposed to RLs of SURTASS LFA sonar signal ≥180 dB re 1 µPa (rms)(SPL) during biologically important seasons;
- Minimize exposure of marine mammals and sea turtles to RLs of SURTASS LFA sonar transmissions above 180 dB re 1 µPa (rms)(SPL) by monitoring for their presence and delaying/suspending SURTASS LFA sonar transmissions when one of these animals enters the LFA mitigation zone; and
- Do not expose known recreational or commercial dive sites to RLs from SURTASS LFA sonar signals >145 dB re 1 µPa (rms) (SPL).

Additionally, NMFS may propose to include additional geographic restrictions, including a 0.54-nmi (1-km) buffer around the LFA sonar mitigation zone and a 0.54-nmi (1-km) buffer around an OBIA boundary during the biologically important season specified for each OBIA. The Navy has determined that these restrictions are practicable and would implement them as part of the suite of mitigation measures.

The Navy would cooperate with NMFS and other federal agencies to monitor impacts on marine mammals and to designate qualified on-site personnel to conduct mitigation monitoring and reporting activities. The Navy would continue to conduct the following monitoring to prevent injury to marine animals whenever SURTASS LFA sonar is transmitting during training and testing activities:

- Visual monitoring for marine mammals and sea turtles from the SURTASS LFA sonar vessels during daylight hours by personnel trained to detect and identify marine mammals and sea turtles;
- Passive acoustic monitoring using the passive SURTASS towed array to listen for sounds generated by marine mammals as an indicator of their presence; and
- Active acoustic monitoring using the HF/M3 sonar, which is a Navy-developed, enhanced HF commercial sonar, to detect, locate, and track marine mammals and, to some extent, sea turtles, that may pass close enough to the SURTASS LFA sonar's transmit array to enter the LFA mitigation zone plus the 0.54 nmi (1 km) buffer zone, if implemented by NMFS.

Economic Resources: Analysis of impacts to economic resources is focused on potential impacts to commercial fisheries, subsistence harvesting of marine mammals, and recreational marine activities. If SURTASS LFA sonar use were to occur in proximity to fish stocks, members of some fish species could potentially be affected by the transmitted LF sounds, but no potential exists for fitness level consequences or impacts to fish stocks. Due to the negligible impacts on fishes from the use of SURTASS

LFA sonar within the required guidelines and restrictions, a negligible impact on commercial fisheries is estimated. The SURTASS LFA sonar study area does not overlap in time or space with subsistence hunts of marine mammals, so there would be no impact on the availability of marine mammal species or stocks for subsistence use. No significant impacts on recreational swimming, snorkeling, diving, or whale watching activities would result from the use of SURTASS LFA sonar due to the application of geographic restrictions for SURTASS LFA sonar use.

Impact Summary

The potential impacts under both action alternatives have been summarized for the resources potentially impacted by SURTASS LFA sonar training and testing activities (Table ES-1).

Public Involvement

On June 5, 2015, the Navy published a Notice of Intent (NOI) in the *Federal Register* (80 FR 32097) to prepare a SEIS/SOEIS for the continued employment of SURTASS LFA sonar and to support consultations associated with expiring MMPA and ESA 5-year regulatory permits for SURTASS LFA sonar (DoN, 2015b). The NOI provides an overview of the proposed action. No comments were received in response to the NOI.

Although the Navy prepared and completed a FSEIS/SOEIS for SURTASS LFA sonar on June 30, 2017, and a Notice of Availability for the FSEIS/SOEIS was published in the *Federal Register* on July 7, 2017, no ROD detailing the Navy's decision, alternative selected, or mitigation and monitoring plan for the employment of SURTASS LFA sonar was issued. The Navy determined that the purposes of NEPA and EO 12114 relevant to SURTASS LFA sonar begun in June 2015 with the publication of a NOI would be furthered by the preparation of this additional SEIS/SOEIS, which is planned to be published in final form in early July 2019, with a ROD to follow in early August 2019.

The Navy has prepared this Draft SEIS/SOEIS to be released to the public in August 2018, with a 45-day comment and review period that would commence when the U.S. Environmental Protection Agency (EPA) publishes the Notice of Availability for the Draft SEIS/SOEIS for SURTASS LFA sonar use in the *Federal Register.* The Draft SEIS/SOEIS would be available for download and review on the Navy's website for SURTASS LFA sonar (<http://www.surtass-lfa-eis.com/>) or in select public libraries. The Final SEIS/SOEIS for SURTASS LFA sonar is planned to be completed and released to the public in July 2019.

Table ES-1. Summary of Potential Impacts to Resource Areas[2]

<table>
<tr><th>Resource Area</th><th>No Action Alternative</th><th>Alternative 1</th><th>Alternative 2</th></tr>
<tr><td colspan="4">Air Quality</td></tr>
<tr><td></td><td>No impact</td><td colspan="2">Minor, localized, and intermittent air emissions, principally in the atmosphere of the global commons with an negligible added concentration of air pollutants.</td></tr>
<tr><td colspan="4">Water Resources</td></tr>
<tr><td></td><td>No impact</td><td>Intermittent increase in ambient noise level during SURTASS LFA sonar transmissions for 360 hr per year</td><td>Intermittent increase in ambient noise level during SURTASS LFA sonar transmissions for 498 hr in years 1 to 4 and 592 hr in year 5 and into the foreseeable future</td></tr>
<tr><td colspan="4">Biological Resources</td></tr>
<tr><td>Marine Fishes</td><td>No impact</td><td colspan="2">Low to moderate probability of non-auditory, auditory, behavioral, masking, or physiological stress impacts may result when fish are in close proximity (<0.54 nmi [<1 km]) of the transmitting SURTASS LFA sonar source</td></tr>
<tr><td>Sea turtles</td><td>No impact</td><td colspan="2">Low to moderate potential of non-auditory, auditory, behavioral, masking, or physiological stress impacts when turtles are in close proximity (<0.54 nmi [<1 km]) of the transmitting SURTASS LFA sonar source</td></tr>
<tr><td>Marine mammals</td><td>No impact</td><td colspan="2">Potential for auditory or behavioral impacts evaluated quantitatively with the best available science; low to moderate probability of non-auditory, masking, or physiological stress assessed with best available scientific information and data</td></tr>
<tr><td>Marine Habitats</td><td>No impact</td><td colspan="2">Small, intermittent, and transitory increase in overall acoustic environment of marine habitats resulting in a negligible impact</td></tr>
<tr><td colspan="4">Economic Resources</td></tr>
<tr><td>Commercial fisheries</td><td>No impact</td><td colspan="2">Minimal potential for impacts to commercially harvested species and no potential for fitness level consequences resulting in negligible impacts on commercial fisheries</td></tr>
<tr><td>Subsistence harvest of marine mammals</td><td>No impact</td><td colspan="2">SURTASS LFA sonar training and testing activities do not overlap in time or space with subsistence hunts of marine mammals, so there would be no impact on the availability of marine mammal species or stocks for subsistence use</td></tr>
</table>

2 If the conclusions for Alternative 1 and 2 were the same, one conclusion was presented for both alternatives.

Table ES-1. Summary of Potential Impacts to Resource Areas[2]

Resource Area	*No Action Alternative*	*Alternative 1*	*Alternative 2*
Recreational marine activities	No impact	Geographic restrictions limit the received level at known recreational dive sites to no greater than 145 dB re 1 µPa (rms) (SPL) and no greater than 180 dB re 1 µPa within 12 nmi (22 km) of emerged lands, resulting in no impact on recreational diving, swimming, or snorkeling. Minimal potential for impacts to fish species and no potential for fitness level consequences resulting in negligible impacts on recreational fisheries. Geographic restrictions limit the sonar levels in coastal waters in which higher concentrations of marine mammals may occur, which correlates to areas of prime whale watching and thus, would result in no impact to whale watching activities	

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ABBREVIATIONS AND ACRONYMS

Acronym	Definition
°C	Degrees Centigrade/Celsius
°F	Degrees Fahrenheit
μPa	microPascal(s)
%	percent or percentage
$\mu g/m^3$	micrograms per cubic meter
ABR	auditory brainstem response
AEP	auditory evoked potential
AIM	Acoustic Integration Model©
AM	amplitude modulated
$animals/km^2$	animals per square kilometer
ANSI	American National Standards Institute
ANT	Antarctic
APPS	Act to Prevent Pollution from Ships
ASN(I&E)	Assistant Secretary of the Navy (Installations and Environment)
ASW	anti-submarine warfare
BIA	Biologically Important Area
BO	Biological Opinion
BE	Biological Evaluation
BRF	Behavioral Risk Function
BRS	Behavioral Response Study
CAA	Clean Air Act
CBLUG	consolidated bottom loss upgrade
CEE	controlled exposure experiment
CEQ	Council on Environmental Quality
CetMap	Cetacean Density and Distribution Mapping
CFR	Code of Federal Regulations
CH_4	methane
CI	confidence interval
CITES	Convention on International Trade in Endangered Species
CLFA	Compact Low Frequency Active
cm	centimeter(s)
CNMI	Commonwealth of the Northern Mariana Islands
CNO	Chief of Naval Operations (U.S.)
CNP	Central North Pacific
CO	carbon monoxide
CO_2	carbon dioxide
CPUE	catch per unit effort
CSM	cross spectral matrix
CW	continuous wave
CWA	Clean Water Act
CV	coefficient of variance
CZ	convergence zone
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Plan
DASNE	Deputy Assistant Secretary of the Navy for Environment
dB	decibel(s)
dB re 1 μPa	decibels referenced to one microPascal
dB re 1 μPa @ 1 m	decibels referenced to one microPascal measured at one meter from center of acoustic source
dB re 1 μPa^2-sec	decibels of the time integral (summation) of the squared pressure of a sound event
DoD	United States Department of Defense
DoI	Department of the Interior
DoN	United States Department of the Navy
DoS	Department of State
DPS	distinct population segment
DSEIS	Draft Environmental Impact Statement
ECS	East China Sea
EEZ	exclusive economic zone

Acronym	Definition
EFH	essential fish habitat
EIS	Environmental Impact Statement
EO	Executive Order (Presidential)
EOG	Executive Oversight Group
EP	evoked potential
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit(s)
ETP	Eastern Tropical Pacific
FAO	Food and Agriculture Organization
FEIS	Final Environmental Impact Statement
FM	frequency modulated
FMP	fishery management plan
FOEIS/EIS	Final Overseas Environmental Impact Statement/EIS
FR	Federal Register
FSEIS	Final Supplemental Environmental Impact Statement
ft	feet/foot
FY	fiscal year
GIS	geographic information system
GOM	Gulf of Maine
GOMx	Gulf of Mexico
HAP	hazardous air pollutants
HAPC	habitat areas of particular concern
HF	high frequency
HF/M3	high frequency/marine mammal monitoring
HLA	horizontal line array
hr	hour(s)
Hz	Hertz
IA	Inshore Archipelago
ICES	International Council for the

Acronym	Definition
	Exploration of the Sea
ICP	Integrated Common Processor
in	inch(es)
IND	Indian (Ocean)
INPOPACOM	U.S. Indo-Pacific Command
IPPC	Intergovernmental Panel on Climate Change
ISR	Intelligence, Surveillance, Reconnaissance
ITA	Incidental Take Authorization
ITS	Incidental Take Statement
IUCN	International Union for Conservation of Nature
IUSS	Integrated Undersea Surveillance System
IWC	International Whaling Commission
JE	Pacific coast of Japan
JW	Sea of Japan (minke stock)
kg	kilogram(s)
kHz	kiloHertz
km	kilometer(s)
kph	kilometers per hour
kt	knot(s)
lb	pound(s)
LF	low frequency
LFA	Low Frequency Active
LFS SRP	Low Frequency Sound Scientific Research Program
LOA	Letter of Authorization
m	meter(s)
M3	marine mammal monitoring
MARPOL	marine pollution
MBTA	Migratory Bird Treaty Act
MF	mid-frequency
MFA	mid-frequency active
MHI	Main Hawaiian Islands
mi	mile(s)
MILCREW	military crew
min	minute(s)
MMC	Marine Mammal Commission

Acronym	Definition
MMPA	Marine Mammal Protection Act
MPA	marine protected area
MPRSA	Marine Protection, Research, and Sanctuaries Act
MSAT	mobile source air toxics
msec	millisecond(s)
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
mt	metric ton(s)
NAAQS	National Ambient Air Quality Standards
Navy	U.S. Department of the Navy
NDAA	National Defense Authorization Act
NDE	National Defense Exemption
NEPA	National Environmental Policy Act
NIND	Northern Indian (Ocean)
NM	National Monument
NMSDD	Navy Marine Species Density Database
NMFS	National Marine Fisheries Service
nmi	nautical mile(s)
NMPAC	National Marine Protected Area Center
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuary Act
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NO_x	nitrogen oxides
NP	North Pacific
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense

Acronym	Definition
	Council
NRFCC	National Recreational Fisheries Coordination Council
NWHI	Northwest Hawaiian Islands
O_3	ozone
OAML	Oceanographic and Atmospheric Master Library
OBIA	offshore biologically important area
OE	Offshore Japan
OEIS	Overseas Environmental Impact Statement
OIC	Officer in Charge
ONI	Office of Naval Intelligence
ONMS	Office of National Marine Sanctuaries
ONR	Office of Naval Research
OPAREA	operating area
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	Office of the Chief of Naval Operations Instruction
OPR	Office of Protected Resources
OW	otariids underwater
OW	Offshore Japan (minke stock)
Pa	Pascal
PADI	Professional Association of Diving Instructors
PE	parabolic equation
PEO	Program Executive Office
P.L.	public law
$PM_{2.5}$	particulate matter less than 2.5 microns in size
PM_{10}	particulate matter less than 10 microns in size
ppm	parts per million
psu	practical salinity unit(s)
PTS	permanent threshold shift
PW	phocids underwater
RDT&E	research, development, test

Acronym	Definition
	and evaluation
RFRCP	Recreational Fishery Resources Conservation Plan
RL	received level
rms	root mean squared
ROD	Record of Decision
ROI	region of influence
SAG	surface active group
SAR	Stock Assessment Report
SCUBA	Self-Contained Underwater Breathing Apparatus
SD	standard deviation
sec	second(s)
SEIS	Supplemental Environmental Impact Statement
SEL	sound exposure level
SFA	Sustainable Fisheries Act
SH	Southern Hemisphere
SIND	Southern Indian (Ocean)
SIP	State Implementation Plan
SL	source level
SME	subject matter expert
SO_2	sulfur dioxide
SOCAL	Southern California
SOEIS	Supplemental Overseas Environmental Impact Statement
SOJ	Sea of Japan
SONAR	sound navigation and ranging
SONG	Swatch-of-no-Ground
SPE	single ping equivalent
SPL	sound pressure level
spp.	species
SRS	sanctuary resource statement
SSP	sound speed profile

Acronym	Definition
SURTASS	Surveillance Towed Array Sensor System
SVP	sound velocity profile
T-AGOS	Tactical-Auxiliary General Ocean Surveillance
TL	transmission loss
tpy	tons per year
TTS	temporary threshold shift
TZCS	Transition Zone Chlorophyll Front
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
U.S.	United States
USDC-NDC	U.S. District Court, Northern District of California
U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
UME	unusual mortality event
USNS	U.S. Naval Ship
USS	United States Ship
VLA	vertical line array
VOC	volatile organic compound
WAU	Western Australia
WDPA	World Database of Protected Areas
WDCS	Whale and Dolphin Conservation Society
WDPA	World Database on Protected Areas
WNP	Western North Pacific
WP	Western Pacific
yd	yard(s)
YS	Yellow Sea

1 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Introduction

The United States (U.S.) Department of the Navy (Navy) proposes to continue utilizing Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) and Compact LFA sonar (CLFA) systems onboard U.S. Navy surveillance ships for training and testing activities conducted under the authority of the Secretary of the Navy in the western and central North Pacific and eastern Indian oceans[3]. In this Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/SOEIS), the terms "SURTASS LFA sonar" or "SURTASS LFA sonar systems" are inclusive of both the LFA and CLFA systems, each having similar acoustic operating characteristics.

The types of uses of SURTASS LFA sonar analyzed in this document differ in part from the Navy's previous documents under the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114. Use of SURTASS LFA sonar for training and testing was addressed in the previous NEPA and EO 12114 documents, and also will be addressed here. The previous NEPA and EO 12114 documents, however, also included certain military operations among the scope of actions analyzed. Specifically, while those previous documents excluded operational use of SURTASS LFA sonar in armed conflict or direct combat support operations, or during periods of heightened national threat conditions, as determined by the National Command Authority[4] (the President and the Secretary of Defense), the previous documents did include analysis of military operations that involved surveillance for and tracking of unknown or adversary underwater contacts. For the reasons discussed below, this SEIS/SOEIS does not include analysis of the potential environmental impacts of any military operations using SURTASS LFA sonar, including activities that involve surveillance for and tracking of unknown or adversary underwater contacts.

As with the use of SURTASS LFA sonar in armed conflict, direct combat support, and during periods of heightened national threat conditions as directed by the National Command Authority, so too use of SURTASS LFA sonar in surveillance for and tracking of unknown or adversary underwater contacts is a military operation directed by the National Command Authority. These events are not conducted for training or testing purposes under the Title 10 authority of the Secretary of the Navy. These activities are military operations, directed by the National Command Authority and conducted to carry out national defense purposes.

The President of the U.S. is the Commander-in-Chief, and has plenary authority to formulate military strategy and to direct and deploy military forces. To carry out that authority and implement those decisions, the President acts through the Secretary of Defense, who in turn directs combatant commanders to carry out the President's direction. The responsibilities of most of these combatant commands are based on geography. Commander, U.S. Indo-Pacific Command (INDOPACOM) is the relevant combatant commander here because his or her geographic area of responsibility includes the western and central North Pacific and eastern Indian oceans.

Combatant commands execute broad continuing missions under a single commander and are composed of forces assigned from two or more military departments. Combatant commands are established and

3 Throughout this document, the terms "training and testing activities" or "covered SURTASS LFA sonar activities" are used to represent the proposed action.

4 In current documents for SURTASS LFA sonar, the term "National Command Authority" is used to describe the same two officials collectively, the President and the Secretary of Defense. This term is used in the ensuing paragraphs.

designated by the President, through the Secretary of Defense, with the advice and assistance of the Chairman of the Joint Chiefs of Staff.

The President establishes the missions, responsibilities, and force structure of the respective combatant commands, as well as their geographic areas of responsibilities, through a classified executive branch document called the Unified Command Plan. The Unified Command Plan development and review process takes into consideration, among other things, the strategic context, global economic situation, and relationship with allies in formulating the command guidance from the President to combatant commanders. The mission of INDOPACOM is to protect and defend the territory of the United States, its people, and interests. With allies and partners, INDOPACOM enhances stability in the Asia-Pacific region by promoting security cooperation, encouraging peaceful development, responding to contingencies, deterring aggression, and, when necessary, fighting to win.

Under 10 USC §164 "Commanders of combatant commands: assignment; powers and duties", "the primary duties of the commander of a combatant command shall be as follows:

> (A) To produce plans for the employment of the armed forces to execute national defense strategies and respond to significant military contingencies.
>
> (B) To take actions, as necessary, to deter conflict.
>
> (C) To command United States armed forces as directed by the Secretary and approved by the President."

Combatant commanders and SURTASS LFA sonar operational units under their direction have a duty to protect the country and defend U.S. forces from attack and have no discretion in whether they carry out that duty. These are a national defense operation, not training or testing. For example, if SURTASS LFA sonar vessels drop a track or fail to acquire contact on an unknown or adversary submarine, that could have real consequences for our national defense. Combatant commanders have no discretion but to carry out assigned duties using SURTASS LFA sonar. Such operations are not within the responsibilities of the Secretary of the Navy and not appropriate for NEPA analysis here.

In contrast, the statutory responsibilities of the military departments (in this case the Department of the Navy) include the responsibility to train and equip forces for operational use by a combatant commander. In the case of SURTASS LFA sonar, the statutory responsibility of the Secretary of the Navy is to train sailors and equip vessels with SURTASS LFA sonar so they are prepared to conduct military operations involving the use of SURTASS LFA. As in past environmental planning documents for SURTASS LFA sonar, this document will continue to analyze the potential environmental impacts associated with training and testing activities conducted under the authority of the Secretary of the Navy, including but not limited to crew proficiency training, participation in training exercises, acoustics testing, maintenance and system checks, and new system development and testing. Military operations using SURTASS LFA sonar, on the other hand, such as surveilling for and tracking unknown or adversary underwater contacts, are excluded from this NEPA analysis because those activities are performed at the direction of the National Command Authority, acting through and in support of a combatant commander, and not the Secretary of the Navy. The Secretary of the Navy has no authority to direct or limit such military operations.

Practical considerations also lead to the conclusion that such operations are not appropriate for NEPA analysis. Environmental compliance processes stretch over years. Unlike training or testing activities, which tend to be scripted and planned in advance, real world demands for naval military operations change daily and vary based on a broad array of threat factors and geo-political considerations. When the next crisis will occur, or where an adversary submarine will transit, is largely unknown. The master of a SURTASS vessel who detects an unknown underwater contact by definition does not know the identity of that contact, its assigned mission or intentions, where it intends to transit or for how long. The operator's mission is to track that contact and pass information on its location to other naval assets in the theater of operations for their awareness and potential engagement. The operational tempo levels and geographic presence required to meet these types of contingencies are not known in advance and cannot be limited by the permitting process for takes of marine mammals that is applied for training and testing. Based on all of these factors, analysis of military operations using SURTASS LFA sonar is not appropriate for inclusion in the proposed action under review in this SEIS/SOEIS.

The geographic scope analyzed in this document also differs from the previous SURTASS LFA Navy documents under NEPA and EO 12114. The geographic scope of the previous NEPA and EO 12114 documents for covered SURTASS LFA sonar activities was the non-polar areas of the Atlantic, Pacific, and Indian Oceans and the Mediterranean Sea. The geographic scope of this SEIS/SOEIS and the Navy's Proposed Action is the western and central North Pacific and eastern Indian Oceans. The Navy scoped the geographic extent of this document to better reflect the areas where the Navy anticipates conducting SURTASS LFA sonar training and testing activities now and into the reasonably foreseeable future. The operating features of SURTASS LFA sonar have remained the same since the 2001 FOEIS/EIS, with the exception that the typical duty cycle of SURTASS LFA sonar (ratio of sound "on" time to total time), based on historical SURTASS LFA sonar operational parameters, is 7.5 to 10 percent (DoN, 2007) rather than 10 to 20 percent (DoN, 2001). In early 2009, the first CLFA sonar vessel became operational, with three of the four SURTASS LFA sonar vessels now operating CLFA sonar; CLFA acoustic operating characteristics are similar to that of the larger SURTASS LFA sonar system.

1.1.1 Litigation

On July 15, 2016, the United States Court of Appeals for the Ninth Circuit issued a decision in Natural Resources Defense Council (NRDC), et al. versus Pritzker, et al., which was an appeal of a district court decision concerning a challenge to National Marine Fisheries Service's (NMFS's) 2012 Marine Mammal Protection Act (MMPA) Final Rule for SURTASS LFA sonar. Both the Navy and NMFS have carefully and fully considered the Ninth Circuit's decision and have addressed it herein, as appropriate. The district court ultimately dismissed the case later in 2017 as a result of a settlement agreement among the parties.

1.1.2 National Defense Exemption under the Marine Mammal Protection Act

On August 10, 2017, after conferring with the Secretary of Commerce and pursuant to Title 16, Section 1371(f) U.S. Code (U.S.C.), the Secretary of Defense determined that it was necessary for the national defense to exempt all military readiness activities that employ SURTASS LFA sonar from compliance with the requirements of the MMPA for two years from August 13, 2017 through August 12, 2019, or until such time when NMFS issues the required regulations and Letters of Authorization (LOAs) under Title 16, Section 1371, whichever is earlier. During the exemption period, all military readiness activities that involve the use of SURTASS LFA sonar are required to comply with all mitigation, monitoring, and reporting measures set forth in the 2017 National Defense Exemption (NDE) for SURTASS LFA sonar (Appendix A).

1.1.3 2019 SEIS/SOEIS for SURTASS LFA Sonar

The Navy has determined that the purposes of NEPA and EO 12114 would be furthered by the preparation of this additional supplemental assessment of the environmental impacts associated with SURTASS LFA sonar activities as described in the Proposed Action (Chapter 2.2). The Navy has scoped this SEIS/SOEIS and the Navy' associated take requests and consultations to reflect those areas of the world's oceans (the western and central North Pacific and eastern Indian oceans) where Navy anticipates conducting SURTASS LFA sonar training and testing activities for the reasonably foreseeable future. The Navy has provided greater detail on the SURTASS LFA sonar training and testing activities in the alternatives analysis (Chapter 2.3). The geographic scope will allow the Navy to more accurately assess and describe only those impacts associated with SURTASS LFA sonar activities in areas where the Navy expects to conduct these activities. Incorporated in this SEIS/SOEIS are the most up-to-date acoustic criteria and thresholds, as well as density and abundance estimates, for assessing the potential for impacts to marine mammals associated with exposure to SURTASS LFA sonar. This SEIS/SOEIS and associated analyses are planned to support consultations associated with regulatory permits and authorizations for SURTASS LFA sonar training and testing activities.

This SEIS/SOEIS has been prepared in compliance with NEPA (42 U.S.C. section 4321 et seq.); EO 12114; Council on Environmental Quality (CEQ) regulations for implementing the procedural provisions of NEPA (Title 40 Code of Federal Regulations [40 CFR] parts 1500 to 1508); Navy regulations for implementing NEPA (32 CFR section 775); and Navy environmental readiness policies.

The Navy, as the lead agency for the Proposed Action, is responsible for the scope and content of this SEIS/SOEIS. In accordance with 40 CFR 1501.6, the NMFS of the National Oceanic and Atmospheric Administration (NOAA) is a cooperating agency, since the scope of the Proposed Action and alternatives involve activities that have the potential to impact protected marine resources under NMFS's jurisdiction, including marine mammals, threatened and endangered species, and essential fish habitat (EFH). NMFS' cooperating agency role and regulatory authorities are further discussed in Section 1.7.2 and its Proposed Action is discussed in Section 2.2. In accordance with CEQ regulations (40 CFR 1505.2), the Navy intends to issue a Record of Decision (ROD) that provides the rationale for choosing one of the alternatives.

1.2 Location

The location of the proposed action is the non-polar areas of the western and central North Pacific and eastern Indian oceans (Figure 1-1). Fifteen representative model areas, with nominal, regional modeling sites to cover the spatial extent of the study area have been selected and are shown to provide geographic context (Figure 1-1).

1.3 Purpose of and Need for the Proposed Action: Employment of SURTASS LFA Sonar

The Navy's statutory mission is to train and equip naval forces that are combat-ready and capable of accomplishing America's strategic objectives, deterring maritime aggression, and maintaining freedom of navigation in ocean areas (10 U.S.C. Section 5062). By law, the Secretary of the Navy is responsible for functions such as training, supplying, equipping, and maintaining naval forces that are ready to achieve national security objectives as directed by the National Command Authority. Preparing and maintaining

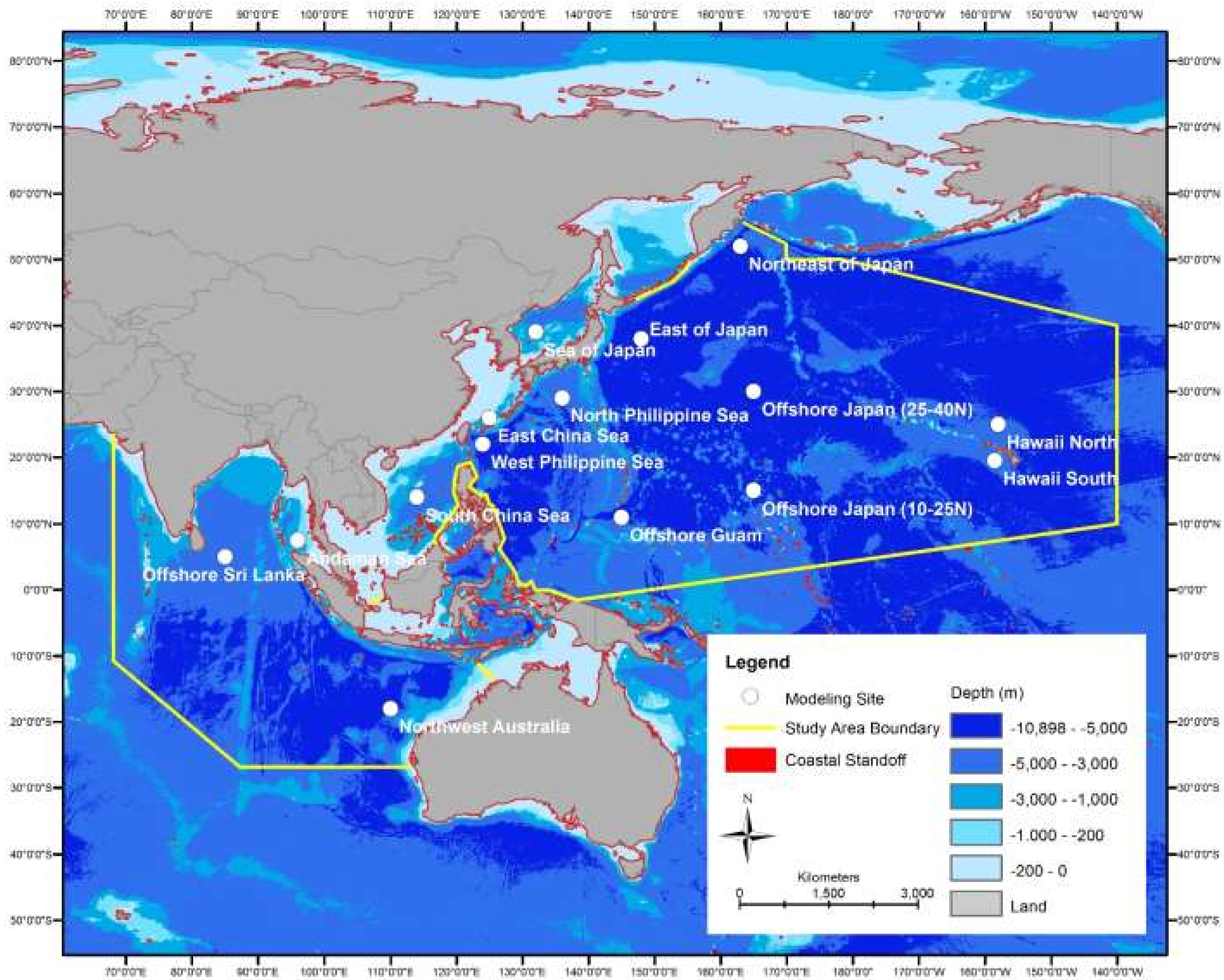

Figure 1-1. Study Area for SURTASS LFA Sonar in the Western and Central North Pacific and Eastern Indian Oceans, Including Nominal Modeling Sites.

forces skilled in anti-submarine warfare (ASW) is a critical part of the Navy's mission. Due to the advancements and use of quieting technologies in diesel-electric and nuclear submarines, undersea submarine threats have become increasingly difficult to locate solely using passive acoustic technologies. At the same time, the distance at which submarine threats can be detected has been decreasing due to these quieting technologies, and improvements in torpedo and missile design have extended the effective range of these weapons. To meet the requirement for improved capability to detect quieter and harder-to-find foreign submarines at greater distances, the Navy developed and uses SURTASS LFA sonar to meet the need for long-range submarine detection and surveillance.

The purpose of the Navy's Proposed Action as detailed in this SEIS/SOEIS is to ensure that the Navy remains proficient in the use of SURTASS LFA sonar in support of the Navy's mission. The need for the Proposed Action is to maintain a system capable of detecting at long ranges the increasingly technologically advanced foreign submarine presence that threatens our national security.

Since acoustic stimuli from use of SURTASS LFA sonar during training and testing has the potential to cause harassment of marine mammals, the Navy submitted an application to NMFS requesting authorization for the taking of marine mammals pursuant to section 101(a)(5)(A) of the MMPA and 50 CFR 216 (NMFS's implementing regulations). Once NMFS determines an application is adequate and complete, NMFS has a corresponding duty to determine whether and how to authorize take of marine mammals incidental to the activities described in the application. To authorize the incidental take of marine mammals, NMFS evaluates the best available scientific information to determine whether the take would have a negligible impact on the affected marine mammal species or stocks and an unmitigable impact on their availability for taking for subsistence uses. NMFS must also prescribe the "means of effecting the least practicable adverse impact" on the affected species or stocks and their habitat, and on the availability of those species or stocks for subsistence uses, as well as monitoring and reporting requirements. NMFS cannot issue an incidental take authorization unless it can make the required findings. The purpose of NMFS's action – which is a direct outcome of the Navy's request for authorization to take marine mammals incidental to SURTASS LFA sonar training and testing activities—is to evaluate Navy's application pursuant to section 101(a)(5)(A) of the MMPA and 50 CFR 216 and issue an incidental take authorization if appropriate. The need for NMFS's action is to consider the impacts of the Navy's activities on marine mammals and ultimately allow the Navy to conduct its activities in compliance with the MMPA if the requirements of section 101(a)(5)(A) are satisfied.

1.3.1 Current Maritime Threats

The continued proliferation of adversary submarines poses threats not only to national security but also to regional geopolitical stability and global commerce. More than 500 submarines are operated by more than 40 countries worldwide (Global Firepower, 2018). As a result, detection of and defense against enemy submarines is a top Navy priority. ASW training and testing activities prepare and equip sailors for countering such threats. Failure to detect and defend against hostile submarines can cost lives, such as the 46 sailors who died when a Republic of Korea frigate (CHEONAN) was sunk by a North Korean submarine in March 2010 (New York Times, 2010).

The Chief of U.S. Naval Operations (CNO) recently presented *A Design for Maintaining Maritime Superiority* (DoN, 2016) that unveiled an updated Navy strategy developed in part to address the Navy's concern regarding Russian and Chinese military expansion. In that document, the CNO stated, "For the first time in 25 years, the U.S. is facing a return to great power competition. Russia and China have advanced their military capabilities to act as global powers. Their goals are backed by a growing arsenal of high-end warfighting capabilities, many of which are focused specifically on our vulnerabilities…" (DoN, 2016). In addition, the increasing military capabilities of North Korea and Iran, particularly the development of their nuclear weapon and missile programs, also represent developing national security concerns.

China has invested heavily in its military forces and has placed a high priority on the modernization of its submarine force, resulting in the rapid growth of the Chinese Navy's fleet, which is projected to surpass the U.S. Navy's fleet in number of ships by the mid-2020s (DoD, 2015; DoN, 2016). The Chinese Navy also operates one of the largest submarine fleets in the world, with about 60 commissioned submarines of all types having been commissioned; current estimates of the Chinese submarine fleet include a potential 48 to 50 diesel-electric and 13 nuclear-powered submarines (Boyd and Waldwyn, 2017; Nuclear Threat Initiative [NTI], 2016; O'Rourke, 2017), although some sources have estimated the size of the Chinese Navy submarine fleet to currently include 70 vessels (Einhorn, 2015). The U.S. Office of Naval Intelligence projects 74 Chinese submarines by 2020, including 11 nuclear-powered and 63 non-nuclear-powered submarines (ONI, 2015).

Although the Russian Navy's submarine fleet is estimated to be only a fraction of the Cold-War era capacity, Russia has invested substantially in modernizing their submarine fleet and capability, including the development and deployment of hybrid diesel-electric (Gady, 2016) and fourth generation nuclear-powered submarines. Early in 2017, Russia launched the second of its powerful *Yasen*-class multipurpose, nuclear attack submarines (Beckhusen, 2017; TASS, 2017). These submarines reflect cutting-edge design characterized by very low-level noise; the *Yasen*-class submarines are thought to be the quietest Russian submarines ever launched. Four more *Yasen* nuclear submarines are planned for deployment by 2022 (TASS, 2017). However, some analysts predict that even the launch of these submarines would not be sufficient to rebuild the Russian Navy to its former capacity (Beckhusen, 2017).

In 2017, North Korea conducted a series of missile tests, demonstrating its ability to strike Guam, Alaska, and anywhere within the continental U.S. with an intercontinental ballistic missile (New York Times, 2017). Iran's advanced missile weaponry, proxy forces, and other conventional capabilities continue to threaten regional Middle Eastern stability. Iran is recognized as a growing military threat due to its influence over Syria and Iraq and proximity to the Straits of Hormuz, which is a chokepoint of global significance for the transport of oil and natural gas products, and its improved ballistic and cruise missile capabilities (Cordesman and Toukan, 2016).

1.4 Scope of Environmental Analysis

This SEIS/SOEIS includes an analysis of potential environmental impacts associated with the Proposed Action and Alternatives in SURTASS LFA sonar's study area in the western and central Pacific and eastern Indian oceans. In addition to the reduction of the geographic scope covered in this SEIS/SOEIS, the types of proposed activities and associated number of LFA sonar transmit hours for those activities have also been updated, based on a reexamination of current and predicted requirements of SURTASS LFA sonar training and testing into the foreseeable future. The resulting environmental resource areas analyzed in this SEIS/SOEIS include air quality, marine water resources, biological resources, and marine economic resources. Further discussion of all environmental resources and their consideration is included in Chapter 3.

1.5 Documentation Incorporated by Reference

Several key source documents are the foundation for this SEIS/SOEIS and appropriate sections of these documents are incorporated by reference in this SEIS/SOEIS, per CEQ guidance. These documents are considered key documents because of the applicability in the action, analyses, or impacts to the Proposed Action detailed herein. Documents incorporated by reference herein, in part or in their entirety, include:

- FOEIS/EIS for SURTASS LFA Sonar (DoN, 2001)—This first impact assessment for SURTASS LFA sonar considered the employment of up to four SURTASS LFA sonar systems in the Atlantic, Pacific, and Indian oceans and Mediterranean Sea.
- FSEIS for SURTASS LFA sonar (DoN, 2007)—This environmental impact document was prepared to remedy the deficiencies identified by order of the U.S. District Court for the Northern District of California, including the need for additional alternatives analysis, mitigation and monitoring, as well as an analysis of the potential impacts of low frequency (LF) sound on fishes.
- FSEIS/SOEIS for SURTASS LFA sonar (DoN, 2012)—In addition to reviewing and updating the information available on the potential impacts of SURTASS LFA sonar on the environment, this impact assessment also provided a comprehensive analysis of offshore biologically important areas (OBIAs), of the 12-nautical mile (nmi) (22.2-kilometer [km]) coastal standoff distance, and of potential cumulative impacts associated with operation of other active sonar sources.
- FSEIS/SOEIS for SURTASS LFA sonar (DoN, 2015a)—Pursuant to the amended summary judgment order issued by the U.S. District Court for the Northern District of California on May 22, 2014, this impact document was prepared for the limited purpose of remedying the NEPA deficiency identified in the Court's order. The Court specified that the Navy failed to use the best available data in its 2012 FSEIS/SOEIS (DoN, 2012) when it determined potential impacts from employment of SURTASS LFA sonar systems on one rather than the more updated five stocks of common bottlenose dolphins in Hawaiian waters.
- FSEIS/SOEIS for SURTASS LFA Sonar (DoN, 2017)—This fifth impact assessment document for SURTASS LFA sonar updated information relevant to determining impacts on the marine environment, including using the latest acoustic criteria and thresholds promulgated by NMFS (NOAA, 2016).

1.6 Relevant Legislation and Executive Orders

The Navy has prepared this SEIS/SOEIS based upon federal legislation, statutes, regulations, and policies that are pertinent to the implementation of the Proposed Action, including those listed below. A description of the Proposed Action's consistency with the applicable laws, statutes, regulations, and policies, as well as the names of regulatory agencies responsible for their implementation, is presented in Chapter 6.

1.6.1 National Environmental Policy Act

NEPA establishes national policies and goals for the protection of the environment and stipulates that environmental factors must be given appropriate consideration in all decisions made by federal agencies regarding their major actions that occur within the U.S. (its lands, territories, and possessions), including waters within 12 nmi [22 km] from the coastline. Further, NEPA (42 U.S.C. sections 4321-4370h) requires an environmental analysis of major federal actions that have the potential to significantly impact the quality of the human environment. The analysis includes an evaluation of the environmental impact, irreparable environmental effects, alternatives to the proposed action, as well as short- and long-term impacts of the federal agency's proposed action. If a determination of significant impact (or potential significant impact) to the human environment is made, NEPA requires that federal agencies take a hard look at the environmental consequences of the proposed action, usually through the preparation of an EIS.

1.6.2 Executive Order 12114, Environmental Effects Abroad of Major Federal Actions

EO 12114 directs federal agencies to make informed environmental decisions for major federal actions outside the U.S. and its territories. Presidential Proclamation 5928, issued December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nmi (22 km) from all coastlines. However, the proclamation expressly provided that existing federal law or any associated jurisdiction, rights, legal interests, or obligations were not extended or otherwise altered. Thus, as a matter of policy, the Navy analyzes environmental actions and potential impacts that have the potential to significantly affect the environment within 12 nmi (22 km) of all coastlines under NEPA (an EIS or SEIS) and those potential impacts occurring beyond 12 nmi under the provisions of EO 12114 (an OEIS or SOEIS).

1.6.3 Council on Environmental Quality Regulations

The U.S.C. of Federal Regulations Title 40 (Protection of the Environment), Chapter V (CEQ), Parts 1500-1508, provide the CEQ regulations for the implementation of the procedural provisions of NEPA.

1.6.4 Navy Regulations

Navy regulations for implementing NEPA (32 CFR part 775) provide Navy policy for implementing CEQ regulations and NEPA.

1.6.5 Marine Mammal Protection Act

The MMPA of 1972 (16 U.S.C. sections 1361 et seq.) established a general moratorium on the taking and importation of marine mammals, with certain enumerated exceptions. Unless an exception applies, the Act prohibits persons or vessels subject to the jurisdiction of the United States from taking any marine mammal in waters or on lands under the jurisdiction of the United States or on the high seas." 16 U.S.C. 1372(a)(1), (a)(2). The term "take," as defined in Section 3 (16 U.S. Code [U.S.C.] section 1362 (13)) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, with two levels of harassment: Level A and Level B. By definition, Level A harassment is any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock, while Level B harassment is any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

The MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens or agencies who engage in a specified activity (other than commercial fishing) within a specified geographical region, if NMFS finds that the taking would have a negligible impact on the species or stock(s) and would not have an unmitigatable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The incidental take authorization must set forth the permissible methods of taking; other means of effecting the least practicable adverse impact on species or stocks and their habitat (i.e., mitigation); and requirements pertaining to the monitoring and reporting of such taking. The John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Public Law 115-232) extended the periods of permitted incidental taking under the MMPA from five years to seven years. The application for incidental taking of marine mammals by SURTASS LFA sonar training and testing activities will be amended to reflect this extension.

Within the 2004 National Defense Authorization Act (NDAA) (Public Law 108-136), the MMPA's definitions of Levels A and B harassment were amended, the small numbers provision was eliminated, and the specified geographic region requirement as applied to military readiness activities or certain scientific research activities conducted by or on behalf of the federal government was also removed. The 2004 NDAA also adopted the definition of "military readiness activity", as set forth in the Fiscal Year 2003 NDAA (Public Law 107-314). A "military readiness activity" is defined as "all training and operations of the Armed Forces that relate to combat" and the "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." For military readiness activities, Level A harassment was redefined as any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild, while Level B harassment was redefined as any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered. Further, NMFS' determination of "least practicable adverse impact on a species or stock and its habitat" must include consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

Two federal agencies are responsible for regulating under the MMPA: NMFS and U.S. Fish and Wildlife Service (USFWS). NMFS is responsible for overseeing the protection of whales, dolphins, porpoises, seals, and sea lions under the MMPA, while USFWS oversees the protection of the solely coastal and land-based marine mammals, including walruses, manatees, sea otters, and polar bears.

1.6.6 Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. sections 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. An endangered species is a species in danger of extinction throughout all or a significant portion of its range, and a threatened species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and NMFS jointly administer the ESA and are responsible for listing a species as either threatened or endangered, as well as designating critical habitat where applicable, developing recovery plans for these species, and undertaking other conservation actions pursuant to the ESA. The ESA generally prohibits the "take" of an ESA-listed species unless an exception or exemption applies. The term "take" as defined in Section 3 of the ESA means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

Section 7(a)(2) of the ESA requires federal agencies to insure 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 NMFS (or the USFWS) for actions that may affect species listed as threatened or endangered or critical habitat designated for such species under Section 4 of the ESA (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 the consulting agency concurs with that determination, consultation concludes informally (50 C.F.R. §402.14(b)). The federal action agency, pursuant to Section 7(a)(4), shall confer with the consulting agency on any action which is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat (50 C.F.R. §402.10). If requested by the federal agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in 50 C.F.R §402.14 (50 C.F.R §402.10(d)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, the consulting agency 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. A similar opinion is included for proposed species or proposed critical habitat if either or both were part of the consultation. If the consulting agency determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitat, they then provide a reasonable and prudent alternative that allows the action to proceed in compliance with Section 7(a)(2) of the ESA. If incidental take is expected and certain conditions are met, Section 7(b)(4) requires the consulting agency to provide an incidental take statement that specifies the impact of any incidental taking and includes mandatory reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

1.6.7 National Marine Sanctuaries Act

In 1992, Title III of the Marine Protection, Research and Sanctuaries Act was re-designated as the National Marine Sanctuaries Act (NMSA) (16 U.S.C. sections 1431 et seq.). Under the NMSA, NOAA established a system of NMS to protect marine areas with special national conservation, recreational, ecological, historical, cultural, archaeological, scientific, educational, or aesthetic qualities. The NMSA authorizes the designation and management of NMS by the Office of National Marine Sanctuaries (ONMS), which is administered by NOAA’s National Ocean Service.

Under Section 304(d) of the NMSA, federal agencies are required to consult with the ONMS on proposed actions that are “likely to destroy, cause the loss of, or injure a sanctuary resource”. The NMSA defines “to injure” as “to change adversely, either in the short or long term, a chemical, biological or physical attribute of, or the viability of. This includes, but is not limited to, to cause the loss of or destroy” (15 C.F.R. § 922.23). ONMS has interpreted injury under the NMSA to include estimated MMPA Level A and Level B harassment of marine mammals found within a NMS.

Sanctuary regulations prohibit destroying, causing the loss of, or injuring any sanctuary resource managed under the law or regulations for that sanctuary (15 CFR part 922). NMSs are managed on a site-specific basis, and military exemptions vary amongst sanctuaries.

1.6.8 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (P.L. 94-265) was enacted to address impacts to fisheries on the U.S. continental shelf. It established U.S. fishery management over fishes within the fishery conservation zone from the seaward boundary of the coastal states out to 200 nmi (370.4 km) (i.e., boundary of the U.S. EEZ). MSFCMA also established regulations for foreign fishing within the fishery conservation zone and issued national standards for fishery conservation and management to be applied by regional fishery management councils. Each council is responsible for developing Fishery Management Plans (FMPs) for domestic fisheries within its geographic jurisdiction. In 1996, Congress enacted amendments to the MSFCMA known as the Sustainable Fisheries Act (P.L. 104-297) to address substantially reduced fish stocks resulting from direct and indirect habitat loss. Under MSFCMA, Federal agencies are required to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency which may adversely affect essential fish habitat (EFH) identified under the MSFCMA. EFH is defined as the waters and substrate necessary to fishes or invertebrates for spawning, breeding, feeding and growth to maturity. Areas designated as EFH contain habitat essential to the long-term survival and health of U.S. fisheries.

1.6.9 Act to Prevent Pollution from Ships

The Act to Prevent Pollution from Ships (APPS) (33 U.S.C. 1901, et seq.) implements the 1973 provisions of the International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1978 (MARPOL 73/78) and the annexes to which the U.S. is a party. The purpose of the APPS is to minimize or limit ship-borne aquatic and air pollution. The APPS applies to all U.S.-flagged ships located anywhere in the world and to all foreign-flagged vessels operating in U.S. navigable waters or while in port under U.S. jurisdiction.

1.6.10 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) (16 U.S.C. section 1451 et seq.) established partnerships between U.S. federal, state, or territory governments to address coastal zone issues. The CZMA provided the framework for coastal and Great Lake States and territories to develop coastal zone management programs that specifically cover land and water coastal resources. Thirty-four coastal states and territories participate in the Coastal Zone Management Program; Alaska withdrew from the program in 2011. NOAA administers the National Coastal Zone Management Program.

The federal consistency provision of the CZMA requires that the activities of federal agencies conducted within and outside the coastal zone that may have reasonably foreseeable effects on any land or water coastal use or natural resource of the coastal zone be carried out in a manner consistent to the maximum extent practicable with the enforceable policies of federally-approved state or territory management programs. Enforceable policies are the legally-binding policies (including constitutional provisions, laws, regulations, land use plans, ordinances, as well as judicial or administrative decisions) whereby a state or territory exerts control over private and public lands, water uses, and natural resources of the coastal zone. The federal consistency requirement was enacted as a mechanism to ensure adequate federal consideration of state and territory coastal management programs and to avoid conflicts between states or territories and federal agencies by fostering consultation and coordination (NOAA, 2000). Under certain circumstances, the President is authorized to exempt specific activities from the federal consistency requirement if he determines that these activities are of U.S. interest and importance.

1.6.11 Clean Water Act

The Clean Water Act (CWA) (33 U.S.C. section 1251 et seq.) was enacted to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Under authority of the CWA, the U.S. Environmental Protection Agency (EPA) regulates discharges of pollutants in surface waters of the U.S. and sets water quality standards for pollutants. Uniform National Discharge Standards promulgated under Section 312(n) of the Clean Water Act (as well as implementing regulations at 40 CFR Part 1700) govern discharges incidental of the normal operation of Navy vessels.

1.6.12 Clean Air Act

In 1963, the Clean Air Act (CAA) (42 U.S.C. §7401 et seq.) was enacted and amended in 1970 and 1990 to protect and enhance the quality of the nation's air resources and protect public health and welfare by regulating air emissions from stationary and mobile sources within the U.S. The CAA authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for criteria pollutants and to regulate emissions of hazardous air pollutants, with each state having established NAAQS. The CAA also regulates the emissions of U.S.-flagged vessels operating marine diesel engines, the sulfur content of their marine fuel, and the vessels themselves. Section 176(c)(1) of the CAA, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the NAAQS for criteria pollutants.

1.6.13 Executive Order 12962, Recreational Fisheries

EO 12962 (60 C.F.R. 30769) was issued in 1995 to ensure that federal agencies strive to improve the "quantity, function, sustainable productivity, and distribution of U.S. aquatic resources" to increase recreational fishing opportunities nationwide. The overarching goal of the Recreational Fisheries EO is to promote conservation, restoration, and enhancement of aquatic systems and fish populations by increasing fishing access, education and outreach, and multi-agency partnerships. The Secretaries of the Interior and Commerce Departments jointly oversee federal actions and programs mandated by this EO.

1.6.14 Executive Order 13089, Coral Reef Protection

EO 13089 was issued in 1998 "to preserve and protect the biodiversity, health, heritage, and social and economic value of U.S. coral reef ecosystems and the marine environment." This EO directs all federal agencies to protect coral reef ecosystems to the extent feasible and instructs particular agencies to develop coordinated, science-based plans to restore damaged reefs and to mitigate current and future impacts on reefs, both within the U.S. and internationally. This EO established the interagency U.S. Coral Reef Task Force to develop and implement a comprehensive program of research and mapping to inventory, monitor, and identify the major causes and consequences of degradation of coral reef ecosystems. The task force is administered by NOAA.

1.6.15 Executive Order 13158, Marine Protected Areas

EO 13158 defines marine protected areas (MPAs) as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." This EO was established to (1) ensure that federal agencies with authority for establishing MPAs take action to enhance or expand protection of existing MPAs and establish or recommend new MPAs; (2) develop a scientifically-based, comprehensive national system of MPAs; and (3) avoid causing harm to MPAs through federally conducted, approved, or funded activities.

1.6.16 Executive Order 13175, Consultation and Coordination with Indian Tribal Governments

EO 13175 provides direction to federal agencies to ensure they conduct "regular, meaningful" consultations and collaborations with Indian tribal officials on the development of federal policies or actions that may have tribal implications. Indian tribes are defined under EO 13175 as any federally-recognized Indian or Alaskan native tribe, band, group, or community.

1.6.17 Executive Order 13840, Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States

Issued in June 2018, this EO revoked and replaced EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*. EO 13840 is intended to advance the economic, security, and environmental interests of the U.S. through improved public access to marine data and information; efficient federal agency coordination on ocean related matters; and engagement with marine industries, the science and technology community, and other ocean stakeholders, including Regional Ocean Partnerships.

Under this EO it is the policy of the United States to: (a) coordinate the activities of executive departments and agencies (agencies) regarding ocean-related matters to ensure effective management of ocean, coastal, and Great Lakes waters and to provide economic, security, and environmental benefits for present and future generations of Americans; (b) continue to promote the lawful use of the ocean by agencies, including United States Armed Forces; (c) exercise rights and jurisdiction and perform duties in accordance with applicable domestic law and—if consistent with applicable domestic law—international law, including customary international law; (d) facilitate the economic growth of coastal communities and promote ocean industries, which employ millions of Americans, advance ocean science and technology, feed the American people, transport American goods, expand recreational opportunities, and enhance America's energy security; (e) ensure that Federal regulations and management decisions do not prevent productive and sustainable use of ocean, coastal, and Great Lakes waters; (f) modernize the acquisition, distribution, and use of the best available ocean-related science and knowledge, in partnership with marine industries; the ocean science and technology community; State, tribal, and local governments; and other ocean stakeholders, to inform decisions and enhance entrepreneurial opportunity; and (g) facilitate, as appropriate, coordination, consultation, and collaboration regarding ocean-related matters, consistent with applicable law, among Federal, State, tribal, and local governments, marine industries, the ocean science and technology community, other ocean stakeholders, and foreign governments and international organizations.

1.7 Public and Agency Participation and Intergovernmental Coordination

Per CEQ regulations (40 CFR 1506.6) as well as Navy regulations and guidance, the public is to be involved in preparing and implementing NEPA procedures. Additionally, the Navy may be required to coordinate and consult with other federal agencies and tribal governments under various environmental statutes and executive orders.

1.7.1 Public Participation

On June 5, 2015, the Navy published a Notice of Intent (NOI) in the *Federal Register* (80 FR 32097) to prepare a SEIS/SOEIS for the continued employment of SURTASS LFA sonar and to support consultations associated with expiring MMPA and ESA 5-year regulatory permits for SURTASS LFA sonar (DoN, 2015b). The NOI provides an overview of the proposed action. No comments were received in response to the NOI.

Although the Navy prepared and completed a FSEIS/SOEIS for SURTASS LFA sonar on June 30, 2017, and a Notice of Availability for the FSEIS/SOEIS was published in the *Federal Register* on July 7, 2017, no ROD detailing the Navy's decision, alternative selected, or mitigation and monitoring plan for the employment of SURTASS LFA sonar was issued. The Navy determined that the purposes of NEPA and EO 12114 relevant to SURTASS LFA sonar begun in June 2015 with the publication of a NOI would be furthered by the preparation of this additional SEIS/SOEIS, which is planned to be published in final form in early July 2019, with a ROD to follow in early August 2019.

Public involvement in the review of the Draft SEIS/SOEIS is stipulated in 40 CFR 1503.1 of CEQ's NEPA implementing regulations as well as in Navy environmental readiness guidance. These regulations and guidance provide for active solicitation of public comment via public comment periods. This Draft SEIS/SOEIS has been made available to the public, when a Notice of Availability (NOA) was published by the EPA in the *Federal Register*. Comments on this Draft SEIS/SOEIS would be accepted for 45 days beginning with the publication of the official NOA in the *Federal Register*. Additionally, in conjunction with filing this Draft SEIS/SOEIS with the EPA, notification correspondence would be sent to appropriate federal, state, and territory government agencies and organizations as well as other interested parties announcing the availability of the Draft SEIS/SOEIS on the SURTASS LFA sonar website.

1.7.2 Cooperating Agency: National Marine Fisheries Service

Since the issuance of an incidental take authorization would allow for the taking of marine mammals, NMFS, in accordance with 40 CFR 1506.3 and 1505.2, intends to adopt this SEIS/OSEIS and issue a separate ROD associated with its decision to grant or deny the Navy's request for an incidental take authorization pursuant to Section 101(a)(5)(A) of the MMPA. The following subsections address the status of Navy's coordination and consultations under the MMPA, ESA, MSFCMA, and NMSA.

NOAA's NMFS is serving as a cooperating agency because the scope of the proposed action and alternatives involve activities that have the potential to affect protected resources under their jurisdiction by law and special expertise, including marine mammals, threatened and endangered species, and EFH. This includes the authority to authorize incidental take of marine mammals, engage in consultations with other federal agencies, which can allow for take of ESA- listed species, and enforce against unauthorized take. NMFS executes these authorities pursuant to the MMPA and ESA outlined in Sections 1.6.5 and 1.6.6. NMFS has additional responsibilities to conserve and manage fishery resources of the United States, which includes the authority to engage in consultations with other federal agencies pursuant to the MSFCMA outlined in Section 1.6.8 and 50 CFR Part 600. In addition, NOAA's ONMS has a statutory responsibility to protect and conserve NMS. For actions that are likely to injure sanctuary resources internal or external to a NMS, this includes the authority to issue authorizations, general or special use permits and to consult with other federal agencies pursuant to the NMSA outlined in Section 1.6.7 and 15 CFR 922.

1.7.3 National Marine Fisheries Service Consultation (ESA and MMPA)

In June 2018, pursuant to requirements of the MMPA and ESA, the Navy submitted application consultation packages for incidental taking of marine mammals and ESA-listed marine species, respectively, that may be associated with the proposed use of SURTASS LFA sonar.

1.7.4 National Marine Sanctuaries Consultation

In accordance with Section 304 (d) of the NMSA, federal agencies are required to consult with the ONMS on actions internal or external to a Sanctuary that are likely to destroy, cause the loss of, or injure any sanctuary resource. Only one national marine sanctuary, the Hawaiian Islands Humpback Whale NMS, is located within the Navy's study area. The Navy has determined that the planned use of SURTASS LFA sonar pursuant to this SEIS/SOEIS does not require consultation under Section 304(d) of the NMSA.

1.7.5 Consultation/Coordination with Indian Tribal Governments

Pursuant to EO 13175, federal agencies are to consult and coordinate with federally-recognized Indian or Native Alaskan tribal governments on actions or policies that may have tribal implications. The Proposed Action includes SURTASS LFA sonar training and testing activities in U.S. waters of Hawaii, Guam, and the CNMI, where no federally-recognized tribes are located. Therefore, no consultation or coordination under EO 13175 is required.

1.7.6 Essential Fish Habitat Consultation/Coordination

Consultation/coordination under the MSFCMA was conducted as part of the analyses for the Navy's 2001 FOEIS/EIS (DoN, 2001) for SURTASS LFA sonar. The information in these documents regarding consultations and agency coordination on the MSFCMA remains valid and is incorporated by reference herein. The Navy is reassessing its Proposed Action relative to the MSFCMA's provisions on EFH to determine if supplemental consultation under the MSFCMA is required.

1.7.7 Coastal Zone Management Consultation/Coordination

Consultation/coordination under the CZMA was conducted as part of the analyses for the Navy's 2001 FOEIS/EIS (DoN, 2001) and 2012 FSEIS/SOEIS (DoN, 2012) for SURTASS LFA sonar. The information in these documents regarding consultations and agency coordination on the CZMA remains valid and is incorporated by reference herein.

Pursuant to the CZMA (15 CFR Part 930) regulations, as part of the analyses for the 2001 FOEIS/EIS, the Navy determined that its Proposed Action would be consistent to the maximum extent practicable with the relevant enforceable policies of the one state and two territories that are located in the current study area for SURTASS LFA sonar: Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). The Navy is reassessing whether its Proposed Action remains consistent or if additional consultation under the CZMA is required.

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2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 Introduction

This chapter describes the SURTASS LFA sonar training and testing activities that comprise the Proposed Action and that are necessary to meet the Navy's anti-submarine warfare (ASW) and national security mission. In subsequent chapters of this SEIS/SOEIS, the analysis of the potential impacts of SURTASS LFA sonar activities on the marine environment are presented.

2.2 Proposed Action

As set forth in Chapter 1, the U.S. Navy proposes to continue utilizing SURTASS LFA sonar systems onboard U.S. Navy surveillance ships for training and testing conducted under the authority of the Secretary of the Navy in the western and central North Pacific and eastern Indian oceans. The U.S. Navy currently has four surveillance ships that utilize SURTASS LFA sonar systems: U.S. Naval Ship (USNS) VICTORIOUS (Tactical-Auxiliary General Ocean Surveillance [T-AGOS] 19); USNS ABLE (T-AGOS 20); USNS EFFECTIVE (T-AGOS 21); and USNS IMPECCABLE (T-AGOS 23). The Navy may develop and field additional SURTASS LFA sonar equipped vessels, either to replace or complement the Navy current SURTASS LFA sonar equipped fleet.

In accordance with the MMPA, the Navy has submitted applications to NMFS requesting authorization for the taking of marine mammals incidental to these training and testing activities as described in this SEIS/SOEIS. NMFS' proposed action regarding SURTASS LFA sonar use will be a direct outcome of responding to the Navy's request for rulemaking and incidental take authorization pursuant to the MMPA, as NMFS may either approve the Navy's request for an authorization (and provide appropriate requirements for the authorized takings) or deny the request.

The Navy is currently approved under the NDE to transmit 255 hours of LFA sonar transmission hours per vessel per year or a total of 1,020 transmission hours per year. Under Alternative 1, the Navy would transmit 360 hours of LFA sonar transmissions per year pooled across all SURTASS LFA equipped vessels, while under Alternative 2, the Navy's Preferred Alternative, the Navy would transmit 496 total hours of LFA sonar transmissions per year across all SURTASS LFA sonar equipped vessels in the first four years, and would increase usage to 592 total hours of LFA sonar transmissions in year five and continuing into the foreseeable future, regardless of the number of vessels.

Under either of the action alternatives, the Navy proposes to implement procedural and geographic/temporal mitigation measures during SURTASS LFA sonar training and testing activities. Specifically, under either action alternative, the Navy would ensure that LFA sonar received levels from the Proposed Action are below 180 dB re 1 µPa (rms) within 12 nmi (22 km) of any emergent land and at the boundary of any designated OBIAs during their effective periods of biological activity. In addition, SURTASS LFA sonar training and testing activities would not occur within the territorial seas of foreign nations (12 nmi [22km]). There are 29 designated OBIAs as described in the NDE, of which four are found in the proposed study area; analysis of additional potential OBIAs is ongoing (Chapter 5, Appendix C). Additionally, LFA sonar received levels from the Proposed Action would not exceed 145 dB re 1 µPa (rms) within known recreational and commercial dive sites or within Hawaii State waters. Mitigation monitoring includes visual, passive acoustic, and active acoustic (high frequency marine mammal monitoring [HF/M3] sonar) monitoring to minimize, to the greatest extent practicable, adverse impacts to marine animals when SURTASS LFA sonar is transmitting by providing the means to detect marine mammals or sea turtles in the 180-dB mitigation zone for SURTASS LFA sonar and then suspending or delaying LFA sonar transmissions. The proposed suite of mitigation measures are described in Chapter 5 (Mitigation, Monitoring, and Reporting) of this SEIS/OEIS. The final suite of mitigation measures resulting from the ongoing planning, consultation, and permitting processes will be documented in the Final EIS/OEIS, the Navy's Record of Decision, and all applicable authorizations or consultation documents.

2.2.1 Description of SURTASS LFA Sonar System

SURTASS LFA sonar is a long-range system that transmits in the low-frequency (LF) band (below 1,000 Hertz [Hz]) that is composed of both active and passive components (Figure 2-1). The active component is the LFA sonar source array while the passive component is the SURTASS receive array.

SONAR is an acronym for SOund NAvigation and Ranging, and its definition includes any system that uses underwater sound, or acoustics, for observations and communications. Sonar systems are used for many purposes, ranging from commercial "fish finders" to military ASW systems used for detection and classification of submarines.

The two basic types of sonar used in the SURTASS LFA sonar system are passive and active sonar:

- Passive sonar detects sound created by a source. This is a one-way transmission of sound waves through water from the source to the receiver. Passive sonar is similar to people hearing sounds that are transmitted through the air to the human ear. Very simply, passive sonar "listens" without transmitting any sound signals.
- Active sonar detects objects by creating a sound pulse or "ping" that is transmitted from the sonar through the water, reflects off a target object, and returns in the form of an echo to be detected by a receiver. Active sonar is a two-way transmission of sound waves through water (sound source to reflector to receiver). Some marine mammals use a type of active biosonar called echolocation to locate underwater objects such as prey or the seafloor for navigation.

SURTASS LFA sonar systems were initially installed on two SURTASS vessels: R/V *Cory Chouest*, which was retired in 2008, and USNS IMPECCABLE (T-AGOS 23). As future undersea warfare requirements continued to transition to littoral[5] ocean regions, a compact version of the LFA sonar system deployable on SURTASS ships was needed.

This compact sonar system upgrade is known as compact LFA or CLFA and consists of smaller, lighter-weight source elements than in the SURTASS LFA sonar system. The CLFA sonar system was installed on the VICTORIOUS Class platforms (e.g., T-AGOS 19, 20, and 21). CLFA sonar improvements include:

- Operational frequency within the 100 to 500 Hz range, matched to shallow-water environments with little loss of detection performance in deep-water environments;
- Improved reliability and ease of deployment; and

5 The term littoral is an often misunderstood term. In reference to naval warfare, the Navy defines "littoral" as the region that horizontally encompasses the land/water mass interface from 50 statute miles (80 km) ashore to 200 nmi (370 km) at sea; this region extends vertically from the seafloor and land surface to the top of the atmosphere (Naval Oceanographic Office, 1999). The more common definition of littoral pertains to the shore or a coastal region, while the marine science definition refers to the shallow-water zone between low and high tide. The Navy's meaning differs because it is based on a tactical, not geographical or environmental, perspective relating to overall coastal operations, including all assets supporting a particular operation regardless of how close, or far, from the shore they may be operating.

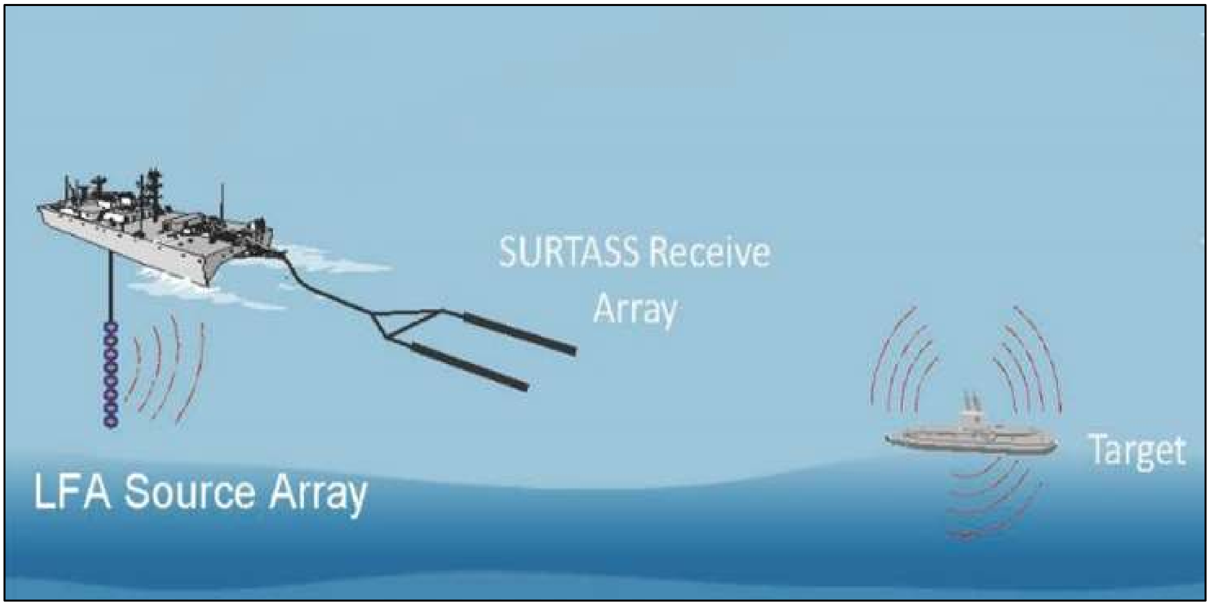

Figure 2-1. Schematic of a SURTASS LFA Sonar System Deployed from a T-AGOS Vessel Including the Passive SURTASS Horizontal Line Array (Receive Array) of Hydrophones and the Active Vertical Line Array of LF Sonar Projectors (Source Array).

- Lighter-weight design with mission weight of 142,000 pounds (lb) (64,410 kilograms [kg]) for the CLFA sonar system versus 324,000 lb (155,129 kg) mission weight for the LFA sonar system.

The operational characteristics of the CLFA sonar system are comparable to the original LFA sonar system as detailed in Subchapter 2.1 of the FOEIS/EIS (DoN, 2001). Therefore, the potential impacts from CLFA sonar are expected to be similar to, but not greater than, the impacts associated with the LFA sonar system. For this reason, in this SEIS/SOEIS the term LFA sonar is used inclusively of the LFA and/or the CLFA sonar systems, unless otherwise specified.

2.2.1.1 Active Sonar System Components

The active component of the SURTASS LFA sonar system, LFA, is an adjunct to the SURTASS passive capability and is employed when active sound signals are needed to detect and track underwater targets of interest. LFA sonar complements SURTASS passive activities by actively acquiring and tracking submarines when they are in quiet operating modes, measuring accurate target range, and re-acquiring lost contacts.

LFA sonar consists of a vertical source array of sound-producing elements that are suspended by cable under one of the T-AGOS vessels (Figure 2-1). These elements, called projectors, are devices that produce the active sonar sound pulses or pings. To produce a ping, the projectors transform electrical energy to mechanical energy (i.e., vibrations), which travel as pressure disturbances in water. The LFA sonar source is a vertical line array (VLA) consisting of as many as 18 source projectors. Each LFA source projector transmits sonar beams that are omnidirectional (360 degrees) in the horizontal, with a narrow vertical beamwidth that can be steered above or below the horizontal. The source frequency ranges between 100 and 500 Hz.

References to Underwater Sound Levels

- References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (root mean square) (dB re 1 µPa at 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).
- In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time; the appropriate units for SEL are dB re 1 μPa^2-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).
- The term "Single Ping Equivalent" (SPE) used herein is an intermediate calculation for input to the risk continuum used in the acoustic impact analysis for SURTASS LFA sonar. SPE accounts for the energy of all LFA sonar transmissions that a modeled animal ("animat") receives during a 24-hr period of a SURTASS LFA sonar use as well as an approximation of the manner in which the effect of repeated exposures accumulate. As such, the SPE metric incorporates both physics and biology. Calculating the potential risk from exposure to SURTASS LFA sonar is a complex process and the reader is referred to Appendix B for additional details. SPE levels will be expressed as "dB SPE" in this document, as they have been presented in preceding environmental compliance documentation for SURTASS LFA sonar: 2001 FOEIS/FEIS (DoN, 2001); 2007 FSEIS (DoN, 2007); 2012 FSEIS/SOEIS (DoN, 2012); 2015 FSEIS/SOEIS (DoN, 2015); and 2017 (DoN 2017a).
- Briefly, SPE accounts for the increased potential for behavioral response due to repeated exposures by adding 5 x log10 (number of pings) to each 1-dB RL increment (Kryter, 1985; Richardson et al., 1995; Ward, 1968). This calculation is done for each dB level received, with summing across all dB levels to determine the dB SPE for that animal. A more generalized formula is provided in the original FOEIS/FEIS (DoN, 2001).

2.2.1.2 Passive Sonar System Components

SURTASS is the passive, or listening, component of the system that detects returning sounds from submerged objects, such as threat submarines, through the use of hydrophones. Hydrophones transform mechanical energy (received acoustic sound waves) to an electrical signal that can be analyzed by the sonar processing system. SURTASS consists of a twin-line (TL-29A),"Y" shaped horizontal line array (HLA) with two apertures that is approximately 1,000 feet (ft) (305 meters [m]) long. The SURTASS HLA can be towed in shallow, littoral environments; can provide significant directional noise rejection; and can resolve bearing ambiguities without the vessel's course having to be changed.

To tow the HLA, a SURTASS LFA sonar vessel must maintain a speed of at least 3 knots (kt) (5.6 kilometers per hour [kph]), with a typical speed of 4 kt (7.4 kph). The return (received) signals, which are usually below background or ambient noise level, are processed and evaluated to identify and classify potential underwater threats.

2.2.1.3 Operating Profile

The operating features of the active component of the SURTASS LFA sonar system, LFA sonar, are:

- The SL of an individual source projector on the LFA sonar array is approximately 215 dB re 1 µPa at 1 m (rms) or less. Since the projectors work together as an array to create the sound field, the array's measured sound field would never be higher than the SL of an individual source projector.
- Frequency range of 100 to 500 Hz.
- The typical LFA sonar signal is not a constant tone but consists of various waveforms that vary in frequency and duration. A complete sequence of sound transmissions (waveforms) is referred to as a wavetrain (also known as a ping). These wavetrains last between 6 and 100 seconds, with an average length of 60 seconds. Within each wavetrain, a variety of signal types can be used, including continuous wave (CW) and frequency-modulated (FM) signals. The duration of each continuous-frequency sound transmission within the wavetrain is no longer than 10 seconds.
- The maximum duty cycle (ratio of sound "on" time to total time) is 20 percent. The typical duty cycle, based on historical SURTASS LFA sonar operational parameters (2003 to 2017), is 7.5 to 10 percent.
- The time between wavetrain transmissions is typically from 6 to 15 minutes.

The Navy's proposed area for SURTASS LFA sonar training and testing activities includes the non-polar areas of the western and central North Pacific and eastern Indian oceans, not including the western Indian Ocean or Sea of Okhotsk.

The SURTASS LFA sonar vessels usually operate independently from one another, but may operate in conjunction with other naval air, surface, or submarine assets. SURTASS LFA sonar vessels generally travel in straight lines or racetrack patterns depending on the scenario. When not towing the SURTASS or LFA sonar arrays, T-AGOS vessels travel at maximum speeds of 10 or 12[6] kt (18.5 to 22 kph). Movements of SURTASS LFA sonar vessels are not unusual or extraordinary and are in line with routine operations of seagoing vessels.

2.3 Alternatives

NEPA's implementing regulations provide guidance on the consideration of alternatives to a federal agency's proposed action and require rigorous exploration and objective evaluation of reasonable alternatives. Only those alternatives determined to be reasonable, and which meet the purpose and need of the proposed action require analysis.

2.3.1 Reasonable Alternative Screening Factors

Screening criteria were developed to aid in assessing the feasibility of proposed alternatives and defining the range of reasonable alternatives. Potential alternatives that meet the Navy's purpose and need were evaluated against the following screening factors:

- The alternative must allow the Navy to meet all training and testing requirements for SURTASS LFA sonar systems, vessels, and crews.

6 The USNS ABLE, EFFECTIVE, and VICTORIOUS may travel at top speeds of 10 kt (18.5 kph) when not towing the SURTASS LFA sonar arrays, while the USNS IMPECCABLE has a top speed of 12 kt (22 kph) when underway.

- The alternative must allow the Navy to meet all requirements for maintenance and repair schedules, and vessel crew schedules for SURTASS LFA sonar vessels.

Two action alternatives (Action Alternative 1 and Action Alternative 2) would allow the Navy to meet its purpose and need and requirements of the screening factors. The No Action Alternative would not allow the Navy to meet any of the screening factor requirements or the Navy's purpose and need.

2.3.2 Alternatives Carried Forward for Analysis

After consideration of the screening factors, the Navy has carried forward for analysis two action alternatives that meet the purpose and need for the proposed action. Both action alternatives will utilize the SURTASS LFA sonar systems within the parameters described in the Operating Profile, as well as with the proposed mitigation measures introduced above and described in further detail in Chapter 5 of this SEIS/SOEIS. Although the No Action Alternative does not meet the purpose and need for the Proposed Action, it was nonetheless carried forward to provide a baseline for environmental consequences.

2.3.2.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur, and the SURTASS LFA sonar training and testing activities would not occur. The Navy's purpose and need would not be met since its ability to train and test to locate and defend against enemy submarines would be greatly impaired. Although the No Action Alternative would not meet the purpose and need for the proposed action, as required by NEPA, the No Action Alternative is carried forward for analysis in this SEIS/SOEIS, as it provides a baseline for measuring the environmental consequences of the two action alternatives.

For NMFS, pursuant to its obligation to grant or deny permit applications under the MMPA, the No Action Alternative involves NMFS's denial of Navy's application for an incidental take authorization under Section 101(a)(5)(A) of the MMPA. If NMFS were to deny the Navy's application, the Navy would not be authorized to incidentally take marine mammals pursuant to the proposed training and testing activities in the study area.

2.3.2.2 Alternative 1

Under Alternative 1, 360 hours of LFA sonar transmissions are planned per year for training and testing activities, pooled across all SURTASS LFA sonar equipped vessels. This alternative represents a substantial reduction in the annual hours of LFA sonar transmissions for all vessels compared to the current authorized transmission hours. The Navy conducted an analysis to determine the minimum number of LFA sonar transmission hours per year required to meet its purpose and need. The following were considered during the Navy's analysis: 1) previous annual LFA sonar transmission hours; 2) the number of LFA sonar vessels available for training and testing activities and the need for their maintenance; 3) recent world events, which have resulted in an increase in the extent of the annual LFA sonar study area and system usage requirements for LFA sonar; 4) Navy requirements setting the minimum level of annual at-sea proficiency training hours for LFA sonar operators and civilian crew, which can only be met by using LFA sonar in an actual at-sea environment; 5) the need to use SURTASS LFA sonar assets to support acoustic research testing using Navy ships of opportunity; and 6) potential participation of LFA sonar vessels in naval exercises (e.g., Valiant Shield, Rim of the Pacific Exercise [RIMPAC]). Based on the results of this analysis, the Navy concluded that to meet the purpose and need for use of the SURTASS LFA sonar system in training and testing activities outlined in this SEIS/SOEIS, the minimum required number of LFA sonar transmission hours is 360 hours pooled across SURTASS LFA sonar equipped vessels.

The SURTASS LFA sonar transmission hours under Action Alternative 1 (360 hours per year pooled across all SURTASS LFA sonar equipped vessels) represent a distribution across five activities including:

- Contractor crew proficiency training (80 hours per year)
- Military crew (MILCREW) proficiency training (64 hours per year)
- Participation or support of naval exercises (72 hours per year)
- Vessel and equipment maintenance (48 hours per year)
- Acoustic research testing (96 hours per year)

Each of these activities utilizes the SURTASS LFA sonar system within the operating profile described above, therefore the number of hours estimated for each activity is merely for planning purposes.

2.3.2.3 Alternative 2—Preferred Alternative

Alternative 2 is the Navy's Preferred Alternative. The annual LFA sonar transmission hours for Alternative 2 are increased above Alternative 1 to 496 hours total per year across all SURTASS LFA sonar equipped vessels in the first four years, with the number of transmission hours increasing to 592 hours across all vessels during year 5 and continuing into the foreseeable future, regardless of the number of SURTASS LFA sonar equipped vessels. While Alternative 1 represented the minimum number of LFA sonar transmission hours required to meet the Navy's purpose and need, Alternative 2 includes the consideration of 1) increased proficiency training of Navy personnel; 2) increased participation of SURTASS LFA sonar equipped vessels in naval exercises; 3) the age of the T-AGOS vessels and the increasing need for maintenance system checks; and 4) additional support of acoustic research testing.

In addition, in year 5 and beyond, the Navy is considering and is in the beginning planning stages for adding new vessels to its ocean surveillance fleet. As new vessels are developed, the onboard LFA and HF/M3 sonar systems will also need to be updated, modified, or even re-designed. As the new vessels and sonar system components are developed and constructed, at-sea testing would eventually be necessary. The Navy anticipates that new vessels or new or updated sonar system components will be ready for at-sea testing beginning in the fifth year of the time period covered by this SEIS/SOEIS. Thus, in addition to the activities described in Alternative 1, the Navy's activity analysis also included consideration of the sonar hours associated with future testing of new or updated LFA sonar system components and new ocean surveillance vessels. This resulted in two annual transmit hour scenarios: Years 1 to 4 would entail 496 hours total per year across all SURTASS LFA sonar equipped vessels, while year 5 and beyond would include an increase in LFA sonar transmission hours to 592 hours across all vessels to accommodate future testing of new ocean surveillance vessels and new or updated sonar system components. Though higher than the hours proposed in Alternative 1, this action alternative still represents a decrease from the currently authorized transmission hours of 1,020 per year.

Alternative 2 also represents an increased number of training and testing hours over that presented in Alternative 1 associated with maintaining the proficiency of contractor crew members and military personnel onboard LFA sonar vessels. While the training hours allocated in Alternative 1 for training of military sonar operators meet the minimum standard required, the increased LFA sonar transmission hours in Alternative 2 would provide additional training and testing capacity for vessels to participate in at-sea exercises with other Navy units and to conduct acoustic research testing.

The SURTASS LFA sonar transmission hours under Action Alternative 2 (496 hours per year pooled across all SURTASS LFA sonar equipped vessels in years 1 to 4 and 592 hours across all vessels in year 5 and beyond) represent a distribution across six activities including:

- Contractor crew proficiency training (80 hours per year)
- Military crew (MILCREW) proficiency training (96 hours per year)
- Participation or support of naval exercises (96 hours per year)
- Vessel and equipment maintenance (64 hours per year)
- Acoustic research testing (160 hours per year)
- New SURTASS LFA sonar system testing (96 hours per year)

Each of these activities utilizes the SURTASS LFA sonar system within the operating profile described above (i.e., frequency range, duty cycle, ping duration, etc.), therefore the number of hours estimated for each activity is merely for planning purposes.

2.3.3 Alternatives Considered But Not Carried Forward For Analysis

The initial FOEIS/EIS for SURTASS LFA sonar considered alternatives to SURTASS LFA sonar, such as other passive and active acoustic and non-acoustic technologies, as discussed in FOEIS/EIS Subchapters 1.1.2, 1.1.3, and 1.2.1; and Table 1-1 (DoN, 2001). These technologies were also addressed in the 2002 NMFS Final Rule (NOAA, 2002) and the 2002 Navy ROD (DoN, 2002). The acoustic and non-acoustic detection technologies considered included radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, biological, and high- or mid-frequency active sonar. The FOEIS/EIS concluded that these technologies did not meet the purpose and need of the proposed action to provide Naval forces with reliable long-range detection of submarines and, thus, did not provide adequate reaction time to counter potential threats. Accordingly, these alternatives were eliminated from detailed study in the FOEIS/EIS in accordance with CEQ Regulation section 1502.14. Furthermore, these technologies were not considered practicable and/or feasible for technical and economic reasons. The non-acoustic technologies were also re-examined in Subchapter 1.1.4 of the 2012 FSEIS/SOEIS for SURTASS LFA sonar (DoN, 2012), with the re-evaluation reaching the same conclusion as the 2001 FOEIS/EIS.

No new information on alternate technologies or their capabilities has arisen since the analyses in presented in the 2001 and 2012 SURTASS LFA sonar documents. These technologies also do not meet the purpose and need of this Proposed Action to provide Naval forces with the ability to train and test appropriately to become proficient in long-range detection of unknown or enemy sub-surface contacts in time to counter potential threats. Therefore, the relevant information from the 2001 and 2012 SURTASS LFA sonar documents remains valid and is incorporated by reference herein.

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3 AFFECTED ENVIRONMENT

This chapter presents a description of the environmental resources and baseline conditions that could potentially be affected by implementing the proposed action or its alternatives. In compliance with NEPA, CEQ, and 32 CFR part 775 guidelines, the discussion of the affected environment (i.e., existing conditions) in the proposed action area of the western and central North Pacific and eastern Indian oceans focuses only on those resource areas potentially subject to impacts resulting from implementation of the proposed action, which occurs in the marine environment. Accordingly, the resource areas detailed in this SEIS/SOEIS are air quality, marine water, biological, and economic resources. Additionally, the level of detail that describes a resource is commensurate with the anticipated level of potential environmental impacts.

Since SURTASS LFA sonar training and testing activities would occur within the marine environment and principally entail the introduction of acoustic energy into that environment, the following resource areas are thus not affected by the proposed action and consequently were not analyzed further in this SEIS/SOEIS:

- Water Resources—Only two components of water resources, marine waters and marine sediments, are germane to a Proposed Action that takes place entirely in oceanic waters. Training and testing activities of SURTASS LFA sonar would have no impact on marine sediments as all equipment is deployed only in the marine water column. No part of the proposed action would affect seafloor sediments. The execution of the Proposed Action would add sound to the ambient ocean environment, and water quality may potentially be affected should pollutants be discharged from the LFA sonar vessels into oceanic waters. As such, only marine water resources are considered further herein.
- Airspace Resources—No airspace is involved with the execution of SURTASS LFA sonar activities. All training and testing activities associated with use of SURTASS LFA sonar occur in the marine environment and enlist no airspace platforms or resources.
- Geological Resources—The Proposed Action and its alternatives are at-sea deployments of in-water sonar systems and related equipment that entail no deployment to the seafloor of any equipment that may cause physical disturbances to marine geological resources, including seafloor sediments.
- Cultural Resources—SURTASS LFA sonar training and testing activities would not impact any marine cultural resources such as shipwrecks since the generation of underwater sound would not affect any cultural artifacts nor is any equipment deployed from the LFA sonar vessels to the seafloor where cultural artifacts would be located.
- Land Use—The Proposed Action and alternatives occur at sea. As such, no construction activities associated with any terrestrial resources would be conducted and the Proposed Action would not involve any activities inconsistent with current or foreseeable land-use approaches and patterns.
- Infrastructure—Maintenance, repair, and porting to access ship staff associated with SURTASS LFA sonar training and testing activities require no expansion or alteration to any shore facilities. No changes to support facilities are planned as part of the Proposed Action.

- Transportation—During training and testing activities of SURTASS LFA sonar, T-AGOS vessels make no unusual maneuvers and operate according to all maritime regulations and normal oceanic vessel operation. No impacts to ocean-going ship or boating traffic would result from the training and testing activities of SURTASS LFA sonar.
- Public Health and Safety—SURTASS LFA sonar is employed such that RLs would not exceed 145 dB re 1 µPa (rms) at dive sites (or in Hawaii State waters) where humans could potentially be affected by SURTASS LFA sonar transmissions. Employment of the SURTASS LFA sonar systems is accomplished by skilled and trained merchant mariners and Navy personnel following all prudent safety measures. As such, no significant impacts to public health and safety are reasonably foreseeable.
- Hazardous Materials and Wastes—No hazardous waste or materials would be handled during the execution of the Proposed Action and no release of hazardous waste or materials is foreseeably expected as a result of the Proposed Action. Although some incidental discharges from the SURTASS LFA sonar vessels are normal for ship operations, SURTASS LFA vessels are operated in compliance with all requirements of the CWA and the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), as implemented under the APPS (33 U.S.C. 1901 to 1915). Operation of the SURTASS LFA sonar system itself would not result in the discharge of pollutants regulated under the APPS. Therefore, no discharges of pollutants regulated under the APPS or CWA are reasonably expected from the operation of the SURTASS LFA sonar vessels nor would unregulated environmental impacts occur in association with the operation of the SURTASS LFA sonar vessels.
- Sociologic—The Proposed Action does not involve any activities that would contribute to changes in sociological resources such as demography, communities, or social institutions.
- Environmental Justice—Implementation of the Proposed Action would not result in adverse impacts to any environmental resource area that would be expected to disproportionately affect minority or low-income human populations in the areas adjacent to the SURTASS LFA sonar study areas, and accordingly, no significant impacts are reasonably foreseeable.

3.1 Regulatory Setting

This section provides a brief overview of the relevant primary federal statutes, executive orders, and guidance that together form the regulatory framework for the resource evaluation of the affected environment. Additionally, Chapter 6 (Other Considerations Required by NEPA) provides a summary listing and status of compliance with applicable environmental laws, regulations, and executive orders that were considered in preparing this SEIS/SOEIS for SURTASS LFA sonar.

3.1.1 National Environmental Policy Act (NEPA)

This SEIS/SOEIS has been prepared in accordance with the President's CEQ regulations implementing NEPA (40 CFR §§ 1500–1508). NEPA (42 U.S.C. §§ 4321–4347) requires federal agencies to prepare an EIS for a proposed action with the potential to significantly affect the quality of the human environment; to disclose significant environmental impacts associated with the proposed action; to inform decision makers and the public of the reasonable alternatives to the proposed action; and to consider agency and public comments on the EIS. Based on Presidential Proclamation 5928, issued 27 December 1988, impacts on ocean areas that lie within 12 nmi of land (i.e., U.S. territorial waters) are subject to analysis under NEPA.

3.1.2 Executive Order 12114, Environmental Effects Abroad of Major Federal Actions

The preparation of this SEIS/SOEIS has been conducted in accordance with Executive Order (EO) 12114 and Navy implementing regulations in 32 CFR Part 187. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial seas (more than 12 nmi (22 km) from emergent land) of any nation and Antarctica, not including the contiguous zones and fisheries zones of foreign nations (exclusive economic zones) (32 CFR § 187.3). Environment is defined in EO 12114 as the natural and physical environment and excludes social, economic, and other environments. As permitted under NEPA and EO 12114, this SEIS and SOEIS for SURTASS LFA sonar have been combined into one document to reduce duplication.

3.1.3 Marine Mammal Protection Act (MMPA)

The MMPA provides protection to the 46 species of marine mammals potentially occurring in the study area for SURTASS LFA sonar. NMFS has jurisdiction over the cetacean and pinniped species that may occur in the study area. An analysis of the potential to “take” marine mammals by MMPA Level A or B harassment in association with training and testing activities of SURTASS LFA sonar has been conducted as part of this SEIS/SOEIS and its associated permit applications.

Although the Navy is currently operating SURTASS LFA sonar under a MMPA NDE for the period of August 2017 through August 2019, the Navy has submitted an application to NMFS requesting rulemaking and an LOA for the continued use of SURTASS LFA sonar from August 2019 through August 2026 in the western and central North Pacific and eastern Indian oceans. The information on marine mammals presented herein forms the basis of the rulemaking and LOA application for SURTASS LFA sonar.

3.1.4 Endangered Species Act (ESA)

Species of marine invertebrates, marine reptiles, marine and anadromous fishes, and marine mammals listed under the ESA potentially occur in the study area for SURTASS LFA sonar as well as critical habitat designated for two species of marine mammals. NMFS has authority over the ESA-listed marine and anadromous species and critical habitats that may occur in the waters in which SURTASS LFA sonar may be operated. The potential for training and testing activities of SURTASS LFA sonar to affect the ESA-listed species or critical habitats has been assessed as part of this SEIS/SOEIS and the related permit applications.

Section 7(a)(2) of the ESA requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action “may affect” a listed species or critical habitat, the agency is required to consult with NMFS or USFWS, depending on which Service has jurisdiction over the species (50 CFR § 402.14(a)). While the Navy currently operates SURTASS LFA sonar in non-polar, worldwide waters under the 2017 ITS and Biological Opinion, pursuant to Section 7 of the ESA, the Navy has initiated consultation with NMFS on the continued employment of SURTASS LFA sonar in the western and central North Pacific and eastern Indian oceans from August 2019 through August 2026. The request for initiation of Section 7 consultation and a Biological Opinion (BO)/Incidental Take Statement (ITS) pursuant to the ESA is based on the species and habitat information presented in this SEIS/SOEIS.

3.1.5 Marine Protection, Research, and Sanctuaries Act (MPRSA)

The MPRSA of 1972 (33 U.S.C. §§ 1401-1445) regulates dumping of toxic materials beyond U.S. territorial waters and provides guidelines for designation and regulation of marine sanctuaries. SURTASS LFA sonar vessels comply with all federal regulations regarding ocean dumping and discharge requirements in waters of the U.S. or the global commons.

3.1.6 National Marine Sanctuaries Act (NMSA)

The NMSA provides for the designation and management of marine areas as national marine sanctuaries that have special national significance. A marine area may be designated as a National Marine Sanctuary (NMS) on the basis of its conservation, recreational, ecological, historical, cultural, archaeological, scientific, educational, or aesthetic qualities. Thirteen NMSs have been designated in U.S. waters but only one of those, the Hawaiian Islands Humpback Whale NMS is located in the study area for SURTASS LFA sonar.

Although for most of the NMSs, prohibitions include exemptions for certain military activities, Section 304(d) of the NMSA requires federal agencies to consult with the ONMS before taking actions internal or external to a sanctuary that are “likely to destroy, cause the loss of, or injure any sanctuary resource” **(**16 USC 1434(d)). According to NOAA policy, injury to sanctuary resources includes estimated MMPA Level A and Level B harassment of marine mammals within a NMS, as both have the potential to adversely change a physical attribute or viability of affected individuals. The Navy has determined that its planned use of SURTASS LFA sonar pursuant to this SEIS/SOEIS does not require consultation under Section 304(d) of the NMSA.

3.1.7 Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and Sustainable Fisheries Act (SFA)

The MSFCMA (16 U.S.C. § 1801 et seq.), enacted in 1976 and amended by the Sustainable Fisheries Act (SFA) in 1996, mandates identification and conservation of EFH in U.S. waters. EFH is defined as waters, including the water column, and benthic substrates necessary (required to support a sustainable fishery and the federally managed species) to fish for spawning, breeding, feeding, or growth to maturity (i.e., full life cycle). EFH waters include aquatic areas and their associated physical, chemical, and biological properties used by fish, and may include areas historically used by fish.

Federal agencies are required to consult with NMFS if their activities have the potential for adverse effects on EFH. The MSFCMA defines an adverse effect as “any impact which reduces quality and/or quantity of EFH [and] may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species’ fecundity), site-specific or habitat wide impacts, including individual, cumulative, or synergistic consequences of actions” (50 CFR 600.810).

Consultation/coordination under the MSFCMA was conducted as part of the analyses for the Navy’s 2001 FOEIS/EIS (DoN, 2001) for SURTASS LFA sonar. The information regarding consultation and agency coordination on the MSFCMA is incorporated by reference herein. The Navy is reassessing its Proposed Action relative to the MSFCMA’s provisions on EFH to determine if supplemental consultation under the MSFCMA is required.

3.1.8 Migratory Bird Treaty Act (MBTA)

The MBTA of 1918 (16 U.S.C. sections 703–712) and Migratory Bird Treat Reform Act of 2004 together provide the foundation for U.S. and international (Canada, Mexico, Japan, and Russia) protection of migratory birds. The 1,026 bird species protected under the MBTA include those species native to the U.S. and present in Canada, Mexico, Japan, and Russia. Native species are those that occur as a result of natural biological or ecological processes. The MBTA prohibits taking, killing, possessing, or purchasing any migratory bird[7] or their parts, nests, or eggs, unless permitted by regulation. USFWS manages and has regulatory responsibility for migratory birds, which include species of seabirds.

Military readiness activities of the U.S. Armed Forces are exempt from the prohibitions of the MBTA unless those activities may result in a significant adverse effect on a migratory bird population. The Armed Forces agency must confer and cooperate with the USFWS to develop appropriate and reasonable conservation measures to minimize or mitigate the significant adverse effects on the potentially affected migratory birds. The Navy has determined that its planned use of SURTASS LFA pursuant to this SEIS/SOEIS does not require consultation nor coordination under the MBTA.

3.1.9 Clean Water Act (CWA)

The CWA (33 U.S.C. § 1251 et seq.) regulates discharges of pollutants in surface waters of the U.S. and additionally provides for the protection of ocean waters (waters of the territorial seas, the contiguous zone, and the high seas beyond the contiguous zone) from point-source discharges (CWA Section 403). In 1996, the CWA was amended to create section 312(n), "Uniform National Discharge Standards for Vessels of the Armed Forces." Section 312(n) directs the EPA and DoD to establish national standards for discharges incidental to the normal operation of armed forces vessels. These national standards preempt State discharge standards for military vessels. Navy vessels operate in compliance with the national discharge standards.

3.1.10 Clean Air Act (CAA)

The CAA (42 U.S.C. §7401 et seq.) regulates discharges of air emissions from stationary and mobile sources within the U.S., including U.S.-flagged vessels that operate using diesel fueled engines while in state waters (typically 3 nmi [5.6 km] from shore except Texas, western [Gulf of Mexico] Florida, and Puerto Rico, where the seaward boundary of the states is 9 nmi [16.7 km] from shore). The CAA authorizes the EPA to establish standards for criteria air pollutants to which all states must conform. Additionally, the General Conformity Rule of the CAA, requires federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the National Ambient Air Quality Standards (NAAQS) for criteria pollutants. Only military tactical vehicles are exempt from the provisions of the CAA, but the President can issue regulations exempting the U.S. Armed Forces with compliance with the General Conformity Rule of the CAA for military assets that are uniquely military in nature; these exemptions are valid for three-year intervals. This SEIS/SOEIS includes an assessment of the air emissions contributed by SURTASS LFA sonar activities in U.S. waters of Hawaii, Guam, and Commonwealth of the Northern Mariana Islands (CNMI) that are within the study area.

3.1.11 Executive Order 12962—Recreational Fisheries

EO 12962 on Recreational Fisheries (60 C.F.R. 30769) was issued in 1995 to ensure that federal agencies strive to improve the "quantity, function, sustainable productivity, and distribution of U.S. aquatic resources" so that recreational fishing opportunities increase nationwide. The overarching goal of this order is to promote conservation, restoration, and enhancement of aquatic systems and fish

7 A migratory bird is any species or family of birds that live, reproduce, or migrate within or across international borders at some point during their annual life cycle. By regulation, a migratory bird is a bird of a species that belongs to a family or group of species native to the U.S. and its territories and is present in Canada, Japan, Mexico, or Russia.

populations by increasing fishing access, education and outreach, and multi-agency partnerships. Since the Proposed Action would have no significant harm to fishes or fisheries and would in no way impair access to recreational fishing areas, the Navy concluded that it has fulfilled its EO 12962 responsibilities regarding recreational fishing uses and resources.

3.1.12 Executive Order 13158—Marine Protected Areas

The purpose of EO 13158 on marine protected areas (MPAs) is the protection of the significant natural and cultural resources within the marine environment by strengthening and expanding the Nation's system of MPAs, creating the framework for a national system of MPAs, and preserving representative habitats in different geographic regions of the marine environment.

MPAs are defined in EO 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." EO 13158 strengthens governmental interagency cooperation in protecting the marine environment and calls for strengthening management of existing MPAs, creating new ones, and preventing harm to marine ecosystems by federally approved, conducted, or funded activities (Agardy, 2000). The Navy assessed the national MPAs in the study area for SURTASS LFA sonar, as specified under EO 13158.

3.1.13 Executive Order 13840—Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States

Issued in June 2018, this EO revokes and replaces EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*. This EO is intended to advance the economic, security, and environmental interests of the U.S. through improved public access to marine data and information; efficient federal agency coordination on ocean related matters; and engagement with marine industries, the science and technology community, and other ocean stakeholders, including Regional Ocean Partnerships.

Under this EO, it is the policy of the U.S. to: (a) coordinate the activities of executive departments and agencies (agencies) regarding ocean-related matters to ensure effective management of ocean, coastal, and Great Lakes waters and to provide economic, security, and environmental benefits for present and future generations of Americans; (b) continue to promote the lawful use of the ocean by agencies, including U.S. Armed Forces; (c) exercise rights and jurisdiction and perform duties in accordance with applicable domestic law and—if consistent with applicable domestic law— international law, including customary international law; (d) facilitate the economic growth of coastal communities and promote ocean industries, which employ millions of Americans, advance ocean science and technology, feed the American people, transport American goods, expand recreational opportunities, and enhance America's energy security; (e) ensure that Federal regulations and management decisions do not prevent productive and sustainable use of ocean, coastal, and Great Lakes waters; (f) modernize the acquisition, distribution, and use of the best available ocean-related science and knowledge, in partnership with marine industries; the ocean science and technology community; State, tribal, and local governments; and other ocean stakeholders, to inform decisions and enhance entrepreneurial opportunity; and (g) facilitate, as appropriate, coordination, consultation, and collaboration regarding ocean-related matters, consistent with applicable law, among Federal, State, tribal, and local governments, marine industries, the ocean science and technology community, other ocean stakeholders, and foreign governments and international organizations.

3.1.14 Department of Defense and Navy Directives and Instructions

In addition to the U.S. federal legislation that governs Navy activities in the marine environment, the Navy is required to comply with environmental readiness guidelines and requirements promulgated in the *OPNAV 5090 Environmental Readiness Program Manual* by the Navy's Energy and Environmental Readiness Division. This SEIS/SOEIS has been prepared according to Navy environmental guidance.

3.2 Air Quality

3.2.1 Introduction

Air pollution is a threat to human health and also damages the environment as well as the exteriors of structures and buildings (EPA, 2007). Air pollution creates haze or smog that reduces visibility and interferes with aviation. To improve air quality and reduce air pollution, the CAA and its amendments (1970 and 1990) were enacted to set regulatory limits on air pollutants and ensure air quality and protect human health and the environmental from air pollution.

A region's air quality is influenced by many factors including the type, concentration, and emission rate of pollutants emitted into the atmosphere, the geographic extent and topography of region, the prevailing meteorological conditions (wind speed and direction, precipitation, and vertical atmospheric temperature gradient), and atmospheric chemistry. Most air pollutants originate from human-made sources, including mobile sources (e.g., cars, trucks, buses) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Air pollutants are also released from natural sources such as volcanic eruptions and forest fires. Air quality in a given location is characterized by the concentration of various pollutants in the atmosphere. Ambient air quality is reported as the atmospheric concentrations of specific air pollutants at a particular time and location. The units of measurement are expressed as a mass per unit volume (e.g., micrograms per cubic meter [$\mu g/m^3$] of air) or as a volume fraction (e.g., parts per million [ppm] by volume).

Although the Proposed Action occurs in the marine environment, because it entails the use Navy ocean surveillance vessels, which use diesel-fueled engines, the air emissions of the SURTASS LFA sonar vessels are subject to the provisions of the CAA while operating in the state waters of Hawaii, Guam, or CNMI. The following section includes information and discussion of criteria air pollutants, air quality standards, sources of air pollutants, permitting, and greenhouse gases.

3.2.2 Criteria Pollutants and National Ambient Air Quality Standards

The principal pollutants defining the air quality, called "criteria pollutants," include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), suspended particulate matter less than or equal to 10 microns in diameter (PM_{10}), fine particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$), and lead (Pb). Some criteria pollutants such as CO, SO_2, Pb, and some particulates are emitted directly into the atmosphere from emission sources, including marine vessels. Ozone, NO_2, and some particulates are formed as the result of atmospheric chemical reactions that are influenced by weather, ultraviolet light, and other atmospheric processes.

Under the CAA, the EPA has established NAAQS (40 CFR part 50) for these criteria pollutants. NAAQS are classified as primary or secondary. Primary standards protect against adverse health effects, while secondary standards protect against welfare effects, such as damage to farm crops and vegetation and damage to buildings. Some air pollutants have long-term and short-term standards. Short-term standards are designed to protect against acute, or short-term, health effects, while long-term standards were established to protect against chronic health effects.

Areas that are and have historically been in compliance with the NAAQS are designated as attainment areas. Areas that violate a federal air quality standard are designated as nonattainment areas. Areas that have transitioned from nonattainment to attainment are designated as maintenance areas and are required to adhere to maintenance plans to ensure continued attainment of the NAAQS. The CAA requires states to develop a general plan to attain and maintain the NAAQS and a specific plan to attain the standards for each area designated nonattainment for a NAAQS. These plans, known as State Implementation Plans (SIPs), are developed by state and local air quality management agencies and submitted to the EPA for approval. The State of Hawaii and the territory of CNMI are both in attainment or unclassified with the NAAQS for all criteria pollutants, but Guam is not (EPA, 2018). One area on Guam, Piti-Cabras, is in non-attainment for the 2010 SO2 NAASQ (EPA, 2017, 2018).

3.2.3 General Conformity

Section 176(c)(1) of the CAA, commonly known as the General Conformity Rule, requires federal agencies to ensure their actions conform to applicable state implementation plans for achieving and maintaining the NAAQS for criteria pollutants. The General Conformity Rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds.

A conformity applicability analysis is the first step of a conformity evaluation and assesses if a federal action must be supported by a conformity determination. This is typically done by quantifying applicable direct and indirect emissions that are projected to result due to implementation of the federal action. Indirect emissions are those emissions caused by the federal action and originating in the region of interest, but which can occur at a later time or in a different location from the action itself and are reasonably foreseeable. The federal agency can control and will maintain control over the indirect action due to a continuing program responsibility of the federal agency. Reasonably foreseeable emissions are projected future direct and indirect emissions that are identified at the time the conformity evaluation is performed. The location of such emissions is known and the emissions are quantifiable, as described, and documented by the federal agency based on its own information and after reviewing any information presented to the federal agency. If the results of the applicability analysis indicate that the total emissions would not exceed the de minimis emissions thresholds, then the conformity evaluation process is completed. Compliance with the General Conformity Rule is presumed if the net increase in reasonably foreseeable air pollutant emissions associated with a federal action would not exceed applicable federal *de minimis* levels.

The Navy conducted an evaluation of the potential air pollutant emissions associated with the Proposed Action occurring within the U.S. state and territory waters that lie within the potential study area for SURTASS LFA sonar, namely Hawaii, Guam, and the CNMI. The evaluation was to determine if requirements of the CAA's General Conformity Rule were applicable to the Proposed Action. Due to Title 10 exemptions, Navy SURTASS LFA sonar vessels would never go into port in Hawaii, Guam, nor the CNMI. As such, the Navy determined that all air emissions generated as a result of the training and testing activities of SURTASS LFA sonar would occur outside of U.S. state and territory waters (i.e., beyond 3 nmi [5.6 km] from shore). Thus, the only activities that would be analyzed pursuant to the CAA are those associated with SURTASS LFA sonar vessels when they are conducting training and testing activities in the waters of the coastal standoff range (<12 nmi [22 km] from land) of Hawaii, Guam, and the CNMI. Since these areas are not subject to the CAA General Conformity rule, the Navy is not required to perform a CAA General Conformity evaluation for the Proposed Action.

3.2.4 Hazardous Air Pollutants

In addition to the six criteria pollutants, the U.S. Environmental Protection Agency (EPA) currently designates 187 substances as hazardous air pollutants (HAPs) under the CAA. HAPs are air pollutants known or suspected to cause cancer or other serious health effects, or adverse environmental and ecological effects (EPA, 2016a). Unlike the criteria pollutants, no national standards have been established for HAPs. The only HAPs emitted during the execution of the Proposed Action would be from the SURTASS LFA sonar vessels, which are considered to be mobile sources. HAPS generated by mobile sources are termed Mobile Source Air Toxics (MSATs). MSATs are compounds emitted from mobile sources that are known or suspected to cause cancer or other serious health and environmental effects.

The primary method for controlling MSATs such as those generated by the SURTASS LFA sonar vessels is to reduce the HAP fuel content and alter the engine operating characteristics to reduce the volume of pollutant generated during engine combustion.

In 2001, the EPA issued its first MSAT Rule, which identified 201 compounds as being HAPs that require regulation. Six MSAT compounds were identified to have the greatest effect on human health: benzene, butadiene, formaldehyde, acrolein, acetaldehyde, and diesel particulate matter. Subsequent EPA rules identified several marine engine emission certification standards that must be implemented as applicable (40 CFR parts 89, 91, 94, 1042, 1043, and 1068).

3.2.5 Greenhouse Gases and Climate Change

Greenhouse gases are gases that trap heat in the atmosphere and contribute to the "greenhouse effect", a natural phenomenon in which heat is trapped within the lowest portion of the Earth's atmosphere by greenhouse gases, causing radiant heating at the surface. Greenhouse gases influence the global climate by trapping heat in the atmosphere that would otherwise escape to space. Greenhouse gas emissions also occur as the result of human activities. The primary long-lived greenhouse gases directly emitted by human activities are CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride, and sulfur hexafluoride; these gases combined are considered by the EPA to endanger both the public health and the public welfare of current and future generations (EPA, 2009c). Carbon dioxide, methane, and nitrous oxide occur naturally in the atmosphere. The heating effect resulting from concentrations of greenhouse gases in the atmosphere, particularly the increased concentrations attributed to human activities, is considered the primary cause of the global warming that has been observed over the last 50 years (EPA, 2009b). Global warming and climate change affect many aspects of the environment.

To estimate global warming potential, which is the heat trapping capacity of a gas, the U.S. quantifies greenhouse gas emissions using the 100-year timeframe values established in the Intergovernmental Panel on Climate Change Fourth Assessment Report (Intergovernmental Panel on Climate Change, 2007), in accordance with reporting procedures of the United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change, 2013). All global warming potentials are expressed relative to a reference gas, CO_2, which is assigned a global warming potential equal to 1. Six other primary greenhouse gases have global warming potentials: global warming potential of 25 for methane, 298 for nitrous oxide, 124 to 14,800 for hydrofluorocarbons, 7,390 to >17,340 for perfluorocarbons, 17,200 for nitrogen trifluoride, and up to 22,800 for sulfur hexafluoride.

Carbon dioxide is the predominant greenhouse gas emitted into the atmosphere (85.4 percent), principally from fossil fuel combustion (EPA, 2015). As a result, greenhouse gas emissions are typically reported in terms of CO_2 equivalency. CEQ guidance recommends that federal agencies consider 25,000 metric tons (mt) of carbon dioxide equivalent (CO_2e) emissions on an annual basis as a reference point below which a quantitative analysis of greenhouse gas is not recommended unless it is easily accomplished based on available tools and data. To estimate the CO_2e of a non-carbon dioxide greenhouse gas, the appropriate global warming potential of that gas is multiplied by the amount of the gas emitted. All seven greenhouse gases are multiplied by their global warming potential and the results are added to calculate the total equivalent emissions of carbon dioxide. Weighted by global warming potential, methane is the second largest component of emissions, followed by nitrous oxide.

Revised 2014 guidance from CEQ, recommends that agencies consider both the potential effects of a proposed action on climate change, as indicated by its estimated greenhouse gas emissions, and the implications of climate change for the environmental effects of a proposed action. The guidance also emphasizes that agency analyses should be commensurate with projected greenhouse gas emissions and climate impacts, and should employ appropriate quantitative or qualitative analytical methods to ensure useful information is available to inform the public and the decision-making process in distinguishing between alternatives and mitigations.

The execution of the Proposed Action is anticipated to release greenhouse gases into the atmosphere. The potential effects of proposed greenhouse gas emissions are by nature global and may result in cumulative impacts because most individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change.

3.3 Marine Water Resources

The potential impacts on the physical environment of the oceans associated with execution of the Proposed Action are the addition of pollutants resulting from the operation of the SURTASS LFA sonar vessels and addition of underwater noise during operation of both LFA sonar and the associated mitigation monitoring system, HF/M3 sonar. With the exception of the addition of sound to the oceanic environment, the operation of these sonar systems would not affect other marine water resources, including seafloor sediments or oceanic water quality.

3.3.1 Marine Pollutants

SURTASS LFA sonar vessels are U.S. Coast Guard-certified and are operated in accordance with all applicable federal, international, and U.S. Navy rules and regulations related to environmental compliance, especially for discharge of potentially hazardous materials into the marine environment. The CWA regulates military vessel discharges into the marine environment under Section 312(n), Uniform National Discharge Standards for Vessels of the Armed Forces. The NDAA of 1996 amended Section 312 of the CWA to direct the DoD and U.S. EPA in the establishment of standards for potential discharges incidental to the normal operation of a military vessel. These discharge standards apply to military vessels operating in U.S. inland and territorial waters (i.e., 12 nmi from shore). Additionally, military vessels are also subject to compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL 1973 as modified by the Protocol of 1978), which is implemented by the APPS (33 U.S.C. 1901 to 1915).

Since the U.S. Navy adheres to regulations of the Uniform National Discharge Standards of the CWA and APPS for its sea-going vessels, unregulated environmental impacts from the operation of the SURTASS

LFA sonar vessels would not occur. Since no impacts associated with the potential addition of pollutants or harmful materials to marine waters associated with the operation of the SURTASS LFA sonar vessels would occur, no further discussion of marine pollutants is included herein.

3.3.2 Ambient Noise

Marine animals use underwater sound to sense and obtain information about the ocean environment. Using both active (echolocation and vocalizations) and passive (listening) acoustics, marine animals employ sound for such functions as communication, navigation, obstacle and predator avoidance, and prey detection (Au and Hastings, 2008). The ability to use sound as an effective sensing medium in the ocean is dependent on the level of ambient or background noise in the ocean environment, since that noise could potentially interfere with an animal's ability to sense (hear) or produce sound.

Ambient noise is the typical or persistent background noise that is part of an environment. Ambient noise is produced by both natural and anthropogenic (human) sources, is typically characterized by a broad range of frequencies, and is directional both horizontally and vertically so that the received sound levels are not equal from all directions. Noise generated by surface ocean waves, wind stress, and biologically-produced (e.g., snapping shrimp) sounds are the primary contributors to the natural ambient noise soundscape in the frequency range of 300 Hz to 5 (kiloHertz) kHz; in polar regions, the sounds generated by moving sea ice dominant the ambient noise environment (Menze et al., 2017). The sound produced by propulsion systems of ocean-going ships, with frequencies centered from 20 to 200 Hz (but ranging as high as 1 kHz), is the dominate source of anthropogenic sound in the ocean (Hildebrand, 2009; Tyack, 2008).

A comprehensive overview of oceanic ambient noise can be found in Urick (1983), Richardson et al. (1995), and Au and Hastings (2008). Previous documentation for SURTASS LFA sonar presented information on the natural and anthropogenic components of ambient ocean noise: FOEIS/EIS subchapter 3.1.1 (DoN, 2001), 2012 SEIS/SOEIS subchapter 3.1.1 (DoN, 2012), and 2017 SEIS/SOEIS subchapter 3.2.1 (DoN, 2017a). Since the information presented therein remains valid and pertinent, it is incorporated by reference in this SEIS/SOEIS. Recent research and information, particularly on LF oceanic noise, follows.

3.3.2.1 Ambient Oceanic Noise Trends

Ambient noise levels in both the Indian and Pacific oceans have increased over the last several decades. In the Indian Ocean, noise in the LF band (5 to 115 Hz) has increased 2 to 3 dB over the past decade, while acoustic data measured from the northeast Pacific Ocean indicate that deepwater LF (10 to 100 Hz) ambient noise levels have been rising for the last 60 years, principally attributable to distant shipping noise (McDonald et al., 2006; Miksis-Olds and Nichols, 2016). Širović et al. (2013) found that measured ambient noise levels of seven remote areas of the tropical and subtropical North Pacific Ocean were lower than those reported for other areas of the North Pacific and were indicative of only light shipping or distant ship noise.

The ambient noise levels in shallower continental shelf environments are more variable as the regional seafloor and topographic conditions strongly affect acoustic propagation. In the continental shelf environment of Southern California, the recent ambient noise levels were not as high as those measured in other coastal continental shelf areas such as in the Norwegian Sea, North Sea, and Eastern Canada (McDonald et al., 2008). Ship-related noise, however, dominated the LF soundscapes of all the shallower, coastal areas and increased in southern California waters by 6 to 9 dB over the 50 years for which data were available (McDonald et al., 2008).

Ambient noise data from the 1950s and 1960s show that noise levels increased at a rate of approximately 3 dB per decade or 0.55 dB per year. Beginning in the 1980s, however, the rate of increase in ambient noise levels slowed to 0.2 dB per year (Chapman and Price, 2011). Andrew et al. (2002) reported an increase of about 10 dB in the 20 to 80 Hz band during a six-year observation period (1995 to 2001), which was less than expected based on a rate of 0.55 dB increase per year (Andrew et al., 2011). Farrokhrooz et al. (2017) recently reported that in the northeast Pacific Ocean, little change had occurred in the 50-Hz noise level over the last four decades but that seasonal trends are obvious in ambient noise data for this region. Seasonal increases in ambient noise in the 17 to 20 Hz band during fall are likely associated with the presence of migrating baleen whales, and the ~2 dB increase in noise in the 40 to 50 Hz band from December through May likely is reflective of the increase in wind speeds at higher latitudes and/or the seasonal changes in shipping lanes (Chen et al., 2014; Farrokhrooz et al., 2017).

3.3.2.2 Ambient Shipping Noise

The overall increasing ambient noise trends in both the Pacific and Indian oceans have primarily been attributed to increasing shipping noises (Miksis-Olds and Nichols, 2016). Recent measurements in the northeast Pacific region show a leveling or slight decrease in sound levels, even though shipping activity continued to rise, which confirms the prediction by Ross (1976) that the rate of increase in ambient ocean noise levels would be less at the end of the twentieth century compared to that observed in the mid-20th century (Andrew et al., 2011). Better design of propulsion systems may have contributed to this reduced increase in oceanic noise levels in at least some ocean areas (Chapman and Price, 2011).

Veirs et al. (2016) reported that ambient noise levels from ship noise not only have increased in the LF frequency band (100 to 1,000 Hz) but also in the high frequency (HF) band (10 to 40 kHz) by 5 to 1 dB at distances <1.6 nmi (3 km) in coastal waters. Thus, noise generated by both ships and boats ranges into the high frequencies used by many odontocetes, such as killer whales, and may mask communication and echolocation signals.

3.3.2.3 Other Ambient Noise Sources

Shipping alone does not fully account for the increases in noise levels in the 30 to 50 Hz LF band that was observed from 1965 to 2003. Other sources of anthropogenic ambient noise in the ocean including noise from oil and gas exploration, seismic airgun activity, and renewable energy sources (e.g., wind farms) are contributors to the overall ocean soundscape. These sources contribute to sound in the lower LF frequency band and have been increasing over time (Miksis-Olds et al., 2013). Many of these anthropogenic sources are located along well-traveled shipping routes and encompass coastal and continental shelf waters that are important marine habitats (Hildebrand, 2009).

In some ocean regions, noise generated by seismic airgun surveys increasingly dominates the ambient noise environment; during summer to autumn of 2008 to 2014 in the Fram Strait region of the North Atlantic Ocean, seismic airgun noise was detected for more than 12 hours per day (Ahonen et al., 2017). Sound produced by renewable-energy production developments, particularly that of offshore wind energy, differ from other types of anthropogenic sound sources in that the underwater noise levels generated from the operation of a wind farms is more persistent and of longer duration. While the anthropogenic noise generated by seismic exploration is transient in nature, the expected lifetime of an offshore wind farm is twenty to thirty years. The associated noises from the operation of the wind farm would result in an almost constant and permanent source of noise in the vicinity of a wind farm (Tougaard et al., 2009).

As ocean ambient noise levels increase overall, remarkably, many sound-producing marine animals may also inadvertently, and probably as a very small measure, contribute to the rising oceanic ambient noise level. For example, some marine mammals that utilize the LF bands for communication have been observed to employ noise compensation mechanisms in loud soundscape environments. Baleen whales have been observed increasing the amplitude of their vocalizations to overcome increasing noise levels at specific frequencies; these compensation mechanisms for an increasingly noisy ocean environment in turn contribute to a slight increase in the naturally-derived component of rising ocean sound levels (Miksis-Olds et al., 2013).

3.3.2.4 Climate Change and Ocean Acidification

Climate change refers to the changes in the Earth's climate, which throughout Earth's history have typically been due to very small variations in the Earth's orbit that alter the amount of the sun's energy the planet receives, causing cooling or warming of the Earth. However, scientists recognized in the middle of the 20th century that the Earth's increasingly warming atmosphere was not due to the historical causes of climate change but appeared instead to be significantly linked to anthropogenic causes. The principal cause in the current global warming trend has been scientifically linked to the unprecedented increased input of greenhouse gases into the Earth's atmosphere (Intergovernmental Panel on Climate Change [IPCC], 2013).

Greenhouse gases primarily include naturally occurring carbon dioxide (CO_2), water vapor, ozone (O_3), methane (CH_4), and nitrous oxide (N_2O), but also include hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. These gases are a natural part of the Earth's atmosphere that regulates the Earth's climate by trapping the heat in the atmosphere that would otherwise escape into space. Without greenhouse gases blanketing the Earth, the surface temperature would be 60° F (15.6° C) colder (Karl et al., 2009). The increased levels of greenhouse gases in the Earth's atmosphere are significant because of their long duration in the atmosphere. After emission, atmospheric CO_2, CH_4, and aerosols can remain elevated for thousands of years, decades, or weeks to days, respectively (Karl et al., 2009).

Global warming and increased CO_2 concentrations in the atmosphere affect the oceans in several ways. Atmospheric warming has resulted in the warming of the oceans because atmospheric CO_2 is absorbed by the oceans as well as by vegetation on land. The greatest increase in ocean temperatures has occurred in surface waters, with the temperature of the upper 246 feet (ft) (75 meters [m]) of the oceans having increased by an average of 0.18° F (0.11°C) per decade from 1971 to 2010 (IPCC, 2013). Thus, as the concentration of CO_2 in the atmosphere has increased, so too has the absorption of CO_2 levels in the ocean. When CO_2 is absorbed in seawater, carbonic acid forms, resulting in the lowering of the pH[8] of seawater as ocean waters become less alkaline than normal (Cao and Caldeira, 2008). This process is known as ocean acidification.

The pH of the world's oceans has been remarkably stable at about 8.2 for millennia, but recent measurements indicate that the average pH has fallen to around 8.1 with further pH decreases (0.4 to

8 pH refers to the potential of hydrogen in water soluble substances and is measured on a scale from 1 to 14, with pH values below 7 (neutral) being acidic and values above 7 being alkaline (basic).

0.7 pH units) predicted over the next century (Gazioğlu et al., 2015). The greatest increases in ocean acidity are predicted to occur in waters at high latitudes, with moderate increases in acidity predicted in tropical and subtropical waters (Cao and Caldeira, 2008). The increase in ocean acidity would initially be less in deeper waters of the ocean, with models predicting that the pH at a depth of 3,281 ft (1,000 m) could decline by 0.2 to 0.5 pH units by 2100, depending on the environmental characteristics and location (Ilyina et al., 2009).

Ocean acidification would have profound effects on the oceans and their biota, even in polar waters. Reef-building corals are already being affected by warming oceans and ocean acidification; microbial communities may also be affected, which could disrupt or change nutrient cycling, efficiency of CO_2 uptake, and cause trophic shifts in the world's oceans (Subramaniam et al., 2017).

3.3.2.4.1 Ocean Acidification and Ambient Ocean Noise

Ocean acidification, caused by the increased absorption of CO_2 by surface ocean waters, which makes them more acidic (decrease in pH), has become a subject of worldwide concern. This concern is not only due to the changes in seawater chemistry and the resulting effects on organisms such as reef-building coral, but also due to the potential impact upon ambient ocean noise via changes in the acoustic absorption coefficient at low frequencies. Simply put, ocean acidification from rising CO_2 levels would result in decreased sound absorption in the LF bands and potentially increased levels of ocean ambient noise. Ocean acidification has a strong dependency on pH at frequencies less than 2 kHz (Joseph and Chiu, 2010). A decrease in ocean acidity of about 0.45 pH units would result in a decrease in sound absorption by about 50 percent for frequencies below 1 kHz. As a result, LF sound would have to travel twice as far to lose the same amount of energy to absorption. Thus, LF sounds would propagate farther, increasing ambient noise levels, with most of the changes occurring in surface waters (Gazioğlu et al., 2015). This decrease in sound absorption may impact ocean ambient noise levels within the auditory range critical for environmental, military, and economic interests (Hester et al., 2008).

To understand better the potential effects ocean acidification may have on ambient noise levels, some researchers have tried to estimate the changes in ambient ocean noise levels due to the decreasing pH of the ocean. Joseph and Chiu (2010) estimated that by 2250, the ambient noise level would increase by 0.2 dB in the frequency range of 50 to 2,000 Hz if the pH of surface waters changed by 0.7 pH units. Reeder and Chiu (2010) also predicted changes of less than 0.5 dB for all frequencies in the deep ocean, with no statistically significant change in shallow water or surface duct environments when there was a decrease in pH from 8.1 to 7.4. Ilyina et al. (2009) estimated that ocean pH could fall by 0.6 by 2100, and sound absorption in the 100 Hz to 100 kHz band could decrease by 60 percent in high latitudes and deep-ocean waters over the same period. These authors further predicted that over the 21st Century, sound absorption in the 100 Hz to 100 kHz frequency band will decrease by almost half in regions of the world's oceans with significant anthropogenic noise, such as the North Atlantic Ocean.

However, underwater sound propagation is complex, and ocean pH is only one component affecting how sound propagates underwater. Since sound absorption is a relatively small factor in acoustic propagation at low frequencies, the impact of these changes in absorption (i.e., less than 1 dB) represent vanishingly small changes that likely would not be significant.

Ocean acidification is predicted to have a potentially more profound affect on the biological ambient noise environment. Rossi et al. (2016a) evaluated the potential for ocean acidification to alter the acoustic behavior of a marine animal that produces one of the loudest sounds in the ocean (up to 210 dB re 1 µPa @ 1 m), the snapping shrimp. In many coastal waters, the ambient noise environment is dominated by the sounds made by snapping shrimp. The results of the Rossi et al. (2016a) study indicate that when exposed to elevated CO_2 levels and the resulting more acidic water conditions, snapping shrimp reduced the sound level (including the SPL) and frequency of their snaps. In an associated study, Rossi et al. (2016b) found the altered biological ambient noise environment that lacked in biological sound production no longer attracted settlement-stage marine fish larvae. Where typically the ambient noise environment carried vital information that provided orientation and navigation clues to coastal species, attracting them to specific coastal habitats, these same larvae were no longer attracted to the coastal habitats (Rossi et al., 2016b).

3.4 Biological Resources

Biological resources include living, native, or naturalized plant and animal species and the habitats within which they occur. Habitat can be defined as the resources and conditions present in a specific area that support plants and animals. In the marine environment, only marine animals or wildlife and marine habitats may potentially be affected by the Navy's Proposed Action. Within this SEIS/SOEIS section, only those marine animals and their habitats potentially affected by SURTASS LFA sonar operations are discussed in detail.

3.4.1 Marine Species Selection Criteria

Since SURTASS LFA sonar systems operate in ocean environments, the potential exists for it to interact with marine or anadromous[9] species and their environments. Marine species have been screened to determine whether or not they may potentially be affected by LF sounds produced by SURTASS LFA sonar. Accordingly, to be evaluated for potential impacts in this SEIS/SOEIS, the marine species must: 1) occur within the same ocean region as the SURTASS LFA sonar operation, 2) possess some sensory mechanism to perceive LF sound, and/or 3) possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. Species that did not meet these criteria were excluded from further consideration.

Marine species must be able to hear LF sound and/or have some organ or tissue capable of changing sound energy into mechanical effects to be affected by LF sound. For there to be an effect by LF sound, the organ or tissue must have acoustic impedance different from water, where impedance is the product of density and sound speed. Since many organisms do not have an organ or tissue with acoustic impedance different from water, they would be unaffected, even if they were in areas ensonified by LF sound. These factors immediately limit the types of organisms that could be adversely affected by LF sound.

A marine species' potential to be affected by SURTASS LFA sonar has been discussed in detail in previous NEPA documentation (DoN, 2007, 2012, 2015, 2017a). Except as noted below, there have been no significant changes to the knowledge or understanding relating to the factors that may affect an organism's ability to sense LF sound, and the previous contents of the SURTASS LFA sonar documentation are incorporated herein by reference. The screening information is summarized and updated, as necessary, in the remainder of this section.

For clarity, the marine species that were considered for potential effects from exposure to SURTASS LFA sonar have been categorized into two groups: those not further considered and those further

9 Anadromous species are fishes that are born in freshwater but migrate to the ocean as juveniles, where they grow to adults before migrating back into freshwater to spawn. Examples of anadromous fishes are salmon, striped bass, and lamprey.

considered herein. What follows is a description of the factors considered for each biological group and the resulting conclusions that led to the group being eliminated or carried forward for further consideration.

3.4.2 Marine Species Not Further Considered

3.4.2.1 Marine Invertebrates

Marine invertebrates are a large and diverse group of marine animals that have no backbone. About 89 percent, or about 178,123 individual species, of marine animals are invertebrate species (World Register of Marine Species Editorial Board, 2018). Marine invertebrates include corals, cephalopods (e.g., squid, octopus) and other mollusks, crustaceans, sponges, and echinoderms and can range in size from the microscopic (e.g., copepods, which are 0.04 to 0.08 inches [*1 to 2 millimeters]*) to the macroscopic (e.g., giant squid that range to 39 ft [12 m]) (McClain et al., 2015; Walter and Boxshall, 2018).

Many marine invertebrates can be categorically eliminated from further consideration herein because: 1) they do not possess the requisite organs or tissues whose acoustic impedance is significantly different from water; and 2) they have high LF hearing thresholds in the frequency range used by SURTASS LFA sonar. For example, siphonophores and some other gelatinous zooplankton have air-filled bladders, but because of their size, they do not have a resonance frequency close to the low frequencies used by SURTASS LFA sonar. Some marine invertebrate species such as corals and abalones (with some species listed under the ESA) do not possess the tissues or auditory sensory organs necessary to detect LF sound.

The studies conducted on the sound perception ability of marine invertebrates indicate that they are exclusively sensitive to particle motion[10] (Mooney et al., 2010; Packard et al., 1990) in the LF range (<1 kHz). Marine invertebrates are generally thought to perceive sound via either external sensory hairs or internal statocysts[11]. Many aquatic invertebrates have ciliated "hair" cells that may be sensitive to water movements, such as those caused by currents or water particle motion very close to a sound source (Budelmann, 1992; Mackie and Singla, 2003). Budelmann and Williamson (1994) demonstrated that the hair cells in cephalopod statocysts are directionally sensitive in a way that is similar to the responses of hair cells on vertebrate vestibular and lateral line systems. The statocysts and hair cells may allow sensing of nearby prey or predators or assist in navigation. Detection of particle motion is thought to occur in mechanical receptors found on various body parts (Roberts et al., 2016). However, most invertebrate hearing studies have reported their findings in terms of SPL rather than particle motion, making their conclusions unsatisfactory in deducing anything about sound perception and the impacts of sound on aquatic invertebrates (Carroll et al., 2017; Popper and Hawkins, 2018). An important distinction between particle motion and sound pressure is that particle motion is directional, while sound pressure is not (it is a scalar quantity that acts in all directions) (Popper and Hawkins, 2018).

No hearing studies have been carried out on the larval stages of marine invertebrates (Kaplan and Mooney, 2016). Existing research indicates that free-swimming invertebrate and fish larvae may use acoustic cues produced by reef fish and crustaceans to orient themselves towards coral reefs. Some

10 Particle motion is the oscillation of water (or air) particles caused by the passage of sound through water. Water particles transmit their oscillatory motion to neighboring particles along the vector in which the underwater sound wave is moving through water. Particle motion is quantified using average displacement (m or dB re 1pm), velocity (m sec^{-} or dB re 1 nm sec^{-2}), and acceleration (m sec^{-2} or dB re 1 µm sec^{-2}) of the particles.

11 A statocyst is a sac-like sensory organ found in many invertebrate animals that is filled with fluid and lined with sensory hair cells.

species of coral larvae apparently are capable of detecting reef sounds, which then instigates an attraction response to the reef location; these corals use the detection of the reef sounds as a means of identifying favorable sites for settlement and development to adult life stages (Vermeij et al., 2010). More recently, Kaplan and Mooney (2016) reported that average coral reef sound levels are so low that they are likely only discernible from very close to a coral reef, although individual transient sounds were louder and likely could be detected further from the reef, depending upon the hearing abilities of the larvae. Adult coral's sensory capabilities appear to be largely limited to detecting water movement using receptors on their tentacles (Gochfeld, 2004). The lack of information on the ability of larval coral or other lifestages, including adults, to sense sound, and thus, potentially be affected by it, leads to the conclusion that sound generated by SURTASS LFA sonar would not affect coral species.

Although some mollusks appear capable of sensing water movement, next to nothing is known about their ability to sense underwater sound or to be affected by it. Non-cephalopod mollusks, such as the abalone, possess no air-filled cavities that would be associated with sensory structures, no information on receptor systems that might be involved in hearing is available, and sound production is rare in mollusk species (Budelmann, 1992). Like larval coral, larval oysters have also been shown to respond to the consistently higher mid-and high-frequency (1.5 to 20 kHz) sound levels produced on oyster reefs, resulting in the larvae being attracted to and settling on the oyster reefs (Lillis et al., 2013).

Among invertebrates, only cephalopods (octopus and squid) and decapods (lobsters, shrimps, and crabs) are known to be capable of sensing LF sound (Budelmann, 1994; Lovell et al., 2005; Mooney et al., 2010; Packard et al., 1990). Audiometric studies on adult invertebrates are also somewhat limited, but like most fish, those invertebrates tested (e.g., cephalopods and crustaceans) show lowest (i.e., most sensitive) thresholds below 1,000 Hz. Packard et al. (1990) showed that three species of cephalopods were sensitive to particle motion, not pressure, with the lowest thresholds of 2 to 3 x 10^{-3} meters per second squared (msec-^{2}) at 1 to 2 Hz. This type of hearing mechanism was confirmed by Mooney et al. (2010), who demonstrated that the statocyst of squid enables the animal to detect sound particle motion, for which a pressure threshold of 110 dB re 1 µPa at 200 Hz was measured. Mooney et al. (2016) reported on the results of a behavioral study that showed one species of squid possessed optimal hearing in the range from 200 to 400 Hz, with responses to 80 Hz. Additionally, behavioral responses to sound stimuli including escape and predator avoidance (inking, which occurred at the lowest sound frequencies and highest sound levels, body color changes, and jetting) (Mooney et al., 2016). Common cuttlefish respond behaviorally to sounds below 1000 Hz (maximum sensitivities near 150 Hz), with escape responses (inking, jetting) observed between 80 and 300 Hz, sound levels above 140 dB re 1 µPa (rms), and particle acceleration of 0.01 msec^{-2}; body pattern changes and fin movements were observed at exposures from 80 to 1000 Hz, SPLs of 85 to 188 dB re 1 µPa (rms), and particle accelerations of 0 to 17.1 msec^{-2} (Samson et al., 2014). Thresholds at higher frequencies have been reported, with a frequency of 1,000 Hz and levels of 134.4 dB re 1 µPa and 139.0 dB re 1 µPa for the oval squid and the octopus, respectively (Hu et al., 2009). However, Mooney et al. (2010) suggested that the measurement techniques of Hu et al. (2009) placed the animals close to the air-sea interface and introduced particle motion to which animals were responding rather than the pressure measurements reported.

Few scientific studies have detailed the sensitivity of crustaceans to underwater sound, especially to particle motion. Popper et al. (2001) reviewed behavioral, physiological, anatomical, and ecological aspects of sound and vibration detection by decapod crustaceans. Many decapods possess an array of hair-like receptors within and upon their body surface that potentially responds to water- or substrate-borne displacements as well as proprioceptive organs that could serve secondarily to perceive vibrations

(Popper et al., 2001), but the acoustic sensory systems of decapod crustaceans are under-studied. Both behavioral and auditory brainstem response (ABR) studies suggest that crustaceans may sense sounds up to 3 kHz but their greatest sensitivity is likely below 200 Hz (Goodall et al., 1990; Lovell et al., 2005 and 2006). Adult American lobsters showed an auditory evoked potential (AEP) response up to 5 kHz (Pye and Watson, 2004). One of the few studies to investigate thresholds of particle motion on invertebrates found that hermit crabs behaviorally respond at a threshold of 0.09 to 0.44 $msec^{-2}$ (rms) (Roberts et al., 2016). Radford et al. (2016) measured the AEP response of the New Zealand paddle crab, a decapod crustacean, to both SPL and particle motion, and contrary to expectations, the SPL hearing thresholds were more sensitive in the LF (100 to 200 Hz) and higher frequency (2 kHz) ranges than the thresholds measured by particle motion. Hearing measurements of particle motion taken after experimental manipulation (crushing) of the paddle crab's statocyst showed that crabs could not sense sound, while the hearing measured by SPL only showed partial hearing loss. These results suggested to Radford et al. (2016) that while the statocyst is the primary hearing organ in the paddle crab, an undiscovered pressure sensitive sensory system may also exist.

Given the relative dearth of information about invertebrate hearing sensitivity, knowledge of their sound production capabilities may amplify our understanding of their sound sensitivity. Popper and Schilt (2008) reported that some invertebrate species produce sound, possibly using it for communications, territorial behavior, predator deterrence, and mating. Sound production has been documented in more than 50 crustacean species, with decapod crustaceans being well studied and known to produce sounds over a wide frequency range (Edmonds et al., 2016). Well known biological sound producers include the spiny and American lobsters (Buscaino et al., 2011; Latha et al., 2005) and the mantis and snapping shrimp (Herberholz and Schmitz, 2001). Snapping shrimp are found worldwide and make up a significant portion of the ambient noise budget between 500 Hz and to 20 kHz (Au and Banks, 1998; Cato and Bell, 1992; Heberholz and Schmitz, 2001). Mantis shrimp produce very LF sounds in the 20 to 60 Hz range (Patek and Caldwell, 2006). Based on the sounds produced by some invertebrate species, some researchers have suggested sensitivity to higher frequency sounds. European spiny lobsters, some of which were exposed to predators, produced ultrasound signals up to about 75 kHz by moving a structure at the base of the antennae over a rigid file (Buscaino et al., 2011); the investigators speculated that the signals might have an anti-predator function or might be used in intraspecific communication. The results of another study suggest that European spiny lobsters likely use sound as an aggregation cue (frequency not specified, although lobsters in the study produced sounds of up to 30 kHz) (Filiciotto et al., 2014).

Little data or information exists on the effects of sound, particularly LF sound, on marine invertebrates. The available information is principally on the effects associated with exposure to LF seismic survey noise (Carroll et al., 2017; Hawkins et al., 2015). Marine invertebrates have experienced anatomical damage to their statocysts, loss and damage to hair cells, neuron swelling, and organ damage as the result of exposure to airgun and other seismic survey noise, with damage remaining up to one year following exposure (André et al., 2011; Carroll et al., 2017; Christian et al., 2003; Day et al., 2016; Solé et al., 2013). Exposure to seismic survey noise has not been shown to cause mortality in larval or adult marine invertebrates nor does evidence exist for population-level effects, such as reduced abundance or catch rates, on marine invertebrates resulting from exposure to seismic survey noise (Carroll et al., 2017). Nedelec et al. (2014) investigated the effect repeated exposure to outboard boat noise had on sea hare (marine mollusk) development. The development of sea hare embryos and mortality of recently hatched sea hare larvae exposed to boat noise playback in the 10 to 3000 Hz range during controlled field experiments was reduced by 21 percent and increased 22 percent, respectively, compared to ambient noise exposure (Nedelec et al., 2014).

Although marine invertebrates would certainly be present in the proposed study area of SURTASS LFA sonar and many species of marine invertebrates are capable of sensing LF sound via localized particle motion, no information exists on how exposure to underwater sound such as LFA sonar may effect marine invertebrates. Neither do metrics nor exposure thresholds exist to enable quantification or assessment of noise impacts on marine invertebrates. Given this lack of a scientific basis upon which to assess impacts on marine invertebrates associated with exposure to SURTASS LFA sonar, no impact assessment on this marine taxa is feasible. However, based on the limited data on how seismic survey noise, which is not similar to LFA sonar acoustically, effects marine invertebrates, no mortality of marine invertebrates is reasonably expected to occur from exposure to LFA sonar nor are population level effects likely. Thus, marine invertebrates, including the potentially occurring species of ESA-listed coral and proposed cephalopod (chambered nautilus) that may occur in the study area for SURTASS LFA sonar are not further considered herein.

3.4.2.2 Seabirds

Seabirds or marine birds are a diverse group that are adapted to living and foraging in the marine environment. As a group, seabirds are distinguished from terrestrial bird species by typically having a longer life span, breeding later, and producing fewer offspring. Seabirds spend time ashore each year, usually during summer, to nest and rear their hatchlings, with many species spending considerable time wholly at sea (Schreiber and Chovan, 1986). Many seabirds are highly migratory, traveling vast distances, with some species migrating across entire ocean basins. Arctic terns, for instance, have the longest recorded migration of any animal, traveling more than 43,200 nmi (80,000 km) annually between breeding and foraging grounds (Voter and Sherley, 2017). The more than 350 species of seabirds that exist globally are classified in nine taxonomic orders, with seabirds from all but one of these orders potentially occurring in the study area for SURTASS LFA sonar (Voter and Sherley, 2017). Seabirds may be found in all parts of the study area, from coastal, nearshore waters to the pelagic, open-ocean waters far from land. However, given the limitations on SURTASS LFA sonar transmissions in the coastal standoff zone surrounding any emergent land and ship operations that typically only entail transit through nearshore waters, the likelihood of SURTASS LFA sonar activities affecting coastal or nearshore seabirds is vanishingly low. The likely potential only reasonably exists for oceanic seabirds to even be exposed to SURTASS LFA sonar activities. Additionally, SURTASS LFA sonar vessels do not entail the deployment or use of any airborne sensors or equipment, so no impacts to flying seabirds are reasonably anticipated.

The potential for seabirds to be exposed to and potentially be affected by SURTASS LFA sonar depends on several factors, including the spatial distribution of foraging habitat in relation to LFA sonar operations, species-specific foraging strategies, and the ability to hear SURTASS LFA sonar transmissions underwater. Since seabirds forage underwater, their foraging strategies and ability to locate prey underwater may be facilitated by their ability to hear underwater sounds.

Seabird foraging behavior primarily involves taking prey within two feet (half a meter) of the sea surface (Ballance et al., 2001). Seabird foraging may be by plunge-diving, aerial-dipping, surface-dipping, surface-plunging, jump-plunging, surface-pecking, pursuit-diving, or scavenging. Most seabirds plunge-dive from the air into the ocean to capture prey, while others perform aerial dipping, which is the act of capturing food from the sea surface while the bird is in flight. Still other seabirds forage by surface-dipping, where they swim on the sea surface and dip below to capture prey near the sea surface; or surface-pecking, where the bird pecks at the water's surface with its beak; or by jump-plunging, which involves jumping upward from the ocean surface to then diving beneath the water surface to capture their prey. Pursuit-divers typically take their prey within 66 to 328 ft (20 to 100 m) of the sea surface after swimming after their prey, propelled either by their wings or feet underwater (Ballance et al, 2001). The deepest depth to which any pursuit-diver has been recorded was an Emperor penguin that dove to a depth of 1,755 ft (535 m) (Kooyman and Kooyman, 1995). Scavenging involves birds consuming dead floating prey on the sea surface. Plunge-diving seabirds such as gannets, boobies, tropicbirds, and brown pelicans are typically submerged for no more than a few seconds when foraging. Pursuit-divers, including penguins, auks, petrels, cormorants, grebes, and loons, swim/dive deeper and stay underwater longer than plunge-divers. Most pursuit-divers stay submerged for several minutes (Ronconi et al., 2010), with Sato et al. (2002) measuring typical mean dive durations up to 7.6 minutes, while Kooyman and Kooyman (1995) measured a maximum duration for diving penguins of 15.8 minutes. It appears that none of these foraging behaviors appear to require the use of underwater sound.

Few data on seabird hearing exist, especially on their underwater hearing ability. Hearing has been measured in only 10 seabird species, the majority of which are sea and diving ducks (Crowell, 2016). Further, little research or published scientific literature exists on the hearing abilities of birds underwater or on the manner in which birds may use sound underwater (Dooling and Therrien, 2012). Additionally, the mechanism(s) by which seabirds might sense underwater sound is unknown. Dooling and Therrien (2012) have speculated that diving birds may not hear as well underwater based on adaptations to protect their ears from pressure changes. Seabirds possess fat columns that connect with the tympanic membrane, suggesting soft tissue analogs to pinnae for channeling sound to the inner ear (Ketten, 2013). Until recently, hearing capabilities have been studied for only a few seabirds (Thiessen, 1958; Wever et al., 1969), and those studies indicated that seabird hearing ranges and sensitivity are consistent with what is known about bird hearing, with greatest hearing sensitivity between 1 and 4 kHz (Beason, 2004; Beuter et al., 1986; Dooling, 2002). Very few birds can hear below 20 Hz and most birds have an upper hearing limit of 10 kHz; no birds have exhibited hearing sensitivity at frequencies higher than 15 kHz (Dooling, 2002; Dooling & Popper, 2000). Wever et al. (1969) measured the hearing sensitivity of the black-footed penguin, a pursuit-diver, using cochlear potentials and reported the best hearing sensitivity to be between 600 Hz and 4 kHz.

Recently, the in-air hearing ability of ten diving bird species was measured with ABR technologies, revealing that all species tested had greatest sensitivity between 1 and 3 kHz, which matched the vocalization range of the species tested (Crowell et al., 2015). Therrien et al. (2012) also tested the hearing in six species of diving and sea ducks and reported the best range of hearing in all six species as between 1 and 4 kHz and the peak in hearing sensitivity at 1.5 to 3 kHz. Crowell et al. (2016) used behavioral methods to derive an in-air audiogram of an aquatic duck and reported best hearing sensitivity at 2.86 kHz and a threshold of 14 dB re 20 µPa. Recently several studies have investigated the hearing capabilities of the great cormorant, a diving seabird. Using psychophysical (behavioral) and ABR methods, Maxwell et al. (2016 and 2017) reported the greatest in-air hearing sensitivity of the great cormorant was observed at 2 kHz with a hearing threshold of 18 dB re 20 µPa (rms) measured by ABR, with the threshold derived from psychophysical methods 23 to 53 dB higher than the ABR threshold. Johansen et al. (2016) also measured the in-air and in-water hearing of the great cormorant using psychophysical and ABR methods and reported that the cormorant could hear both in the air and underwater, and measured the same frequency of hearing sensitivity 2 kHz, for both air and underwater with hearing thresholds of 45 dB re 20 µPa (rms) in-air and 79 dB re 1 µPa (rms) in-water. In related experiments using psychophysical (behavioral) methods, Hansen et al. (2017) reported greatest underwater hearing sensitivity also at 2 kHz but a slightly different hearing threshold of 71 dB re 1 µPa (rms). The great cormorant's audiogram derived from both psychophysical and ABR methods was the typical U-shaped curve (Johansen et al., 2016). Although diving birds are able to hear underwater, their underwater hearing acuity is not as high as other aquatic, non-avian species, likely based on adaptations to protect their ears from pressure changes (Dooling & Therrien, 2012). Adaptations for diving may have evolved to protect in-air hearing ability and may contribute to reduced sensitivity underwater.

The known hearing range of seabird species is above the frequency range at which SURTASS LFA sonar transmits, and it is unknown, based on the available scientific information on seabird underwater hearing abilities, if diving seabirds can even hear, let alone be effected by LFA sonar transmissions. Diving seabird species have the greatest potential for exposure to SURTASS LFA sonar transmissions, since they remain submerged underwater longer and at greater depths than surface feeding species. Pursuit-diving seabirds, such as cormorants, murres, boobies, auklets, puffins, petrels, murrelets, and shearwaters would be the most likely species to potentially be exposed to SURTASS LFA sonar transmissions when foraging underwater.

No data are available on physiological effects to bird ear structures or behavioral responses due to underwater acoustic exposures. In general, birds are less susceptible to both permanent threshold shift (PTS) and temporary threshold shift (TTS[12]) than mammals (Saunders and Dooling, 1974), so an underwater sound exposure would have to be intense and of a sufficient duration to cause either PTS or TTS. A bird has the ability to avoid an intense sound by returning to the sea surface, thereby limiting the exposure duration to underwater sound. Additionally, birds have the ability to regenerate hair cells in the ear, usually resulting in considerable anatomical, physiological, and behavioral recovery within several weeks (Saunders and Dooling, 1974). Still, recovery from intense exposures is not always achievable, even over periods up to a year after exposure, and damage and subsequent recovery vary significantly by species (Ryals et al., 1999). Birds may be able to protect themselves against damage from sustained noise exposures by regulating inner ear pressure, an ability that may protect ears while in flight (Ryals et al., 1999). Some of the only data on the behavioral responses of seabirds to underwater sound is that of the effect of fishing gear pingers. Some seabird species, such as common murres, appear to respond with avoidance when exposed to the noise of 1.5 kHz-pingers (SL of 120 dB re 1 µPa rms) affixed to gillnets, although the pinger noise appeared to have no effect on rhinoceros auklets, which became entangled in the fishing gear at the same rate as pinger-less nets (Melvin et al., 1999 and 2011).

Thresholds have only been estimated for a limited number of seabirds (USFWS, 2016), but not for the species of seabirds that may occur in the potential study area for SURTASS LFA sonar. However, given that the few data on underwater hearing in seabirds indicates best sensitivities at 2 kHz (Hansen et al. 2017; Johansen et al., 2016), which is considerably above the 100 to 500 Hz frequency range of SURTASS LFA sonar, very little potential exists for most diving seabirds to experience auditory impacts from exposure to LFA sonar transmissions. USFWS (2016) estimated injury thresholds for seabirds exposed to various types of sonar in the Navy's Northwest Testing and Training Area. USFWS determined a

12 Permanent threshold shift (PTS) is a severe condition and auditory injury that occurs when sound intensity is very high or of such long duration that the result is permanent hearing loss and irreparable damage (Southall et al., 2007). Temporary threshold shift (TTS) is a lesser impact to hearing caused by underwater sounds of sufficient loudness to cause a transient hearing impairment for a period of time. With TTS, hearing is not permanently or irrevocably damaged, so TTS is not considered an injury.

threshold of 220 dB SEL re 1 µPa^2-sec referenced to the frequencies of best hearing between 1 to 5 kHz, but no injury was estimated for sonar sources such as SURTASS LFA sonar.

It is highly unlikely that a seabird would experience a behavioral response given several factors. There are currently only four SURTASS LFA sonar vessels and sonar systems, with the potential for new or replacement vessels in year 5 and beyond; activities occur over a vast potential study area; and LFA sonar transmits at a very low duty cycle. It is likely that the physical presence of a SURTASS LFA sonar vessel and its slow speed when towing the LFA sonar array would alert any seabird in the area, so that it would be very unlikely that birds would forage in the ship's vicinity. Also, the V-shaped hull and encased propeller system of the T-AGOS vessels in addition with their low travel speed during training and testing activities makes the likelihood of a vessel strike of seabird at or near the sea surface to be so vanishingly low to be negligible. If a seabird were to dive near the vessel, the LFA sonar would have to be transmitting to potentially affect the bird, which it only does up to a 20 percent maximum (but more typically, 7.5 to 10 percent), and the bird would need to dive deep enough to encounter the LFA sonar sound field. Given these factors, the potential for a behavioral response is vanishingly small. There are no data that indicate whether seabirds use sound underwater and thus have the potential to experience masking. While studies of stress responses in seabirds related to foraging have been conducted (Paredes et al., 2015), no exposure studies have been conducted to determine the potential for a stress response from exposure to underwater sound. Without sufficient information, it is impossible to determine the potential for masking or physiological stress from exposure of seabirds to LFA sonar. However, as stated earlier, given the foraging strategies of seabirds and the operational profile of LFA sonar, seabirds are very unlikely to be in proximity to transmitting LFA sonar, resulting in a very limited potential for masking or a stress response to occur.

Although seabirds possess auditory organs and may be capable of hearing LFA sonar transmissions, their known in-air and underwater hearing sensitivity is in the 1 to 4 kHz range, which is above the transmission frequencies of SURTASS LFA sonar. Given the paucity of data on underwater hearing sensitivities of seabirds, how seabirds use underwater sound, and the responses of seabirds to sound exposures, it is impossible to precisely determine if SURTASS LFA sonar transmissions have the potential to affect seabirds. The underwater hearing sensitivity of seabirds combined with the low likelihood of seabirds being underwater and near the SURTASS LFA sonar source while it is transmitting together are indicative of the highly unlikely potential for biologically meaningful responses by seabirds to occur from exposure to LFA sonar or for the potential for fitness level consequences. Therefore, seabirds, including those species listed under the ESA and MBTA, have been excluded from further evaluation in this SEIS/SOEIS.

3.4.2.3 Sea Snakes

Sea snakes are wholly or partially aquatic reptiles that primarily inhabit coastal areas in subtropical to tropical oceans, notably the Indian Ocean and western Pacific Ocean (Young, 2003). Sea snakes lack gills and must surface to breathe, typically diving to water depths no deeper than 328 ft (100 m) (Heatwole, 1999), and staying submerged for about 30 minutes, although some species can stay submerged for up to 1.5 to 2.5 hours (Heatwole and Seymour, 1975).

All but one of the nearly 60 species of sea snakes potentially occur in the shallow waters of the study area for SURTASS LFA sonar. As many as 32 species of sea snakes occur in the waters of northern Australia alone (Marine Education Society of Australasia, 2015), one of which, the dusky sea snake (*Aipysurus fuscus)*, is listed under the ESA as endangered.

The dusky sea snake occurs in water depths less than 33 ft (10 m) amongst the corals and sand substrate of isolated, inner coral reef lagoons off northwestern Australia in the Ashmore Reef area (Timor Sea) and off Papua New Guinea in the Celebes Islands (Celebes Sea) (McCosker, 1975; Australian Government, 2016). Little is known about the population status of the venomous, benthic dusky sea snake, as no current or historical population data exist, but local surveys of some Australian reefs indicate severe population declines. Sea snakes typically have patchy distributions and can be found in very dense aggregations in certain locations within their ranges (Heatwole, 1997).

Although sea snakes possess no external ear and lack many of the interior auditory components that facilitate hearing, sea snakes do possess sensory organs or tissues that allow them to perceive underwater sound via vibration. Snakes possess an inner ear with a functional cochlea that is connected to their jawbones by a middle ear bone, through which they may perceive vibrational information (Friedl et al., 2008). Christensen et al. (2012) conducted experiments on a terrestrial python species to determine if they detected sound pressure or sound-induced mechanical vibrations through their body. Their experimental results suggested to Christensen et al. (2012) that snakes lost hearing sensitivity to sound pressure when their outer and middle ears were completely reduced so that they now are primarily capable of detecting and responding to sound-induced, low-level vibrations, with greatest sensitivity below 400 Hz. Researchers have speculated that sea snake's inner ear may receive sound signals in water via their lungs, which may function similarly to swim bladders in fish. Westhoff et al. (2005) recorded ABRs to underwater vibrations and demonstrated that sea snakes are sensitive to low-amplitude water motion, although the sensitivity was comparatively low (low-amplitude water displacement from 100 to 150 Hz), it may be sufficient to detect movements of prey such as fish. Sea snakes also rely on their other sensory capabilities in place of hearing, with the turtle-headed sea snake, for instance, relying primarily on scent for chemical cueing of prey (Shine et al., 2004).

Research on hearing ability in snakes is limited, particularly for sea snakes. Additionally, a great deal of variability exists in the reported hearing sensitivity of terrestrial snakes and conclusions regarding snake hearing ability are not clear, particularly as earlier research measured responses to SPL rather than vibration. Based on cochlear potential data from 19 snake species, the best hearing of snakes was estimated in the range of 100 to 500 Hz with absolute sensitivity of most species ranging from 25 to 55 dB SPL (30 to 50 dB re 20 µPa at approximately 200 Hz) (Christiansen et al., 2012; Dooling et al., 2000). Midbrain AEP data showed the same absolute sensitivity, but reported a much narrower frequency range in hearing sensitivity for several snake species, with the AEP sensitivity range of 150 to 450 Hz for one species versus 60 to 600 Hz measured by cochlear potential (Hartline 1971; Hartline and Campbell, 1969). Current scholarship suggests that snakes hear optimally in-air between 80 and 600 Hz, with some species hearing sounds up to 1,000 Hz. Christensen et al. (2012) noted that pythons had a flat audiogram with a best sensitivity of 78 dB re 20 µPa at 160 Hz, which was close to that measured for the rattlesnake. Young (2003) extrapolated from terrestrial snake data and corrected for water to derive a high hearing threshold for the sea snake in water of approximately 100 dB. Recently in a project funded by the Australia and Pacific Science Foundation, a team of Australian researchers measured the AEP of one sea snake species to determine their underwater hearing abilities. The resulting unpublished audiograms of the Stokes' sea snake showed a limited frequency range of about 40 to 1000 Hz, peaking at 60 Hz (Australia and Pacific Science Foundation, 2017). No information is available on the vocalization ability of sea snakes.

Sea snakes are predominately shallow diving, occur in very low densities, and typically inhabit coastal waters in which LFA sonar would not be transmitted above the 180 dB SPL level. It is, thus, unlikely that sea snakes would be exposed to LFA sonar transmissions at all and not at a sound intensity that would adversely affect them. Although sea snakes may be able to detect some component of LFA sonar transmissions, no information is available on how exposure to LF sonar or other anthropogenic sound sources affects sea snakes. Based on the dearth of information on the hearing ability and effects of underwater sound on sea snakes as well as the nearshore occurrence of sea snakes, the Navy has concluded that an impact assessment of sea snakes is not currently feasible. Further, given their extremely low sensitivity to sound pressure, if exposed to LFA sonar transmissions, sea snakes are highly unlikely to be subject to behavioral reactions and the risk of injury is so vanishingly small as to be discountable. For these reasons, sea snakes are eliminated from further consideration herein.

3.4.3 Marine Species Further Considered

Three marine taxa are further considered herein for potential impacts associated with SURTASS LFA sonar activities. These taxa include marine and anadromous fish, marine mammal, and sea turtle species that may occur in the study area for SURTASS LFA sonar in the western and central North Pacific and Indian oceans.

3.4.3.1 Marine and Anadromous Fish

The study area for SURTASS LFA sonar spans two ocean basins and encompasses a wide variety of marine habitats. Although about 78 percent of marine fish species occur in coastal or inshore waters less than 656 ft (200 m) deep, the remainder are found in the open ocean waters in which SURTASS LFA sonar is most likely to be used (Moyle and Cech, 2004). Even considering this smaller percentage of open ocean species that may be exposed to SURTASS LFA sonar activities results in thousands of potentially occurring marine fish species and multiple life stages of each species. Additionally, many highly migratory fish species may move into and out of the study area for SURTASS LFA sonar either annually or seasonally. Given this vast and highly variable number of possible fish species in the study area, it is not feasible to describe and discuss the potentially occurring marine fish species individually, as is done for the other two taxa further considered, sea turtles and marine mammals. By comparison, a total of 55 species represent the potentially occurring marine mammal and sea turtle species in the study area for SURTASS LFA sonar.

Fish are able to detect underwater sound, although there is remarkable variation in hearing capabilities amongst fish species. In general, however, most all fish that are known to detect sound can at least hear frequencies from below 50 Hz upwards to 800 Hz, while many fish can detect sounds to approximately 1 kHz and still other can detect sounds to about 2 kHz. Thus, many species of marine fish could potentially hear SURTASS LFA sonar transmissions. Of the estimated 33,700 living species of fish (Froese and Pauly, 2017), of which roughly 18,765 are marine species (WoRMS Editorial Board, 2018), hearing and sound production has only been studied in a very small percentage of species.

Marine fish can be categorized and assessed in many ways, either taxonomically, anatomically, ecologically, migrationally, commercially, or behaviorally. One of the key features in determining the impact that underwater sound may have on fishes is their anatomy, specifically the presence or absence of a gas or swim bladder[13]. Fishes that possess a swim bladder that is involved in hearing are most sensitive to underwater sound since they are able to detect particle motion and sound pressure. Fish species that possess swim bladders are more susceptible to sound pressure and barotrauma injuries to their ears and other body tissues than are fishes without swim bladders (Carlson, 2012; Halvorsen et al.,

13 A gas or swim bladder is an internal gas-filled organ in most bony (teleost) fishes that functions in storing oxygen, controlling buoyancy, maintaining hydrostatic position, and producing sound (Mohr et al., 2017).

2011; Stephenson et al., 2010). Possessing a swim bladder may also increase many fishes' ability to detect sounds over a broad range of frequencies and from greater distances (Popper et al., 2014). Thus, to the extent possible, information about marine and anadromous fishes in this SEIS/SOEIS is described from the basis of the presence or absence of a swim bladder and the associated affect on hearing and acoustic impacts.

With thousands of potentially occurring marine and anadromous fishes in the study area for SURTASS LFA sonar, it would be impossible to consider all species that may be affected by SURTASS LFA sonar activities. For this reason, descriptive species information is presented only for those marine and anadromous fish species or distinct population segments (DPSs)[14] of fish species listed under the ESA. However, some of the ESA-listed fish species that occur in the western Pacific or Indian oceans do not meet the criteria for co-occurrence with SURTASS LFA sonar activities. These fishes occur in inland, inshore, or very shallow[15] coastal waters where SURTASS LFA sonar would not operate and where fishes would be protected by the coastal-standoff-range mitigation measure for SURTASS LFA sonar. The ESA-listed marine and anadromous fish species that are excluded from further consideration on this basis are:

- Chinese sturgeon (*Acipenser sinensis*)—this anadromous sturgeon is listed for the Yangtze River basin, where it occurs only in the middle and lower Yangtze River and very close to shore in the East China and Yellow seas (NOAA, 2013).
- Dwarf Sawfish *(Pristis clavata)—is* restricted to shallow (< 33 ft [10 m]) tropical coastal, estuarine, and riverine waters of the western-central Pacific and Eastern Indian oceans, but the population is considered to now be limited to waters of northern and northwestern Australia and is likely extinct in the waters of Papua New Guinea and Indonesia; no records of occurrence in offshore waters have been substantiated (Kyne et al., 2013; NOAA, 2014a).
- Green sawfish (*Pristis zijsron*)—as a species, this sawfish is listed as endangered and is distributed in inshore estuarine and riverine habitats in waters typically no more than 16 ft (5 m) in the Indo-West Pacific, although the green sawfish is considered very rare in the Indian Ocean and may be extirpated from most of its historic range (NOAA, 2014a).
- Kaluga sturgeon *(Huso dauricus)*—this endangered fish only now occurs in the lower reaches of the Amur River in Russia and China (NOAA, 2013).
- Largetooth sawfish (*Pristis pristis*)—is an endangered species that occurs in shallow (<33 ft [10 m]) coastal, inshore, and river habitats of the Indo-Pacific and western Atlantic oceans, although currently this sawfish occurs only in isolated and often remote, very small populations throughout its historic range (NOAA, 2014a).
- Narrow sawfish (*Anoxypristis cuspidata*)—listed as endangered throughout its range, the narrow sawfish's distribution is restricted to shallow (130 ft [40 m]), inshore habitats with salinities between 25 and 35 practical salinity units (psu) in the western Pacific and Indian oceans, with a preference for muddy estuarine benthic habitats (NOAA, 2014a).

14 Under the ESA, a DPS is a vertebrate population or group of populations of a species that is discrete from other populations and is significant to the entire species.

15 Generally, SURTASS LFA sonar activities are conducted in waters deeper than 656 ft (200 m) in which potential objects of surveillance would be most likely to occur. However, testing and training activities using the CLFA source array and TL-29A receive array could be conducted in shallower water, depending upon the circumstances.

The remaining nine ESA-listed marine and anadromous fish species that potentially occur in the study area for SURTASS LFA sonar are considered herein. No marine or anadromous fish species with potential occurrence in the study area for SURTASS LFA sonar are currently proposed for listing under the ESA.

3.4.3.1.1 Fish Physiology, Hearing, and Sound Production

In previous documentation for SURTASS LFA sonar, detailed information on the hearing anatomy and measured hearing capabilities of fish was presented (DoN, 2007, 2012, 2017a). Since this SEIS/SOEIS builds upon that foundational information, only a basic overview of fish hearing and capabilities are presented here, in addition to any recent scientific advances in fish physiology and hearing.

Of the 100 or more fish species for which hearing has been studied, all are able to detect sound underwater. However, compared to the entirety of the fish taxa, this represents only a very small number of species that have been studied. It is apparent that many bony (teleost) fish, but apparently no elasmobranchs (sharks and rays), are capable of producing vocalizations and using these sounds in various behaviors. Hearing and sound production are documented in well over 240 fish species, encompassing at least 58 families and 19 orders, although it is likely that with additional study, many more fish species will be found to produce sounds.

Fish have two sensory systems that together allow them to detect sound underwater: inner ears and a lateral line system (Higgs and Radford, 2013). A fundamental component of both sensory systems is the highly-specialized sensory hair cell, by which mechanical energy (sound and motion) is converted to electrical signals. The ear and lateral line system send these electrical signals to the fish's brain along separate pathways, however.

All fish species have ears that can detect sound and convey information about gravity and particle motion (Popper et al., 2014). The fish inner ear is located in the head just behind the eye, and unlike terrestrial vertebrates, the inner ear of fish is not connected to an external opening in the head. The principal ear structures that function in fish hearing are three semicircular canals and otolith organs (Ladich and Popper, 2004; Schellart and Popper, 1992). The sensory regions of the semicircular canals and otolith organs contain many sensory hair cells. It is the relative motion between the otolith and the sensory hair cells that ultimately results in responses to sound or body motion. The precise size and shape of the ear varies amongst fish species (Popper and Coombs, 1982; Popper and Schilt, 2008; Popper et al., 2003). This variability in the inner ear morphology and hearing structures amongst fish species has resulted in wide diversity in hearing sensitivities, sometimes even in members of the same taxonomic family of fishes (Ladich and Schulz-Mirbach, 2016).

The lateral line system of fish consists of a series of receptors along the length of a fish's body that are sensitive to external particle motion from sources within a few body lengths of the animal (Popper and Schilt, 2008). By comparing the responses of different hair cells along the lateral line, fish are likely able to locate the source of vibrations (Coombs and Montgomery, 1999; Montgomery et al., 1995; Webb et al., 2008). The sensory hair cells along the lateral line system detect particle motion at frequencies from below 1 to about 400 Hz (Coombs and Montgomery, 1999; Hastings and Popper, 2005; Higgs and Radford, 2013; Webb et al., 2008).

The ear and the lateral line overlap in the frequency range to which they respond. The lateral line appears to be most responsive to signals ranging from below 1 to about 150 to 200 Hz (Coombs et al., 1992; Webb et al., 2008), while the ear responds to frequencies from about 20 Hz to several thousand

Hz in some species (Popper and Fay, 1993; Popper and Schilt, 2008; Popper et al., 2003). The specific frequency response characteristics of the ear and lateral line system varies amongst fish species.

Hearing in many fish is improved by their ability to detect sound pressure via a gas or swim bladder (or other gas-filled structures) that re-radiates energy in the form of particle motion to the auditory organs of the ears. Fish species without a swim bladder detect little of the pressure component of sound (Popper and Fay, 1993). Being able to detect sound pressure as well as particle motion not only increases hearing sensitivity but also broadens the frequency bandwidth of hearing (Fletcher and Crawford, 2001; Sand and Hawkins, 1973). Hearing sensitivity is further amplified by the proximity of the swim bladder or gas bubbles to the inner ear or connections between the swim bladder and inner ear, which appear to enable higher-frequency hearing and better detection of sound pressure.

Fishes can be categorized by possession of similar anatomical features that affect their hearing capabilities and sensitivity (Popper and Fay, 2011). The categories of fishes include (Popper et al., 2014):

- Fishes with no swim bladder or other gas chamber (e.g., some flatfish, some tuna, sculpins, and elasmobranchs)—hearing is limited to particle motion detection frequencies well below 1 kHz;
- Fishes with swim bladders that is not involved in hearing (e.g., salmonids, such as steelhead trout and Pacific salmon, and sturgeons)—these species lack the anatomical hearing specializations and principally detect particle motion below 1 kHz;
- Fishes with a swim bladder or gas chamber that is involved in hearing (e.g., catfish, carp, sardines, and anchovies)—these fishes detect frequencies below 1 kHz, possess anatomical specializations to enhance hearing, and can detect sound pressure up to a few kHz;
- Fishes with a swim bladder and high-frequency hearing (e.g., Atlantic cod)—species can detect frequencies below 1 kHz and possess anatomical specializations and are capable of sound pressure detection at frequencies from to 10 to over 100 kHz, and possibly as high as 180 kHz (DoN, 2017b; Ladich and Fay, 2013).

Sensitivity to sound in most fish species occurs from below 100 Hz to several hundred hertz or several thousand hertz in a few species (Mann et al., 1997 and 2001). For those fish species for which hearing has been measured, greatest hearing sensitivity generally occurs in the range from 100 to 200 Hz and up to 800 Hz (Popper, 2003). Some member of one type of marine fishes (clupeiforms) with a swim bladder involved in hearing are able to detect sounds to about 4 kHz (Colleye et al., 2016; Mann et al., 1997 and 2001), with one subfamily in this taxa apparently able to detect very HF sounds, although their best hearing is still <1 kHz. Evidence suggests that at least some fish species can detect infrasound, typically defined as sounds below ~30 Hz. Infrasound hearing has been demonstrated in Atlantic salmon, Atlantic cod, plaice, Atlantic eel, and a perch (Karlsen, 1992a and 1992b; Knudsen et al., 1992; Sand and Karlsen, 1986; Sand et al., 2000). In all cases studied so far, however, detection in this frequency range only seems to occur when the fish is within a few body lengths of the sound source and not when the fish are further away.

The ability of fish to process complex soundscapes is also being better defined. Fay (2009) reviewed the literature on directional hearing abilities in fish. A number of species have been shown to be able to discriminate and orient to different sound sources. All fish are capable of detecting particle motion, and recent studies have shown that plainfin midshipmen fish follow the path of particle motion, not pressure, when orienting to and approaching sound sources (Zeddies et al., 2012). Possessing directional hearing in mammals helps reduce the effects of noise on signal detection ability, and presumably does so in fish as well. Likewise, the ability to differentiate between two sound signals that are presented simultaneously has been demonstrated in goldfish (Fay, 2009). These demonstrated abilities suggest that fish are capable of analyzing acoustic soundscapes, as has been shown in mammals, birds, and insects. This directional hearing ability also offers at least some fish to mitigate masking effects. As reviewed in Sisneros and Rogers (2016), fish were able to lower their masking levels when sources were separated by 20° and 85°, with this directional hearing providing them the ability to spatially filter sound to increase their signal detection ability.

Many species of fish produce sounds, with Myrberg (1981) reporting more than 50 fish families produce some kind of sound using special muscles or other structures that have evolved for this role, or by grinding teeth, rasping spines and fin rays, burping, expelling gas, or gulping air. Sounds are often produced by fish when they are alarmed or presented with harmful stimuli (Bass and Ladich, 2008; Myrberg, 1981; Zelick et al., 1999), but few species of fish produce sounds for purely social communication (Parmentier and Fine, 2016). Some of the sounds fish produce may involve the use of the swim bladder as an underwater resonator. Sounds produced by vibrating the swim bladder may be at a higher frequency (400 Hz) than the sounds produced by other moving body parts. The swim bladder drumming muscles are correspondingly specialized for rapid contractions (Bass and Ladich, 2008; Zelick et al., 1999). Sounds are used in reproductive behavior by a number of fish species, and the current data lead to the suggestion that males are the most active sound producers. Sound activity often accompanies aggressive behavior in fish, usually peaking during the reproductive season. Those benthic fish species that are territorial in nature often produce sounds regardless of season but particularly during periods of high-level aggression (Myrberg, 1981).

3.4.3.1.2 Threatened and Endangered Marine and Anadromous Fish Species

Nine species of marine and anadromous fishes listed under the ESA may occur in the study area for SURTASS LFA sonar (Table 3-1). Anadromous fish species, such as salmon, are born in fresh water, migrate to the ocean where they grow into adults, after which they return to the fresh water streams or lakes of their birth to spawn; most Pacific salmon species die after spawning. Populations of many ESA-listed fish species have been delineated into DPSs or evolutionarily significant units (ESU). *Brief descriptions are included here of each listed or proposed fish species', DPSs, or ESU's distribution, habitat, population, and hearing or sound producing capabilities.*

➢ ***ESA-listed Fishes with No Swim Bladder or Gas Chamber***

Since none of the three ESA-listed species of elasmobranchs potentially occurring in the study area for SURTASS LFA sonar (oceanic whitetip shark, scalloped hammerhead shark, and giant manta ray) possess swim bladders, their hearing sensitivity is limited to the detection of particle motion.

- *Oceanic Whitetip Shark (Carcharhinus longimanus)*

Effective March 1, 2018, as a species, the oceanic whitetip shark has been listed as threatened under the ESA (NOAA, 2018a). No critical habitat for the species has been designated, as NMFS determined that it was not currently determinable (NOAA, 2018a). The oceanic whitetip shark is listed as vulnerable on the IUCN Red List (Baum et al., 2015).

The oceanic whitetip shark was historically considered to be the most globally abundant and common pelagic shark in tropical waters. Although no global abundance exists for this shark, the available data and information suggest that overall this species has undergone a population decline that varies in

Table 3-1. Status under the ESA of the Marine and Anadromous Fish Species Listed Under the ESA that Potentially Occur in the Study Area for SURTASS LFA Sonar and that are Evaluated in this SEIS/SOEIS for Potential Impacts Associated with Exposure to SURTASS LFA Sonar.

Family	*Fish Species*	*ESA Status*	
		Threatened	***Endangered***
Carcharhinidae	Oceanic whitetip shark (*Carcharhinus longimanus)*	Throughout Its Range	
Mobulidae	Giant Manta Ray (*Manta birostris*)	Throughout Its Range	
Sphyrnidae	Scalloped hammerhead shark (*Sphyrna lewini)*	Indo-West Pacific DPS	
Acipenseridae	Sakhalin sturgeon (*Acipenser mikadoi)*	Throughout Its Range	
Salmonidae	Chinook salmon (*Oncorhynchus tshawytscha*)	Puget Sound ESU	Upper Columbia River Spring-run ESU
		California Coastal ESU	Sacramento River Winter-run ESU
		Upper Willamette River ESU	
		Central Valley Spring-run ESU	
		Snake River Fall-run ESU	
		Lower Columbia River ESU	
		Snake River Spring/Summer-run ESU	
	Chum salmon (*Oncorhynchus keta)*	Columbia River ESU	
		Hood Canal Summer-run ESU	
	Coho salmon (*Oncorhynchus kisutch)*	Lower Columbia River ESU	Central California Coast Coho ESU
		Oregon Coast ESU	
		Southern Oregon/Northern California Coasts ESU	
	Sockeye salmon (*Oncorhynchus nerka)*	Lake Ozette ESU	Snake River Sockeye ESU
	Steelhead trout (*Oncorhynchus mykiss)*	California Central Valley DPS	Southern California Coast DPS
		Central California Coast DPS	
		Lower Columbia River DPS	
	Steelhead trout (continued)	Middle Columbia River DPS	

Table 3-1. Status under the ESA of the Marine and Anadromous Fish Species Listed Under the ESA that Potentially Occur in the Study Area for SURTASS LFA Sonar and that are Evaluated in this SEIS/SOEIS for Potential Impacts Associated with Exposure to SURTASS LFA Sonar.

Family	*Fish Species*	*ESA Status*	
		Threatened	*Endangered*
Salmonidae (Continued)		Northern California-Coast DPS	
		Puget Sound DPS	
		Snake River Basin ESU	
		South Central California Coast DPS	
		Upper Columbia River ESU	
		Upper Willamette River DPS	

Note: ESU=evolutionarily significant unit

extent regionally. In areas of the central and western Pacific Ocean, the abundance of oceanic whitetip sharks has declined by 86 to more than 90 percent (Young et al., 2016). Rice and Harley (2012) and FAO (2012) estimated the 2010 population in the western and central Pacific Ocean to include roughly 200,000 individuals, with the population severely depleted (NOAA, 2016e). While the data on the oceanic whitetip shark for the Indian Ocean are uncertain and less reliable, the best available information indicate varying levels of population decline, with the species having become rare throughout the Indian Ocean during the last two decades (Young et al., 2016). In some regions of its global range, however, such as in northwestern Atlantic Ocean, the oceanic whitetip shark populations have stabilized since 2000 (Young et al., 2016).

The oceanic whitetip shark is one of the most widely distributed shark species, occurring worldwide in pelagic tropical and subtropical waters of the Atlantic, Pacific, and Indian oceans (Baum et al., 2015). This shark occurs most commonly in open ocean waters between 10° N and 10° S but occurs in lower numbers in outer continental shelf waters and around deep-water oceanic islands as well as oceanic waters between 30° N and 35° S (Baum et al., 2015; Compagno, 1984; Young et al., 2016). The occurrence of the oceanic whitetip shark is thought to be rare in the northeastern Atlantic Ocean and Mediterranean Sea, as these areas are near the northern extent of the species' range. Oceanic whitetip sharks occur in waters between 59° to 82° F (15° and 28° C) and exhibit a strong preference for the surface mixed layer when water temperatures are above 68° F (20° C). This shark typically is found in the upper 328 ft (100 m) of the water column but has been documented diving to water depths of 840 ft (256 m) and even as deep as 3,550 ft (1,082 m) for short periods (~13 minutes) (Carlson and Gulak 2012; Young et al., 2016).

Although the oceanic whitetip shark is known as a highly migratory species capable of making long distance movements (Howey-Jordan et al., 2013), members of at least some regional populations in Brazil and the Bahamas (Cat Island) exhibit some degree of site fidelity (Tolotti et al., 2015). Tagged oceanic whitetip sharks in the western Indian Ocean and western North Atlantic Ocean traveled from 1,048 to 3,510 nmi (1940 to 6,500 km) from their tagging locations (Filmalter et al., 2012; Young et al., 2016). In the central North Pacific Ocean, tagged oceanic whitetip sharks have shown complex movement patterns that were generally limited to the tropical waters north of the North Equatorial Countercurrent (Musyl et al., 2011).

- *Giant Manta Ray (Manta birostris)*

The giant manta ray has been listed as threatened under the ESA as of February 21, 2018 (NOAA, 2018b). Critical habitat has not be designated as NMFS has concluded that it presently undeterminable. The giant manta ray is listed as vulnerable on the IUCN Red List of Threatened Species (Marshall et al., 2011).

The giant manta ray is considered a rare species throughout most of its range except in limited aggregation areas. Overall population size for the giant manta ray is unknown, but subpopulations appear to be small (about 100 to 1,500 individuals, sparsely distributed, and highly fragmented (Marshall et al., 2011; Miller and Klimovich, 2016). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2013) reported that 10 worldwide populations of the giant manta ray have been studied, with 25 other aggregation sites having been noted, but the species is considered rare in all other areas, indicating that global population of giant manta rays is likely small. The rate of population decline appears to be high in several regions, with as much as an 80 percent decline over the last three generations (approximately 75 years), and a global decline of about 30 percent is strongly suspected (Marshall et al., 2011). The largest global aggregation site of giant manta rays is located in Pacific Ocean waters off Ecuador, where 1,500 individuals have been estimated and as many as 600 individuals are estimated at the largest aggregation site in the Indian Ocean (Mozambique) (CITES, 2013; Miller and Klimovich, 2016).

The giant manta ray is the largest living ray and has a circumglobal distribution in tropical, subtropical, and temperate oceanic waters but has also been observed in nearshore, highly productive waters and in waters surrounding coastal and offshore islands. The largest aggregation site in the world is located within the Ecuadorian waters of the Machalilla National Park and the Galapagos Marine Reserve (Hearn et al., 2014). In the Northern Hemisphere, the giant manta ray has been documented to occur as far north as southern California and Mutsu Bay, Japan waters in the Pacific; New Jersey and the Azores Islands in the Atlantic; and the Sinai Peninsula, Egypt in the Indian Ocean, while in the Southern Hemisphere, these rays have been observed as far south Peru, French Polynesia, and New Zealand in the Pacific; and Uruguay and South Africa in the Atlantic and Indian oceans (Marshall et al., 2011).

Giant manta rays appear to exhibit a high level of flexibility in their habitat use, especially water depths. Tagging studies have shown that the giant manta rays dive to water depths of 837 to 1,476 ft (200 to 450 m) at night (Rubin et al., 2008; Stewart et al. 2016) but are capable of diving to depths exceeding 3,281 ft (1,000 m) (Marshall et al., 2011). Considered a migratory species capable of traveling relatively long distances, the maximum estimated distance travelled by a tagged giant manta ray is 138 nmi (1,500 km) from an island off the Ecuadorian coast to Darwin Island in the Galapagos Islands (Hearn et al., 2014). Clark (2010) suggested that giant manta rays might conduct seasonal migrations to follow prey. A more recent study, however, using tagging, stable isotope, and genetic analysis of giant manta rays in Mexican waters provided evidence that giant manta rays may actually occur in well-structured subpopulations that exhibit a high degree of residency, especially to specific sites such as cleaning stations and feeding sites (Marshall et al., 2011; Stewart et al., 2016).

- *Scalloped Hammerhead Shark (Sphyrna lewini)*

The scalloped hammerhead shark is listed under the ESA, with the Indo-West Pacific DPSs listed as threatened. Based on the known geographic range of the species and genetic studies, the Indo-West

Pacific DPS is bounded to the south by 36° S; to the north by 40° N; to the west by 20° E; and to the east, the boundary line extends from 130° W due north to 4° S, due west to 150° W, and then due north to 10° N (NOAA, 2014b). NMFS has not yet designated critical habitat for the scalloped hammerhead shark (NOAA, 2014b). The IUCN's Red List of Threatened Species lists the scalloped hammerhead shark as endangered (Baum et al., 2007).

No global estimates for the scalloped hammerhead shark are available, but where fisheries catch data are available, significant population declines have been observed, with declines in abundance of 50 to 90 percent over 32 year periods in some parts of the species' range (Baum et al., 2007). From Asian shark fin market data and statistical analysis, Clarke et al. (2006) estimated that from 1 to 3 million hammerhead sharks (*Sphyrna* spp.) are traded per year. Due to the extensive areal extent and complexity of the Indo-West Pacific DPS, NMFS estimates that although it is still observed throughout the entirety of the DPS range, likely there are multiple patterns of declining abundance within the DPS (NOAA, 2014b). For example, in Australian waters, the abundance of the scalloped hammerhead shark has declined about 58 to 85 percent (Heupel and McAuley, 2007); off South Africa, from 1978 to 2003, the catch per unit effort (CPUE) declined 64 percent (Baum et al., 2007); and decreases in CPUE in Papua New Guinea and Indonesia suggests localized population declines (NOAA, 2014b).

The scalloped hammerhead shark is a coastal and semi-oceanic species with a circumglobal distribution in warm-temperate to tropical coastal and oceanic waters, including bays and estuaries, that may occur in waters as deep as 902 ft (275 m), with occasional dives to even deeper depths (1,680 ft [512 m]) (Compagno, 1984; Compagno et al., 2005; Jorgensen et al., 2009). In the western Pacific Ocean, the scalloped hammerhead shark occurs in the waters of Japan, China, Vietnam, Thailand, Indonesia, the Philippines, eastern Australia, and New Caledonia (Compagno et al., 2005; Miller et al., 2014a). In the Indian Ocean, populations of this shark occur in the waters from South Africa to the Red Sea and eastward to Pakistan, India, Myanmar, and Western Australia (Miller et al, 2014a).

Scalloped hammerheads are highly mobile and partially migratory (Maguire et al., 2006). Tagging and genetic studies indicate wide-ranging movements and occasional long-distance dispersals in waters with similar oceanographic conditions, but DPSs are isolated by bathymetric barriers and oceanographic conditions (NOAA, 2014b). For instance, adult scalloped hammerheads generally move distances <108 nmi (200 km) but have occasionally been reported traveling up to 1,080 nmi (2,000 km).

➢ ***ESA-listed Fishes with a Swim Bladder/Gas Chamber Not Involved in Hearing***

Although the following ESA-listed marine fishes are bony (teleost) fishes that possess swim bladders, no evidence exists that the swim bladder is involved in hearing. Further, these fishes possess no known auditory structures or tissues that would function to enhance hearing.

- *Sakhalin Sturgeon (Acipenser mikadoi)*

Endangered throughout its range under the ESA, the Sakhalin sturgeon is listed as critically endangered on the IUCN's Red List of Threatened Species (Mugue, 2010). No critical habitat will be designated for the Sakhalin sturgeon since its geographical range is entirely outside U.S. jurisdiction. Apparently never abundant, the population size of Sakhalin sturgeon has been declining for over 100 years to the extent that now only a few sturgeons are observed each year. The most current population estimate ranges from 10 to 30 adults entering the Tumnin River, Russia to spawn annually, with none captured during fish surveys from 2010 and 2013 (Mugue, 2010). Introduced into the Amur River estuary, five to 10 Sakhalin sturgeons are caught annually (Meadows and Coll, 2013).

The Sakhalin sturgeon occurs only in the waters of the western North Pacific Ocean from the Sea of Japan (as far south as Hokkaido, Japan and Wonsan, North Korea) north to the Bering Strait, including the Sea of Okhotsk, and associated rivers (Mugue, 2010; Shmigirilov et al., 2007). Sakhalin sturgeon migrate into freshwater rivers to spawn, principally now only in the Tumnin River, but rare adults have been observed in the Viyakhtu and Koppi rivers, Russia (Shmigirilov et al., 2007). Japanese researchers believe the Sakhalin sturgeon to be extinct in Hokkaido, Japan (Omoto et al., 2004).

An anadromous fish, the Sakhalin sturgeon lives from 15 to 20 years (NOAA, 2013), and begins spawning migrations to freshwater rivers once it reaches a length of about 4.4 ft (1.35 m) (Koshelev et al., 2012). Spawning occurs from June through July in the Tumnin River, Russia, and from April to May in rivers of Hokkaido, Japan (Mugue, 2010; Paul, 2007). Juveniles remain in freshwater or estuaries until the fall of their birth year, when they migrate to the sea (Birstein, 1993).

- *Chinook Salmon (Oncorhynchus tshawytscha)*

The Chinook salmon population in the waters of the U.S. Pacific northwest has been divided into 17 evolutionary significant units (ESUs). Of these Chinook salmon ESUs, seven are listed as threatened, two are listed as endangered, and one ESU, the Upper Klamath-Trinity River ESU, is a candidate for listing under the ESA (Table 3-1); fishes associated with all these ESA-listed ESUs may occur in the North Pacific part of the study area for SURTASS LFA sonar. Critical habitat has been established for all nine ESA-listed ESUs of Chinook salmon and includes the freshwater spawning, rearing, and migration sites, as well as estuarine and marine juvenile and adult forage and migrational areas in the inland waters of California, Oregon, and Washington states. After significantly declining throughout its U.S. range, the majority of the ESA-listed Chinook ESUs are considered to be stable or improving, but two ESUs, the Upper Willamette Spring-Run ESU and the Sacramento River Winer-Run ESU, are considered to be under stress and declining (NOAA, 2016i; Northwest Fisheries Science Center, 2015).

Chinook, or king, salmon range throughout the North Pacific Ocean from Hokkaido, Japan and the Anadyr River, Russia and Monterey Bay, California northward to the Bering Strait and Chukchi Sea, as well as in associated inland tributaries and estuaries. Largest of the Pacific salmon species, the Chinook salmon is an anadromous fish that is highly migratory. After hatching in freshwater, Chinook salmon spend 3 months to 2 years in freshwater inland habitats before migrating often hundreds of miles seaward to estuaries and finally to the ocean, where they mature and remain from 1 to 6 years, but more commonly remain at sea between 2 and 4 years (USFWS, 2009). As adults, Chinook salmon return to their natal (birth) river or streams to mate, spawn, and die.

The life history and ecology of Chinook salmon exhibit a level of complexity and variability not known in other Pacific salmon species. Populations of Chinook salmon exhibit a great deal of variation in size, age of maturation, and habitat preference with at least some portion of this variation being genetically determined. For instance, a small population of male Chinooks remains in fresh water to mature and only spends 2 to 3 months in saltwater before returning to freshwater. At least one resident population of Chinook salmon in Lake Cushman, Washington never migrates to saltwater (Good et al., 2005). Additionally, not all Chinook salmon migrate to freshwater at the same time of year. Different seasonal (i.e., spring, summer, fall, or winter) migration "runs" or movements of Chinook salmon from the ocean to freshwater exist, even within an individual river system. These runs are identified on the basis of the season when adult Chinook salmon enter freshwater to begin their spawning migration. Entry into freshwater systems is thought to be mediated by water temperature and the water flow regime of the natal tributary.

Two types of Chinook salmon have evolved: the ocean- and stream-types. Ocean-type Chinook salmon tend to migrate along the coast while stream-type Chinooks are found offshore in the North Pacific. Stream-type Chinooks, found most commonly in headwater streams of large river systems, perform extensive offshore migrations into the North Pacific Ocean before returning to their natal streams in the spring or summer months. Stream-type Chinook salmon migrate during their second or sometimes their third spring to summer season (Busby et al., 1997). At the time of saltwater entry, stream-type (yearling) Chinook salmon are much larger than their ocean-type counterparts and are able to move offshore relatively quickly. Ocean-type Chinook salmon live in estuaries for longer periods in earlier lifestages and tend to utilize estuaries and coastal areas more extensively in the juvenile lifestage, and as noted, spend their adult life stage in coastal ocean waters. Ocean-type Chinook salmon return to their natal streams or rivers in fall through summer, with summer and fall migrational runs predominating. In most rivers, migration in the late summer or autumn of the first year represents the majority of the ocean-type emigrants. If environmental conditions are not conducive to emigration, ocean-type Chinook salmon may remain in fresh water for their entire first year.

- *Chum Salmon (Oncorhynchus keta)*

Two of four chum salmon ESUs, the Columbia River and Hood Canal Summer-run ESUs, are listed as threatened under the ESA, with fishes from both ESUs potentially occurring in the North Pacific portion of the study area for SURTASS LFA sonar. Critical habitat for chum salmon has been designated in the transboundary inland waters of Washington and northwestern Oregon to protect freshwater spawning, rearing, and migrational sites as well as estuarine migrational and rearing areas (NOAA, 2005b). Once the most abundant of all Pacific salmon species, seven of the 16 historical spawning populations of chum salmon in the Hood Canal Summer-run ESU are now extinct, with the overall population of this ESU estimated in the early 2000s at several thousand and declining by 6 percent per year (Good et al., 2005). Although productivity of the Hood Canal Summer-run ESU remains low, recent information indicates that population rates have slightly increased in the last five years (NOAA, 2016k). The population of the Columbia River ESU is even lower, with an estimated population in the early 2000s of only 500 fish, and 14 of 16 spawning populations in this ESU are now considered extinct (Good et al., 2005). Abundances of the populations of chum salmon in the Columbia River ESU remain very low, with only three populations considered stable or very slightly increasing, while the other populations are in danger of extinction/extirpation (NOAA, 2016l).

The chum salmon has the widest natural geographic and spawning distribution of any Pacific salmonid, primarily because its occurrence extends farther north into the polar waters of the Arctic Ocean. With spawning populations ranging from Korea and Japan as far north as Russia in the western North Pacific, major spawning populations of chum salmon occur only as far south as Tillamook Bay on the northern Oregon coast in the eastern North Pacific Ocean. Like other Pacific salmon species, the chum salmon is anadromous and migrates from freshwater tributaries to saltwater, returning to the freshwater river or stream of birth to spawn once and die. However, one resident population in Puget Sound never migrates from the waters of the sound (USFWS, 2009a). Chum salmon do not travel as far upstream to spawn as other salmon, generally spawning close to saltwater. Like Chinook salmon, chum salmon are semelparous, only spawning once before dying.

Most chum salmon mature and return to their natal river of stream to spawn between 3 and 5 years of age, with 60 to 90 percent of the fish maturing at 4 years of age (USFWS, 2009a). Only one form, the sea-run, of chum salmon exists. Chum salmon spawn in the lowermost reaches of rivers and streams, typically within 62 mi (100 km) of the ocean, with spawning sites often located near springs. They migrate almost immediately after hatching to estuarine and ocean waters, in contrast to other Pacific salmonids, which migrate to sea after months or even years in freshwater (Pauly et al., 1998). This means that survival and growth of juvenile chum salmon depends less on freshwater conditions than on favorable estuarine and marine conditions.

- *Coho Salmon (Oncorhynchus kisutch)*

Four of the seven coho salmon ESUs in the U.S. are listed under the ESA with an additional ESU, the Puget Sound/Strait of Georgia, listed currently as a species of concern (Table 3-1). ESA-listed coho salmon may occur in the North Pacific part of the LFA study area. The Central California Coast ESU is listed as endangered while the Lower Columbia River, Oregon Coast, and Southern Oregon/Northern California Coast ESUs are listed as threatened. Critical habitat has been established for three of the four listed ESUs; critical habitat for the Lower Columbia River has been proposed but has not yet been designated. Critical habitat for the Central California Coast ESU encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between Punta Gorda and the San Lorenzo River (inclusive) in California, including two streams entering San Francisco Bay: Arroyo Corte Madera Del Presidio and Corte Madera Creek, while critical habitat for the Southern Oregon/Northern California Coasts ESU encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between the Mattole River in California and the Elk River in Oregon, inclusive (NOAA, 1999). Critical habitat for the Oregon Coast ESU includes 72 of 80 occupied watersheds, contained in 13 sub-basins, totaling approximately 6,665 stream miles along the Oregon Coast, south of the Columbia River and north of Cape Blanco (Oregon) (NOAA, 2008a). The abundance of coho salmon south of Alaska has declined despite the establishment of large hatchery programs. Hatchery programs for coho salmon have been so successful that most salmon runs now consist of more than twice the number of hatchery-raised versus naturally-occurring coho salmon. The overall population trend for the ESA-listed ESUs in the early 2000s indicated declining abundances, particularly in the Central California Coast ESU, although abundances for some years show promising increases (Good et al., 2005). More recently, the abundance of the Oregon Coast ESU has shown long-term increases (NOAA, 2016m), while little change has been apparent in the population status of the Southern Oregon/Northern California ESU (NOAA, 2016o).

The distributional range of coho salmon extends from central California to Alaska and from Japan to Russia, principally in coastal marine waters, with these salmon not ranging as widely in open ocean waters as other species of Pacific salmon. The extent of coho migrations appears to extend westward along the Aleutian Island chain ending somewhere around Emperor Seamount (Pacific Fisheries Management Council [PFMC], 2000).

Coho salmon are anadromous, migrating from the marine environment into the freshwater streams and rivers of their birth to mate, spawn once, and die. Although anadromy is the norm, some coho salmon remain resident in freshwater, such as in Puget Sound/Strait of Georgia, where some coho salmon spend their entire lives (Emmett et al., 1991). Coho salmon exhibit a simple, 3-year life cycle, spending the first year or so of life in freshwater. Juvenile cohos spend about 15 months developing in freshwater, and then from spring through summer (April to August), peaking in May, migrate into the waters of the North Pacific Ocean. Upon entering the ocean, coho may spend several weeks or their entire first summer in coastal waters before migrating into open ocean waters (PFMC, 2000). Adult cohos spend two years in the ocean before returning to freshwater to complete their life cycle by spawning and dying (Emmett et al., 1991). Some males known as "jacks" return to freshwater sooner as two-year-old spawners. The adult spawning migrations begin in summer and are completed by fall, with spawning having occurred by mid-winter. Spawning occurs earlier at the northern extent of the coho's geographic range (PFMC, 2000).

- *Sockeye Salmon (Oncorhynchus nerka)*

Two of seven sockeye salmon ESUs in the U.S. have been listed under the ESA; the Ozette Lake ESU is listed as threatened while the Snake River ESU is listed as endangered; sockeye from both the ESA-listed ESUs potentially may occur in North Pacific portion of the study area for SURTASS LFA sonar. Critical habitat for the Snake River ESU consists of the river reaches of the Columbia, Snake, and Salmon Rivers and Valley and Alturas Lake Creeks, as well as Stanley, Redfish, Yellowbelly, Petitt, and Alturas Lakes (NOAA, 1993). The Hoh/Quillayute sub-basin is the focus of critical habitat for the Ozette Lake ESU and specifically includes all bodies of water in the watershed of Ozette Lake, which contains five rivers and three creeks (NOAA, 2005b). The sockeye salmon is listed as least concern on the IUCN Red List of Threatened Species (Rand, 2011).

Sockeye salmon are the third most abundant, after pink salmon and chum salmon, of the seven species of Pacific salmon. However, the Snake River ESU has remained at very low population levels of only a few hundred fish, though there have been recent increases in the number of hatchery reared fish returning to spawn (Good et al., 2005). The Ozette Lake ESU population is small, particularly when compared to historical levels, and the population status has only slightly improved, with the natural-origin spawning population estimated to include only 2,679 sockeye salmon (NOAA, 2016j). The abundance of the Snake River ESU, albeit still very low, shows an increasing trend in the population, with the introduction of hatchery stock thought to have prevented this ESU from becoming extinct (NOAA, 2015c).

Sockeye salmon range from about 44°N to 49°N and occur around the northern Pacific Rim of the Pacific Ocean, ranging from the Klamath River and its tributaries (Northern California and Oregon) to the Kuskokwim River, Alaska in the east and from Hokkaido, Japan to the Anadyr River, Russia in the west (Gustafson et al., 1997). Sockeye salmon prefer cooler ocean conditions than most other species of Pacific salmon and require lake environments for the first half of their lives, spending the remainder of their life cycle foraging in estuarine and marine waters of the North Pacific Ocean. For instance, nearly 90 percent of Asian sockeye salmon are reared in Kuril Lake in the Ozernaya River Basin, Kamchatka Peninsula, Russia (Gustafson et al., 1997).

Sockeye salmon are primarily anadromous and only spawn once before dying, but like Chinook salmon, exhibit a more varied life history and ecology than other species of Pacific salmon. Distinct landlocked populations (kokanee) of sockeye salmon exist that never migrate to marine waters, spending their entire life cycle in freshwater habitats (Burgner, 1991; Emmett et al., 1991). With the exception of certain river- and sea-type populations, the vast majority of sockeye salmon spawn in or near lakes (lake-type), where the juveniles develop for 1 to 3 years prior to migrating into marine waters. For this reason, the major distribution and abundance of sockeye salmon stocks are closely related to the location of rivers with accessible lakes in their watersheds for juvenile development, so that their occurrence in riverine habitats is more intermittent than that of other Pacific salmon. Sockeye spend approximately the first half of their life cycle in lake environments, with the remainder of their four to six year life cycle spent foraging in estuarine and marine waters of the Pacific Ocean. "Lake-type" juvenile sockeye salmon rear in lakes for 1 to 3 years before migrating to the sea, while "river-type" sockeyes spawn in rivers without spending any time in lake developmental habitat, developing to juveniles during 1 to 2 years in the slow-velocity sections of rivers. In Washington and British Columbia, lake residence is typically closer to 1 to 2 years, whereas juvenile lake-residence is closer to 3 to 4 years in Alaska. "Sea-type" sockeye salmon migrate to the sea after spending only a few months in freshwater. Sockeye salmon spend between 1 and 4 years in the ocean before migrating back up the rivers to spawn and die (Gustafson et al., 1997).

After entering saltwater, the young sockeye spend the first season in coastal waters before moving in deeper offshore waters. Upon maturity, sockeye salmon in the Pacific Northwest return to freshwater from June to August, peaking in early July (Emmett et al., 1991). Adult sockeye salmon enter Puget Sound tributaries from mid-June through August, whereas Columbia River populations begin river entry in May. Salmon in Puget Sound spawn from late September to late December, sometimes into January, while salmon in the Columbia River spawn from late September to early November, with a small number of fish in the Cedar River spawning into February (Gustafson et al., 1997).

- *Steelhead Trout (Oncorhynchus mykiss)*

Steelhead and rainbow trout are the same species, with steelhead trout exhibiting an anadromous lifestyle while rainbow trout remain wholly in freshwater throughout their lives and do not migrate into the ocean. In the U.S., steelhead trout are divided into 15 DPSs, with 11 ESUs listed under the ESA. The Southern California DPS is listed as endangered while 10 other DPSs listed as threatened under the ESA (Table 3-1), and a twelfth DPS, the Oregon coast DPS, is listed as a Species of Concern (NOAA, 2006a, 2007a). Steelhead trout from all 11 ESA-listed ESUs may potentially occur in the North Pacific portion of the LFA study area. Critical habitat has been designated for all of the ESA-listed DPSs of steelhead trout and includes the inland, freshwater river and stream habitat as well as coastal estuarine and marine habitat of California, Oregon, Washington, and Idaho (including Puget Sound) (NOAA, 2005a, 2005b, and 2016p). The population status of steelhead trout in U.S. waters is variable, with some DPSs declining or increasing, and others remaining unchanged. Some populations of the Northern California DPS may already be extirpated or extinct, with the summer-run populations considered to be more at risk (NOAA, 2016n). No overall abundance is available for the entire steelhead population.

The current distribution of steelhead trout ranges from the freshwater inland and marine waters from southern California to the Bering Sea and Bristol Bay of Alaska and to the Kamchatka Peninsula in Russia. Steelhead trout do not range into the deep central oceanic gyre waters of the North Pacific Ocean as do other Pacific salmonid species and occur in most streams in the Puget Sound region and many Columbia and Snake River tributaries (Pauley et al., 1986).

Steelhead trout exhibit one of the most complex life histories of any salmonid species. In addition to having a wholly freshwater ecotype

[16] (rainbow trout), steelhead trout in the Pacific Northwest region of Washington, Oregon, and British Columbia can be divided into two phylogenetic groups, inland and coastal steelheads, separated by the Columbia and Fraser tributary systems in the Cascade Mountains (Busby et al., 1996). Steelhead trout can also be divided into two biological or reproductive ecotypes, stream-maturing and ocean-maturing, which are differentiated by their state of sexual maturity at the time of return entry to freshwater and the duration of their spawning migration. Stream-maturing steelhead are sexually immature when they enter freshwater from the ocean and require several months to mature and spawn while ocean-maturing steelhead are sexually mature when they freshwater and spawn thereafter. Like chinook,

16 An ecotype is a locally adapted population of a widespread species that show minor morphological or physiological changes resulting from selection of a particular habitat and which are genetically induced.

steelhead trout also exhibit have two adult migrational movement patterns, with summer- and winter-runs. Most summer runs occur east of the Cascades, with steelhead trout entering streams in summer to reach the spawning grounds by the following spring. A few rivers in western Washington also have established runs of summer steelhead. Steelhead trout that are part of winter-runs spawn closer to the ocean, requiring less travel time to spawn.

Steelhead trout are capable of spawning more than once but most die after spawning twice (NOAA, 1997). In waters north of Oregon, repeat spawning is uncommon, and more than two spawning migrations are rare. The frequency of two spawning migrations is higher in waters of Oregon and California, but more than two spawning migrations are rare. The largest number of spawning migrations known is five, which occurred in the Siuslaw River in Oregon (Busby et al., 1996).

Steelhead trout are the most long-lived of the salmon family, living as long as 11 years. Steelheads typically migrate to marine waters after spending two to four years in freshwater, but some juvenile steelheads have been known to live up to seven years in freshwater before migrating to the ocean. Males generally mature at two years of age with females maturing at three years. Steelhead trout typically remain in marine waters for two to three years prior to returning to their natal stream to spawn. Spawning migrations can occur throughout the year and adults typically spawn between December and June (Busby et al., 1996). Some populations of trout actually return to freshwater after their first season in the ocean, but do not spawn in freshwater, and then return to the sea after one winter season in freshwater.

3.4.3.2 Sea Turtles

Although well adapted for life in the marine environment, sea turtles are air-breathing marine reptiles that rely partially on the terrestrial environment for nesting and hatching of their offspring. Habitat use by sea turtles is typically linked to lifestage, with many species of sea turtles found only in the pelagic environment during their post-hatchling lifestage and during transocean migrations. Most species of sea turtles are migratory and may only occur seasonally or during specific lifestages in the study area for SURTASS LFA sonar. Additionally, due to severe exploitation in the past, most sea turtle species currently occur only in parts of their former ranges and in very low numbers, particularly in the pelagic environment, where sea turtles are widely dispersed. Due to the devastation of sea turtle populations worldwide, all sea turtle species are protected under Appendix I of CITES, which prohibits international trade to and from signatory countries, and all but one sea turtle species is protected under the ESA.

Seven species of sea turtles are distributed circumglobally in the Atlantic, Pacific, and Indian oceans and Mediterranean Sea. However, the distribution of one sea turtle species, the Kemp's ridley turtle, is restricted to the Atlantic Ocean and Mediterranean Sea. Thus, the Kemp's ridley turtle does not occur in the study area for SURTASS LFA sonar and will not be considered further in this SEIS/SOEIS. Five of the six sea turtle species considered in this SEIS/SOEIS are listed under the ESA as threatened or endangered (Table 3-2). The global populations of the ESA-listed green and loggerhead turtles have been divided into DPSs. Only the DPSs that potentially occur within the study area for SURTASS LFA sonar area are considered herein. DPSs of both the green and loggerhead turtles have been designated in the southwestern Indian Ocean, which is the only part of the Indian Ocean not included in the study area for SURTASS LFA sonar. Accordingly, these DPSs are also not further considered herein. The flatback turtle

Table 3-2. Sea Turtle Species and Their Associated Distinct Population Segments (DPSs) Occurring in the Study Area for SURTASS LFA Sonar that are Evaluated for Potential Impacts Associated with Exposure to SURTASS LFA Sonar in this SEIS/SOEIS and Their Status Under the ESA. Species Listed in Alphabetical Order by Family.

Family	***Species***	***ESA Status***	
		Threatened	***Endangered***
Cheloniidae	Flatback turtle (*Natador depressus*)	Foreign Species; Not Listed	
	Green turtle (*Chelonia mydas)*	Central West Pacific DPS	Central North Pacific DPS
			East Indian-West Pacific DPS
			North Indian DPS
	Hawksbill turtle (*Eretmochelys imbricata)*		Throughout Range
	Loggerhead turtle (*Caretta caretta*)	Southeast Indo-Pacific Ocean DPS	North Indian Ocean DPS
			North Pacific Ocean DPS
	Olive ridley turtle (*Lepidochelys olivacea)*	All Other Populations	Pacific Coast of Mexico (Breeding Population)
Dermochelyidae	Leatherback turtle (*Dermochelys coriacea)*		Throughout Range

(*Natator depressus*), is not listed under the ESA, as its distribution is restricted to coastal waters off Australia, Papua New Guinea, and Guinea.

Hearing has been studied in four of the seven species of sea turtles, with the hearing sensitivity of the green, loggerhead, Kemp's ridley, and leatherback turtles reported to be <2 kHz, with greatest hearing sensitivity from 200 to 750 Hz (Bartol et al., 1999; Bartol and Ketten, 2006; Dow Piniak et al., 2012b; Lavender et al., 2012; Lenhardt 1994; Lenhardt et al., 1983; Martin et al., 2012; Mrosovsky, 1972; O'Hara and Wilcox, 1990; Ridgway et al., 1969). Since it is likely that all the potentially occurring species of sea turtles hear LF sound, at least as adults (O'Hara and Wilcox, 1990; Ridgway et al., 1969), the six species of potentially occurring sea turtles, namely the flatback, green, hawksbill, leatherback, loggerhead, and olive ridley turtles, are considered in this SEIS/SOEIS. Information is provided about what is known about sea turtle hearing and sound production capabilities, and each species' status, abundance, distribution, seasonality, diving and swimming capabilities.

3.4.3.2.1 Sea Turtle Hearing and Sound Production

Despite the small number of sea turtle species, only limited data and information on sea turtle hearing and sound production exist. Sea turtles have no ear pinnae (external ear openings), as their middle ears are covered by a layer of fat that is overlain by a thick layer of skin on their external head surface called the tympanum; this layer of fat over the middle ear appears to be a distinguishing feature of sea turtle ear morphology. Sea turtle ears are adapted to hear both underwater and in air, with sound being received either by bone conduction (Lenhardt et al., 1985), resonance of the middle ear cavity (Willis et al., 2013), or standard tympanic middle ear path (Christensen-Dalsgaard et al., 2012). Research conducted on green, loggerhead, Kemp's ridley

[17], and leatherback turtles indicates that sea turtles hear LF sounds both in-water and in-air. Electrophysiological, behavioral, and morphological studies on hearing have been conducted on hatchling leatherback turtles (Dow Piniak et al., 2012a); juvenile green turtles (Bartol and Ketten, 2006; Dow Piniak et al., 2012b; Ridgway et al., 1969; Piniak et al., 2016); juvenile Kemp's ridley turtles (Bartol and Ketten, 2006); as well as post-hatchling, juvenile, and adult loggerhead turtles (Bartol et al., 1999; Ketten and Bartol, 2005/2006; Lavender et al., 2011, 2012; Martin et al., 2012). Additional investigations have examined adult green, loggerhead, and Kemp's ridley sea turtles (Mrosovsky, 1972; O'Hara and Wilcox., 1990). No published studies to date have reported audiograms of olive ridley or hawksbill turtles (Bartol et al., 1999; O'Hara and Wilcox, 1990; Ridgway et al., 1969). Further details on these studies were provided in DoN (2017a).

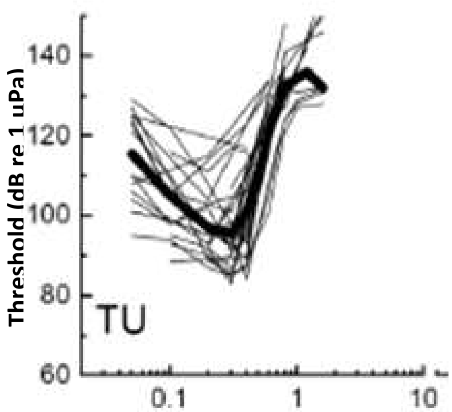

Figure 3-1. Composite Underwater Audiograms for Sea Turtles with Composite of All Audiograms Shown as Heavy Black Line (DoN, 2017e).

The available scientific research on sea turtle hearing capabilities indicates that overall, sea turtle's best hearing ranges is in the LF range between 200 and 700 Hz (Figure 3-1). To better illustrate the underwater hearing capabilities of sea turtles, the Navy compiled known data on sea turtle hearing and developed a composite audiogram (Figure 3-1) (DoN, 2017e). In-water, sea turtles are capable of detecting sound between 50 and 1,600 Hz, with best hearing from 100 and 400 Hz and hearing sensitivity dropping off at higher frequencies (Bartol and Ketten, 2006; Ketten and Bartol, 2005/2006; Piniak et al., 2016). In-air, juvenile sea turtles appear capable of hearing sounds between 50 to 800 Hz, with a maximum hearing sensitivity around 300 to 400 Hz (Piniak et al., 2016; Ridgway et al., 1969).

Very little is known about sound production or how sound is used for communication or other purposes by sea turtles. Some sea turtle species, such as the leatherback turtle, produce sounds when ashore nesting (Mrosovsky, 1972), but no underwater sound production by sea turtles has ever been documented. Cook et al. (2005) noted that the broadband sounds female leatherbacks made during nesting, breath noises (inhalations/exhalations), grunts, and gular pumps[18], ranged in frequency from 300 to 500 Hz (which is in the hearing range of leatherbacks),

17 Even though the Kemp's ridley turtle does not occur in the study area for SURTASS LFA sonar, information about this sea turtle's hearing is included to provide a complete overview of what informs our understanding of sea turtle hearing.

18 The gular organ in sea turtles is similar to the larynx and functions in respiration.

and appeared to be associated with respiration, although their possible role in communication could not be excluded. Species of freshwater turtles produce sounds, up to 17 distinct sounds in one species (Giles, 2009), but the purpose for these vocalizations is not fully understood.

3.4.3.2.2 Sea Turtle Population Estimates

Sea turtles are difficult to observe and enumerate at-sea, especially in the open ocean environment, due to their small size, surface coloration, low percentage of time spent at the sea surface, low and greatly dispersed numbers, and small proportion of body visible at the sea surface. Population estimates or abundances of sea turtles are generally derived worldwide from counts of breeding females when they return to shore to nest or by counting the nests in which females have laid their eggs. This later method further complicates population estimation, as female turtles typically nest more than once per nesting season. An additional complication in depending upon counts of nesting females is that not all females reproduce every year. Although sea turtle population estimates derived from nest counts are the best available data, they often underestimate the total population, as they only represent counts of nesting females, and do not account for non-nesting females, males, or juveniles of the species. Unless otherwise noted herein, sea turtle abundances are counts of nesting females. Few density data are available for sea turtles, except for some densities estimated at nesting beaches and these are rarely representative of the density of sea turtles in a particular region of the ocean environment in any given season.

3.4.3.2.3 Potentially Occurring Sea Turtles

- ***Flatback turtle (Natador depressus)***

The flatback turtle is listed under Appendix 1 of CITES, is considered data deficient by the IUCN, and is not listed under the ESA. Since this species is currently listed as data deficient by the IUCN, no species' status can be correctly assessed. The flatback turtle is classified as vulnerable under the Australian Environment Protection and Biodiversity Conservation Act. No estimate of the overall flatback turtle population size is available. Whiting et al. (2008) estimated an annual abundance of 3,250 flatback turtles at Cape Domett, Western Australia, and Sutherland and Sutherland (2003) estimated that 4,234 flatback female turtles came ashore at one the largest flatback rookeries on Crab Island, Australia during the austral winter in 1997. These abundances are the only estimates available for two of the four flatback genetic stocks occurring in Australia. Each of the two major nesting rookeries for flatback turtles in Queensland, Australia reported 100 nesting females per year and up to 500 nesting females at one of those rookeries (Limpus et al., 2013; Wilderman et al., 2017).

Flatback turtles have the most restricted distributional range of all sea turtle species. Flatback turtles occur principally in habitats with soft sediments throughout the continental shelf waters of northern Australia (including the waters off Western Australia, Northern Territory, and Queensland), Papua New Guinea, and Papua, Indonesia and are not found elsewhere in the world (Limpus, 2007). Flatback turtles do not have a pelagic or oceanic lifestage, and remain in relatively shallow, continental shelf waters throughout all developmental lifestages (Walker and Parmenter, 1990). This restricted water depth range is thought to be the cause for flatback turtles remaining endemic to Australia and parts of southern Indonesia (Van Buskirk and Crowder, 1994; Walker and Parmenter, 1990).

Nesting only takes place along the coast of northern Australia, where it occurs year-round at some beaches but only seasonally at other rookeries. Pike (2013) reported that there are 223 unique nesting sites for flatback turtles. Flatback turtles produce clutches of eggs that are about half the size of other hard-shelled turtles but their eggs are larger and develop into hatchling turtles with twice the mass of other hard shelled turtles (Walker and Parmenter, 1990). Foraging grounds are located in Indonesia and Papua New Guinea.

Once thought to be non-migratory, tagged flatback turtles have been recorded moving up to 702 nmi (1,300 km) between nesting beaches in northern Australia to foraging areas in Indonesia (southern Irian Jaya) (Limpus et al., 1983). Little is known about the diving or swimming behavior of the flatback turtle. Sperling (2007 and 2008) found that flatback turtles spend about 10 percent of their time at or near the water's surface; dive as deep as 98 ft (30 m); and dive for long periods of time, with a mean dive duration of 50 min and a maximum of 98 min. Sperling (2008) also discovered two apparent distinct dive types for flatback turtles that had not been described for other turtle species, which accounted for 2 to 5 percent of the dives the tagged turtles made during the study. Salmon et al. (2010) detailed the diving behavior of juvenile flatback turtles and noted that even at 3 weeks of age, they are capable of diving for 5.8 min to water depths as deep as 36 ft (11 m), with most dives <2 min in duration to shallow water depths (<13 ft [4 m]). The juvenile flatback turtles principally exhibited two types of dive profiles, V- and W-shaped dives, were capable of making repeated dives to the maximum water depth, and typically swam slowly when diving, on average <0.2 kt (9 cm/sec), but some of the juveniles were capable of swimming >1.9 kt (1 m/sec) (Salmon et al., 2010).

- ***Green Turtle (Chelonia mydas)***

Eleven worldwide DPSs for the green turtle have been designated as either threatened or endangered under the ESA (Table 3-3) (NOAA, 2016b). The green turtle is protected under CITES and is listed as endangered by the IUCN Red List of Threatened Species, with declining populations (Seminoff, 2004). Three ESA DPSs were listed as endangered (Central South Pacific, Central West Pacific, and Mediterranean DPSs) with eight DPSs listed as threatened (Figure 3-2[19]). The DPS boundaries were derived based on genetic analysis of tissue collected from female green turtles when they came ashore to nest. Thus, the DPS boundaries are indicative of the nesting populations of green turtles but are not indicative of the overall movements of green turtles. Green turtles often make long, oceanic migrations between nesting and feeding grounds, so green turtles from multiple DPSs may be found on foraging grounds or in the pelagic ocean environment.

Of the 11 green turtle DPSs, only four DPSs (Central West Pacific, Central North Pacific, East Indian-West Pacific, and North Indian DPSs) are located in the study area for SURTASS LFA sonar (Table 3-2). In 1998, critical habitat was designated in the coastal waters around Culebra Island, Puerto Rico and its outlying keys from the mean high water line seaward to 3 nmi (5.6 km); this critical habitat remains in effect for the North Atlantic DPS of the green turtle. NMFS has determined that additional critical habitat is not determinable at this time (NOAA, 2016b).

No complete global population estimates exist for the green turtle. Seminoff (2004) compiled known population data and information but no overall abundance could be derived due to the disparate data (number of nesting females, nests, eggs, and hatchlings) reported for the major worldwide green turtle rookeries. However, more recently, estimates of the female nesting abundance for each green turtle DPS were derived, resulting in a best estimate of the global population of green turtles as 570,926 turtles (NOAA, 2016b; Table 3-3). The two largest worldwide nesting populations occur at Tortuguero, Costa Rica (Caribbean), where on average, 22,500 females nest per season; and Raine Island, Australia

19 The DPS ranges depicted in Figure 3-2 correspond to the nesting beach ranges for each DPS.

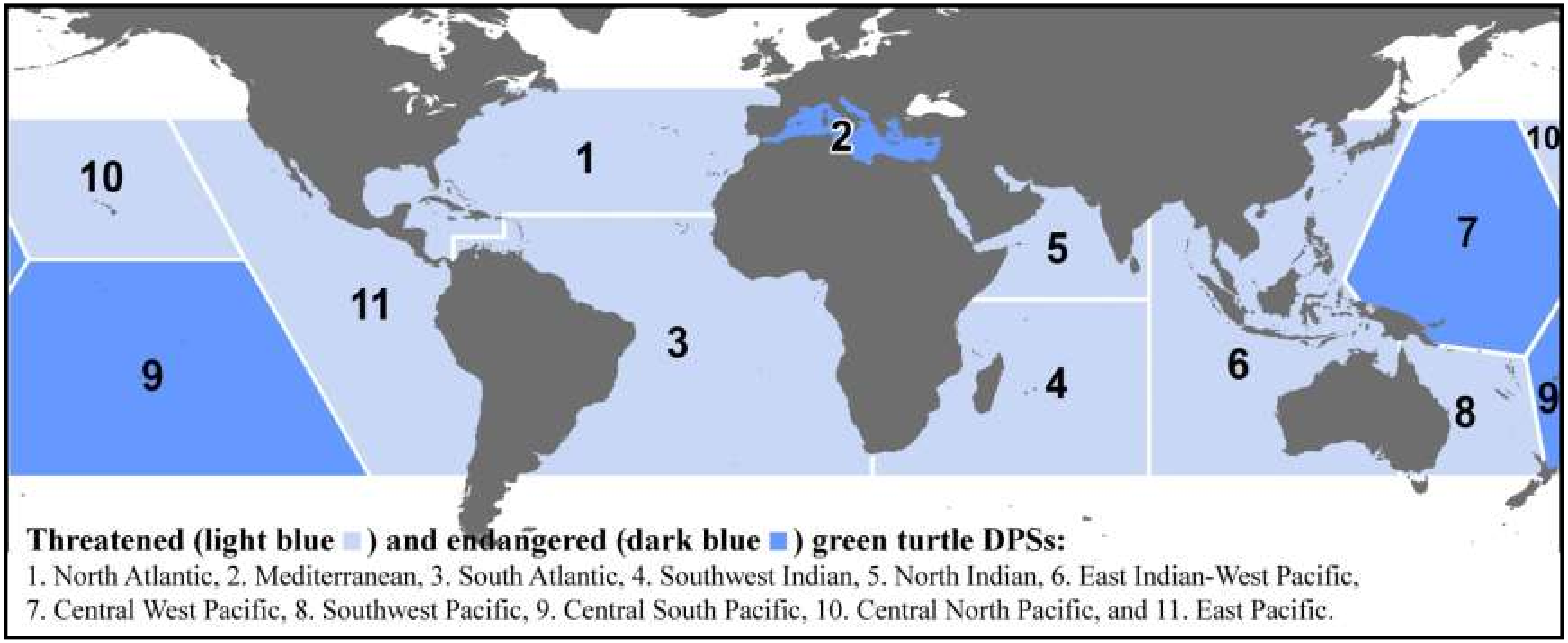

Figure 3-2. Global Distribution of the Threatened and Endangered Distinct Population Segments (DPSs) Listed Under the ESA for the Green Turtle (NOAA, 2016c).

Table 3-3. Green Turtle DPSs, ESA Status, and Estimated Abundances with Worldwide Total Estimated Abundance (Seminoff et al., 2015).

Green Turtle DPS	*ESA Status*	*Estimated Abundance (nesting females)*
North Atlantic	Threatened	167,424
Mediterranean	Endangered	698[20]
South Atlantic	Threatened	63,332
Southwest Indian	Threatened	91,059
North Indian	Threatened	55,243
East Indian-West Pacific	Threatened	77,009
Central West Pacific	Endangered	6,518
Southwest Pacific	Threatened	83,058
Central South Pacific	Endangered	2,677
Central North Pacific	Threatened	3,846
East Pacific	Threatened	20,062
Total		570,926

(Great Barrier Reef), where 18,000 females nest per season on average (Seminoff et al., 2015). The populations of green turtle in the waters of the CNMI were estimated as 795 to 1,107 turtles in Tinian waters and 297 turtles in Pagan waters; 97 percent of these populations are composed of juveniles and subadults (DoN, 2014). Although no abundance exists for the number of green turtles that occur in Hawaii, the Hawaiian green turtle population is increasing and has increased by 53 percent over the last 25 years (NMFS, 2018a). The number of nesting female green turtles at one of the two largest nesting areas in the western North Pacific, the Ogasawara Islands of Japan, has been increasing since the late 1970s, with a maximum number of 582 nesting females in 2008 (Kondo et al., 2017).

Green turtles are widespread throughout tropical, subtropical, and warm-temperate waters of the Atlantic, Pacific, and Indian oceans and Mediterranean Sea between 30° N and 30°S (Lazell, 1980). Except during the juvenile lifestage and adult migrations when green turtles are found in the oceanic environment, green turtles principally inhabit the neritic zone, typically occurring in nearshore and inshore waters where they forage primarily on sea grasses and algae (Mortimer, 1982). Green turtles make long pelagic migrations between foraging and nesting grounds, swimming thousands of miles across the open ocean (Bjorndal, 1997; Pritchard, 1997). Nesting of green turtles occurs in over 80 countries worldwide (Hirth, 1997). Pike (2013) estimated that green turtles use 1,781 unique nesting beaches worldwide. Green turtles may nest more than once, remaining in the nesting vicinity between nesting periods. After hatching, juvenile green turtles begin an oceanic lifestage that spans several years, after which green turtles typically migrate to neritic developmental and foraging habitats (Seminoff, 2004). Researchers have suggested that late-stage juveniles migrate from the pelagic developmental habitat to neritic habitat that they select foraging areas proximal to their natal beaches

20 Median value

(Naro-Maciel et al., 2007; Prosdocimi et al., 2012); this natal homing of late-stage juveniles has also been shown in loggerhead and hawksbill turtles.

In the central Pacific Ocean, green turtles occur around most tropical islands, including the Hawaiian Islands where green turtles are the most common turtle species. Foraging in the Main Hawaiian Islands, about 90 percent of the Hawaiian adult green population migrates to French Frigate Shoals in the Northwest Hawaiian Islands, where nesting and mating occurs; nesting rookeries in French Frigate Shoals are the largest in the central North Pacific (Seminoff et al., 2015). Green turtles occur year-round in Guam and in the CNMI, particularly in the waters of Tinian and Pagan (DoN, 2014). Nesting of green turtles occurs on Guam and on Tinian Island, CNMI, from February through August with highest nesting occurring at Unai Dankulo beaches (DoN, 2014; Seminoff et al., 2015), although nesting also occurred on Rota in the 2000s (Kolinski et al, 2006). Two larger nesting areas for green turtles in the western North Pacific are found in the Ogasawara Islands of Japan and in Micronesia. The waters of the main Japanese islands as well as other areas of the western North Pacific are foraging and developmental grounds for green turtles hatched in the Ogasawara Islands (Seminoff et al., 2015; Tachikawa et al., 1994). Green turtles now only nest on seven beaches in China, with post-hatchlings from Chinese beaches having been observed migrating in multiple directions either into the South China Sea or to Okinawan waters (Song et al., 2002); green turtles also nest on the shores of Vietnam, the Philippines, and Indonesia (NOAA, 2016b). Two primary nesting locations are found in the North Indian DPS, one in Oman and one in Yemen (NOAA, 2016b), but nesting also occurs along the shores of Pakistan, India, and Sri Lanka, with turtles migrating from the primary nesting areas in the northwest Indian Ocean to foraging habitat in the Arabian Sea, the Red Sea, Pakistan, and southward to the waters off Somalia (Khan et al., 2010; Rees et al., 2012; Al Saady et al., 2005). Widespread nesting of green turtles occurs throughout the eastern Indian Ocean, with nesting occurring at 58 sites, including large rookeries in Western Australia and Indonesia (Seminoff et al., 2015). Foraging grounds in the eastern Indian Ocean include the waters around the Andaman and Nicobar Islands and Indonesia (Andrews et al., 2006a; Suganthi, 2002).

Green turtles typically make shallow and short-duration dives to no more than 98 ft (30 m) for <23 min, but dives in excess of 453 ft (138 m) and for durations of 307 min have been recorded, with these deeper dives occurring more usually during winter (Blanco et al., 2013; Brill et al., 1995; Broderick et al., 2007; Hays et al., 2000; Hochscheid et al., 1999; Rice and Balazs, 2008). Migrating turtles in Hawaii showed a strong diurnal pattern, with maximum dive depths of 13 ft (4 m) occurring during the day, with deeper dives to more than 44.3 ft (13.5 m) occurring at night (Rice and Balazs, 2008). Hochscheid et al. (1999) reported that green turtles exhibit dives that are U, V, and S shaped. In their study of nesting green turtles in the Mediterranean Sea, Hochscheid et al. (1999) noted that the tagged turtles remained in coastal waters even during inter-nesting periods, and dove no 131 ft (25 m) but remained underwater for up to 40 min. Godley et al. (2002) reported travel speeds for three green turtles in nesting, open-ocean, and coastal habitats, with speeds ranging from 0.3 to 1.5 kt (0.6 to 2.8 kph), with crossing of deeper, open waters associated with faster swim speeds. Song et al. (2002) reported average swimming speeds ranging from 0.8 to 1.6 kt (1.4 to 3 kph) for migrating green turtles.

- ***<u>Hawksbill Turtle (Eretmochelys imbricata)</u>***

The hawksbill turtle is listed as critically endangered under the IUCN Red List of Threatened Species (Mortimer and Donnelly, 2008) and as endangered throughout its range under the ESA, and is protected by CITES (Appendix I). Critical habitat for the hawksbill turtle has been established in the Caribbean Sea coastal waters surrounding Mona and Monito Islands, Puerto Rico from the mean high water line seaward 3 nmi (5.6 km) (NOAA, 1998). In contrast to all other sea turtle species, hawksbill turtles nest in low densities on dispersed, small beaches, making population estimation even more challenging. Hawksbill nesting occurs in at least 70 countries, although much of it now only occurs at extremely low numbers (Mortimer and Donnelly, 2008). Although population data are generally lacking for the hawksbill turtle, the best estimate of the number of annual nesting females worldwide is 22,004 to 29,035 turtles, which represents about 88 nesting areas (NMFS and USFWS, 2013a), and overall, the population trend is of decreasing populations (Mortimer and Donnelly, 2008). The largest populations of hawksbill turtles occur in the Yucatan Peninsula, Mexico; the Republic of Seychelles; Oman; and Australia (NMFS and USFWS, 2013a). Only four regional populations in the Pacific remain with more than 1,000 females nesting annually (one in Indonesia and three in Australia). The largest nesting population of green turtles in the Pacific Ocean occurs in eastern Australia, with some 6,500 females nesting per year, while in the Indian Ocean, about 2,000 females nest in Western Australia and 1,000 nest in Madagascar annually (Limpus, 2009; NMFS and USFWS, 2013a). The largest nesting aggregation in the northwest Indian Ocean is located in Oman, where 600 to 800 hawksbill's nest annually (NMFS and USFWS, 2013a). Fewer than 20 hawksbill turtles nest annually in the Hawaiian Islands, while the population in the CNMI's consisting primarily of juvenile and subadult hawksbill turtles was estimated as 151 turtles around Pagan Island, while 50 to 71 hawksbill turtles were reported from around Tinian Island, but no hawksbill nesting occurs (DoN, 2014; NMFS and USFWS, 2013a).

Hawksbill turtles typically occur in tropical and subtropical waters of the Atlantic, Pacific, and Indian oceans between about 30° N and 30° S latitudes (NMFS and USFWS, 2013a), and are especially often encountered in shallow lagoons and coral reefs. Hawksbill turtles even inhabit inshore waters of mangrove-lined bays and estuaries but are most typically associated with nearshore coral reefs environments. No hawksbills are reported from the Mediterranean Sea (Spotila, 2004). The largest populations live in the waters of the Caribbean Sea, the Seychelles, Indonesia, and Australia. Juvenile hawksbill turtles occur year-round in the waters of Pagan and Tinian, CNMI, although no nesting occurs on the beaches of these islands (DoN, 2014). In the U.S. Pacific, hawksbills occur in Hawaii, American Samoa, Guam, and the CNMIs. Through satellite tracking, the Hamakua Coast of Hawaii has been identified as an important foraging ground for Hawaiian hawksbills. In the northeastern Indian Ocean (Bay of Bengal), the hawksbill population found in the Andaman and Nicobars Islands is the largest in the Northern Indian Ocean (Andrews et al., 2006a). Hawksbill turtles are observed in Japanese waters but only nest in the Ryukyu Islands (Kamezaki and Matsui, 1997).

Hawksbills were once thought to be non-migratory residents of reefs adjacent to their nesting beaches, but recent tagging, telemetry, and genetic studies confirm that hawksbills are highly migratory, migrating hundreds to thousands of miles between feeding and nesting grounds (Plotkin, 2003). While the migratory habits of hawksbills are still largely unknown, it appears that similarly to other hard-shelled turtles, hawksbill turtle hatchlings and juveniles exhibit a pelagic phase when they spend years in the open ocean, although specifics about their occurrences at sea during these early lifestages are not known. After several years spent in the pelagic environment, hawksbill turtles shift habitats to coastal, neritic developmental and foraging habitat. Juveniles remain in developmental habitats until they are reproductively mature, when females migrate back to their natal beaches to mate and nest. Gaos et al. (2017) recently reported that the neritic foraging grounds of juvenile hawksbill turtles in the eastern Pacific Ocean are located near their natal beaches, indicating that sea turtles have fidelity to specific nearshore areas not only for nesting and mating but also for foraging; this finding has also been suggested for loggerhead and green turtles.

Hawksbill turtles appear to exhibit a diurnal diving strategy, actively foraging during the day and resting at night (Blumenthal et al., 2009; Okuyama et al., 2010), although Gaos et al. (2012) observed foraging dives during both the day and night. Not known as deep divers, hawksbill's typically perform shallow dives to water depths between 33 and 164 ft (10 to 50 m), with mean dive depths between 16 to 26 ft (5 and 8 m) (Gaos et al., 2012; Van Dam and Diez, 1996). In the Seychelles, von Brandis et al. (2010) recorded the mean dive depths of juvenile hawksbill turtles as 27 ft (8.2 m) and 27.4 min, respectively. Hawksbill turtles are amongst the longest-duration divers, with routine dives ranging from 34 to 74 min (Starbird et al., 1999). The maximum dive depth recorded for hawksbill turtles is 299 ft (91 m) with a maximum dive duration of 138 min (Blumenthal et al., 2009; Hochscheid, 2014; Storch et al., 2005). Dive times have been shown to vary greatly during the inter-nesting intervals, with means of 30, 60, and 45 min (Walcott et al., 2013). Bell and Parmenter (2008) found that during the 14-day inter-nesting period of hawksbill turtles off eastern Australia, the mean dive time, dive depth, and surface intervals were 31.2 min, 19 ft (5.7 m), and 1.6 min, respectively, with the maximum water depth to which an inter-nesting female dove was 71 ft (21.5 m). Hawkes et al. (2012) reported that turtles outside Dominican Republic waters travelled an average of 19.4 nmi (36 km) per day, which resulted in a minimum speed estimate of 0.8 kt (1.5 kph), while turtles on the foraging areas moved 0.4 to 0.6 kt (0.67 to 1.17 kph). Storch et al. (2005) reported descending and ascending dive speeds of 0.7 and 0.6 kt (0.37 and 0.31 m/sec), respectively.

➢ ***Loggerhead Turtle (Caretta caretta)***

Under the ESA, nine loggerhead turtle subpopulations or DPSs have been identified and designated worldwide as endangered or threatened (Table 3-4; Figure 3-3). As a species, the loggerhead turtle is classified as vulnerable by the IUCN Red List of Threatened Species, with 10 global subpopulation identified, whose IUCN status ranges from least concern to critically endangered (Table 3-4) (Casale and Tucker, 2017).

Five loggerhead DPS are listed as endangered under the ESA (Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean), while four DPS are listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean) (NOAA and USFWS, 2011) (Table 3-4; Figure 3-3), although only the North Pacific Ocean, North Indian Ocean, Southeast Indo-Pacific Ocean DPSs occur in the study area for SURTASS LFA sonar (Table 3-2). In 2014, critical habitat was designated for the Northwest Atlantic Ocean DPS in the northwestern Atlantic Ocean and the Gulf of Mexico that includes nearshore reproductive habitat, winter habitat, breeding areas, constricted migratory corridors, and Sargassum habitat (NOAA, 2014). Critical habitat for the Northwest Atlantic Ocean DPS includes 38 marine areas along the coastlines and offshore of North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, and Texas. Also in 2014, the USFWS, which has jurisdiction over sea turtles on land, designated critical habitat for the Northwest Atlantic Ocean DPS about 685 miles of coastal beach to protect 88 loggerhead nesting beaches in coastal counties of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi (DoI, 2014).

No complete population estimates for each loggerhead DPS exist, but Casale and Tucker (2017) estimated the size of each IUCN subpopulation by combining the nesting counts, for a minimum estimate of 200,246 loggerhead turtles (Casale and Tucker, 2017). One of the two major global populations of loggerhead turtles occurs in the waters of the western Atlantic Ocean and northern Gulf of Mexico (Northwest Atlantic DPS), where the total nesting population in the U.S. has been estimated at approximately 68,000 to 90,000 nests per year (i.e., nesting females). The most recent count of

Table 3-4. International Union for Conservation of Nature and Natural Resources (IUCN) Red List Classification of the Conservation Status of Loggerhead Global Populations (Casale and Tucker, 2017).

Global Subpopulation/DPS	*IUCN Red List Conservation Status*	*ESA Status*	*Current IUCN Estimated Abundance (nests per year)*
Mediterranean Sea	Least Concern	Endangered	7,200
North Indian DPS		Endangered	
Northeast Atlantic Ocean	Endangered	Endangered	15,000
Northeast Indian Ocean	Critically Endangered		25
North Pacific Ocean	Least Concern	Endangered	9,053
Northwest Atlantic Ocean	Least Concern	Threatened	83,717
Northwest Indian Ocean	Critically Endangered		70,000
South Atlantic DPS		Threatened	
Southeast Indian Ocean	Near Threatened		2,955
Southeast Indo-Pacific Ocean DPS		Threatened	
South Pacific Ocean	Critically Endangered	Endangered	NA
Southwest Atlantic Ocean	Least Concern		7,696
Southwest Indian Ocean	Near Threatened	Threatened	4,600
Total for all IUCN Subpopulations			200,246

Note: NA=not available

65,807 nesting females was reported for Florida in 2016, where the largest concentration of loggerhead nesting occurs in the Northwest Atlantic DPS (Florida Fish and Wildlife Conservation Commission [FFWCC], 2018). The nesting population in Florida had declined sharply, but since 2007, the nesting population of female loggerheads has increased by 65 percent, with an increase of 19 percent in the number of nesting females from 1989 through 2017 (FFWCC, 2018). The second largest nesting aggregation of loggerhead turtles occurs in the northwestern Indian Ocean in Masirah, Oman, where 20,000 to 40,000 females nest were reported annually (Baldwin et al., 2003), but more recent estimates note a decline in the number of nesting females, with the most current estimate of 11,000 nests annually at Masirah (Environment Society of Oman, 2016). The abundance of the entire Northwest Indian Ocean subpopulation was estimated as 70,000 nests per year (Castale and Tucker, 2017). These two most abundant global populations represent 75 percent of the world's nesting female loggerheads (Casale and Tucker, 2017). The largest nesting aggregation in the southeastern Indian Ocean is located on the coast of northwestern Australia where as many as 1,000 to 3,000 loggerheads nest (Hamman et al., 2013). All loggerhead nesting in the North Pacific Ocean occurs only in Japan, where more than 4,000 females historically nested, but the number of nesting females in Japan has declined, with fewer than 1,000 females now nesting in Japan annually (Conant et al., 2009; Hamann et al., 2013; Kamezaki et al., 2003). Castale and Tucker (2017) estimated the number of annual nests in the North Pacific as 9,053.

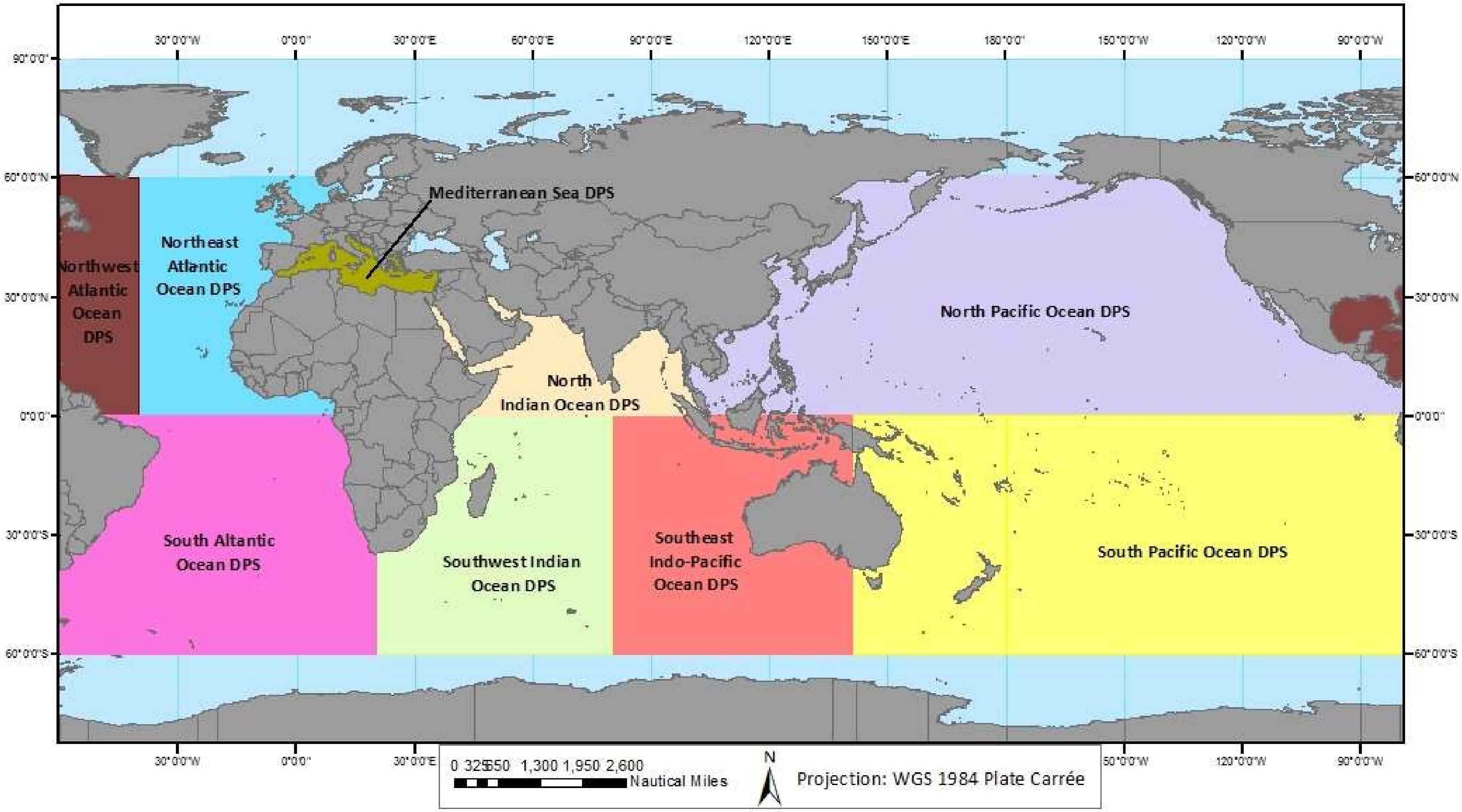

Figure 3-3. Global Distribution of the Threatened and Endangered Distinct Population Segments (DPSs) of the Loggerhead Turtle (NOAA and USFWS, 2011); Only the North Pacific Ocean, North Indian Ocean, and Southeast Indo-Pacific Ocean DPSs are Located in the Study Area for SURTASS LFA Sonar.

Loggerhead turtles are found in coastal to oceanic temperate, tropical, and subtropical waters of the Atlantic, Pacific, and Indian Oceans and the Mediterranean Sea (Dodd, 1988). No migrational movements north/south across the equator are known. Habitat usage varies with lifestage. Loggerheads are highly migratory, capable of traveling hundreds to thousands of miles between feeding and nesting grounds. In the Pacific Ocean, loggerheads nest only in a limited number of sites in Japan and eastern Australia, New Caledonia, Vanuatu, and Tokelau, while foraging occurs in the Gulf of California and along Baja California, and in waters of Peru and Chile (Conant et al., 2009; Kamezaki et al., 2003; Limpus and Limpus, 2003). North Pacific loggerhead turtles make two transoceanic migrations, with hatchling and juvenile turtles making a 5,400 nmi (10,000 km) migration eastward across the North Pacific Ocean from nesting beaches in Japan (including the Ryukyu Archipelago) to developmental and foraging habitat off western North and Central America. Hatchlings use the Kuroshio and North Pacific Currents as transport (Bowen et al., 1995).

As late juveniles or adults, loggerhead turtles make a return westward migration across the North Pacific to return to Japanese waters to mate and nest. Thus, juvenile loggerheads are distributed in the pelagic waters of the North Pacific Gyre, with juvenile loggerheads originating from Japanese nesting beaches exhibiting high site fidelity to the Kuroshio Extension Bifurcation region, an area dominated by extensive meanders and mesoscale eddies (Polovina et al., 2006). Kobayashi et al. (2008) and Polovina et al. (2006) observed that pelagic foraging habitat of loggerhead turtles is characterized by elevated primary productivity (i.e., higher chlorophyll *a* concentrations) and sea surface temperatures in the range of 58° to 68° F (14.5° to 20° C), which are characteristics of the North Pacific Transition Zone in the North Pacific Ocean, which is an important foraging habitat for loggerhead turtles. When the larger or older juvenile loggerhead turtles migrate from their developmental and juvenile foraging grounds, researchers have shown that they migrate specifically to foraging areas near their natal beaches. Bass et al. (2004) and Bowen et al. (2004) described the natal homing of juvenile loggerhead turtles to neritic foraging near their natal beaches; this finding has also been shown for juvenile hawksbill and has been suggested for green turtles.

Although loggerhead turtles occur in Hawaiian waters, principally juvenile loggerheads are observed in offshore waters migrating between the Japanese nesting grounds and foraging and developmental habitats in the eastern North Pacific. The highest densities of loggerheads in the central North Pacific Ocean occur north of the Hawaiian Islands in association with the North Pacific Transition Zone (Polovina et al., 2000). In the western Pacific Ocean, loggerheads have been reported to forage as far south as the Philippine Islands and the mouth of the Mekong River, Vietnam (Limpus 2008; Sadoyama et al., 1996). Following nesting in Japan, satellite-tagged female loggerheads were observed to migrate to two different foraging grounds of the western North Pacific, the more neritic waters of the East China Sea and the oceanic waters along the perimeter of the Kuroshio Current (Hatase and Sakamoto, 2004; Hatase et al., 2002; Sakamoto et al., 1997). No loggerhead turtles nest in the CNMI and during recent surveys, no loggerhead turtles were observed; oceanographic conditions north of the CNMI may function as a barrier to loggerhead occurrence in these islands (DoN, 2014).

Outside of the waters of the Arabian Sea in the northwestern Indian Ocean, loggerhead turtles are not common. In the northern Indian Ocean, nesting of loggerhead turtles primarily occurs in Oman and is rare elsewhere. In the eastern Indian Ocean, all nesting of loggerhead turtles occurs on beaches of Western Australia (Dodd, 1988). In the Indian Ocean, loggerhead turtles migrate, sometimes long distances, between their nesting grounds in Oman and foraging grounds off Oman, Yemen, southern Africa, Madagascar, Western Australia, and Indonesia. Tagging data have shown that nesting turtles from the dense nesting aggregations along the Oman coast use the waters of the Arabian Sea for foraging and seasonal migrational movements (Conant et al., 2009).

Polovina et al. (2003) observed that loggerhead turtles spent about 40 percent of their time at the water surface, and 70 percent of their dives were to no more than 16 ft (5 m) in water depth. Arendt et al. (2012) reported time at the surface was 3 to 6 percent of the time spent diving. Similarly, Howell et al. (2010) found that more than 80 percent the time, loggerheads in the North Pacific Ocean dove to water depths <16 ft (5 m), but 90 percent of their time was spent diving to depths <49 ft (15 m). In their study of free-ranging loggerhead turtles, Hochscheid et al. (2010) noted that the loggerheads infrequently spent extended periods, lasting on average 90 min, at the sea surface during the day. This irregular behavior was suggestive of possible recovery from extensive anaerobic diving or as a means of re-warming their core body temperature after diving to depth (Hochscheid et al., 2010). Even as larger juveniles and adults, loggerheads' routine dives are only to 30 to 72 ft (9 to 22 m) (Lutcavage and Lutz, 1997). Migrating male loggerheads along the east coast of the U.S. dove to water depths of 66 to 131 ft (20 to 40 m) (Arendt et al., 2012). Tagged loggerheads in the open Pacific Ocean dove as deep as 525 ft (160 m) (Polovina et al., 2003), but an adult loggerhead made the deepest recorded dive to 764 ft (233 m), staying submerged for 8 min (Sakamoto et al., 1990). Five different dive types of loggerhead turtle dives have been identified by Houghton et al. (2002) for inter-nesting loggerheads, with mean dive durations ranged from 2 to 40 min for the different dive types. The longest duration dive by a loggerhead turtle was 614 min during deep-bottom resting dives (Broderick et al., 2007). Mean inter-nesting travel speeds range from 0.3 to 0.37 kt (0.58 to 0.69 kph) (Abecassis et al., 2013). Migrating females swam at minimum speeds of 0.7 to 0.9 kt (1.3 to 1.7 kph) (Godley et al., 2003). Loggerheads in the Mediterranean Sea swam at a mean speed of 0.9 kt (1.6 kph), with a maximum speed near 1.6 kt (3 kph). Sakamoto et al. (1990) reported loggerhead diving swim speeds ranging from 0.4 to 1.89 kt (0.2 to 0.97 m/sec).

➢ ***Olive Ridley Turtle (Lepidochelys olivacea)***

The global population of olive ridley turtles is protected by CITES, classified as vulnerable under the IUCN (Abreu-Grobois and Plotkin, 2008), and listed as threatened under the ESA everywhere except the breeding stocks of the Mexican Pacific coast, which are listed as endangered under the ESA. No critical habitat has been designated for the olive ridley turtle. Although the olive ridley turtle is the most abundant sea turtle worldwide, many of its populations have declined or disappeared from historic areas. While many populations of olive ridley turtles have dramatically declined, some populations are stable or even increasing. For example, the once depleted population in La Escobilla, Mexico, which is the only remaining arribada beach in Mexico, has significantly increased, with the number of olive ridley nests increasing from 50,000 nests in 1988 to over 1,000,000 nests by 2000 (uncorrected for nest frequency) (Márquez et al., 2002). However, globally, the increase in some populations has not offset the overall significant decreases in olive ridley populations. Abreu-Grobois and Plotkin (2008) estimated the worldwide population of olive ridley turtles as 841,309 to 851,590 nesting females, while NMFS and USFWS (2014) estimated 1.15 to 1.62 million olive ridley turtles worldwide. Although most olive ridley females nest in mass aggregations of hundreds to thousands of turtles, called arribadas[21], some olive ridley females are solitary-nesters with widely dispersed nest sites. Solitary nesting occurs on the beaches of 43 countries (NMFS and USFWS, 2014). The most recent abundances of nesting females

21 An arribada is a Spanish term for the mass, synchronous nesting events characteristic to olive and Kemp's ridley turtles. During a period of 1 to 10 days, large numbers (100 to 10,000) of female ridley turtles come ashore at night to nest; arribada events can reoccur over 30 day intervals (Hamann et al., 2003).

recorded at the worldwide major arribada nesting beaches include Ostional (134,400) and Nancite (8,320) on Costa Rica's Pacific coast; La Flor (27,906) in Pacific Nicaragua; La Escobilla (574,937) and Ixtapilla (3,261 to 11,429) in Pacific Mexico; and the Rushikulaya/Gahirmatha/Orissa region, India (150,000 to 200,000) (Abreu-Grobois and Plotkin, 2008). From data collected at sea, Eguchi et al. (2007) estimated the juvenile and adult olive ridley population in the eastern tropical Pacific (ETP) Ocean (area encompasses major arribada beaches in Mexico and Central America) as 1.39 million olive ridley turtles.

Olive ridley turtles occur in tropical to warm-temperate waters of the Pacific, Atlantic, and Indian oceans, but do not occur in the Gulf of Mexico or Mediterranean Sea (Spotila, 2004). Information from tagged olive ridley turtles indicates a preference for waters with the rather narrow temperature range of 77° to 82.4° F (25° to 28°C) (Polovina et al., 2004; Swimmer et al., 2009). To remain in waters of this optimal temperature range, Swimmer et al. (2006) noted that when oceanographic conditions changed, olive ridley turtles in the tropical Pacific altered their dive depths. Worldwide, olive ridleys have been recorded in coastal waters of over 80 countries, with nesting occurring in 60 countries (Abreu-Grobois and Plotkin, 2008). Although olive ridley turtles occur in the western and central Pacific Ocean, their distribution in these areas is more restricted to open ocean waters. Olive ridley turtles are not common in the Hawaiian Islands, CNMI, and Guam, and nesting on any of these islands or any U.S. Pacific Island territory is extremely rare (DoN, 2014; NMFS, 2018b; State of Hawaii, 2013). Genetic analysis of olive ridleys caught as bycatch in Hawaiian longline fisheries suggests that the Hawaiian Islands represent some type of convergence area for olive ridleys since two-thirds of the bycaught olive ridleys were hatched in the eastern Pacific rookeries while the other third of olive ridley turtles derived from rookeries in the western Pacific and Indian oceans (State of Hawaii, 2013). Olive ridley turtle's occurrence in Japanese waters is considered rare and no nesting is known (DuPree, 1995; Kamezaki and Matsui, 1997). Olive ridley turtles occur more commonly in oceanic and neritic environments of the Indian Ocean (Abreu-Grobois and Plotkin, 2008).

Olive ridley turtles exhibit a complex natural history, all of which is not well understood. These turtles utilize a variety of oceanic habitats, depending upon their lifestage and geography. Most olive ridley turtles are highly migratory and spend much of their non-breeding life cycle in the oceanic environment, although some olive ridleys have been observed to inhabit coastal areas, including bays and estuaries, with no migration to the open ocean, particularly those turtles occurring in the western Atlantic Ocean (Plotkin, 2010; Pritchard, 1976). While olive ridley turtles migrate vast distances, they do not make trans-oceanic migrations typical of some other sea turtle species. Using satellite telemetry tags, scientists have documented both male and female olive ridleys leaving the breeding and nesting grounds off the Costa Rica-Pacific coast and migrating to the deep waters of the central Pacific Ocean. Hatchling olive ridley turtles begin a pelagic stage, during which they are transported by major ocean currents far from their natal beaches. Information is generally lacking, however, on the dispersal of post-hatchling and juvenile olive ridley turtles (NMFS and USFWS, 2014). At sexual maturity, olive ridley turtles migrate and aggregate in shallow, coastal waters near nesting beaches. Some males, however, do not migrate to the neritic environment, but remain in the open ocean and mate with females as they move towards their natal beaches (Kopitsky et al., 2000). The post-breeding and nesting migrations of olive ridley turtles are complex and varied, with no apparent or interannually varying migrational pathways (Abreu-Grobois and Plotkin, 2008; NMFS and USFWS, 2014). In the eastern Pacific Ocean, olive ridley turtles are considered nomadic, moving thousands of miles over vast expanses of the ocean in search of food, possibly using water temperature as an environmental cue and seeking oceanographic features, such as thermal fronts and convergence zones, to locate suitable feeding areas (Plotkin, 2003; Spotila, 2004). In the ETP, tagged olive ridley have been observed spending as much as 36 percent of time in the vicinity of the Costa Rica Dome, a nutrient-rich circulation feature that encompasses waters of increased productivity and is a known foraging area for fish and marine mammals (Swimmer et al., 2009). Although during their pelagic stage, juvenile olive ridleys are transported by prevailing ocean currents and circulation, it is not clear that adult olive ridley turtles always use ocean currents for transport, passively floating with the currents, as data from satellite-tagged olive ridleys in the ETP and North Pacific indicated that the turtles actively swam against or across the prevailing currents (Beavers and Cassano, 1996; Polovina et al., 2004).

Diving in olive ridley turtles is not as well studied as in other sea turtle species (Hochscheid, 2014). Olive ridley turtles are capable of deep dives, having been recorded diving to a maximum water depth of 1,339 ft (408 m) (Swimmer et al., 2006), although routine feeding dives to depths from 33 to 361 ft (10 to 110 m) are more common (Bjorndal, 1997; Lutcavage and Lutz, 1997; Polovina et al., 2003 and 2004). Polovina et al. (2003) reported that olive ridley turtles only remained at the surface for 20 percent of the time, with about 75 percent of their dives to 328 ft (100 m) and 10 percent of total dive time spent at depths of 492 ft (150 m). Swimmer et al. (2006) noted that olive ridleys spent nearly 100 percent of their time in the top 199 ft (60 m) of the water column with very few dives exceeding 328 ft (100 m). Beavers and Cassano (1996) noted that in their satellite-tagging study of a male olive ridley turtle that the turtle dove longer at night than during the day. The maximum dive duration measured for tagged olive ridley turtles was 200 min in waters off northern Australia for post-nesting and foraging turtles, with the mean of the dives ranging from 24.5 to 48 min (McMahon et al., 2007). Inter-nesting females made routine dives of 54.3 min while breeding and post-breeding males apparently made shorter duration dives of 28.6 min and 20.5 min, respectively (Lutcavage and Lutz, 1997). Whiting et al. (2007) documented the movement and foraging behavior of inter-nesting olive ridley turtles and found that the turtles dove to maximum depths of 492 to 656 ft (150 to 200 m) during maximum dive durations of 120 to 150 min, and the olive ridleys traveled 89 to 567 nmi (165 to 1,050 km) to five foraging areas during the inter-nesting period. Migrating adults had a mean speed of 0.6 kt (1.1 kph) (Plotkin, 2010), which could have been an underestimate due to the minimum distance between satellite positions. Whiting et al. (2007), however, reported swim speeds of 1.7 to 3 kt (0.87 to 1.54 kph) during foraging excursions of inter-nesting adult olive ridley turtles.

- ***Leatherback turtle (Dermochelys coriacea)***

The leatherback turtle is the largest turtle in the world and one of the largest living reptiles. As a species, the leatherback is listed as vulnerable under the IUCN (Wallace et al., 2013), endangered throughout its range under the ESA, and is protected under CITES. Seven subpopulations of leatherback turtles have been recognized by the IUCN (Wallace et al., 2013): East and West Pacific; Northeast and Southwest Indian Ocean; and the Northwest, Southwest, and Southeast Atlantic subpopulations (Table 3-5; Figure 3-4). The IUCN Red List classifies the East and West Pacific and Southwest Indian and Atlantic Ocean subpopulations as critically endangered (Wallace et al., 2013). ESA critical habitat for the leatherback turtle has been designated in the Caribbean Sea waters adjacent to Sandy Point Beach, St. Croix, U.S. Virgin Islands, as well as in the northeast Pacific Ocean waters (NOAA, 1979b, 2012a). Northeastern Pacific critical habitat ranges along the California coast from Point Arena to Point Arguello east of the 9,843 ft (3,000 m) depth contour and from Cape Flattery, Washington to Cape Blanco, Oregon east of the 6,562 ft (2,000 m) depth contour, which together comprise an area ~41,914 miles2 (108,558 km2) of marine habitat and include waters from the ocean surface down to a maximum depth of 262 ft (80 m) (NOAA, 2012a).

Table 3-5. Worldwide Subpopulations, Conservation Status, and Abundance Estimates of Leatherback Turtles as Identified by the International Union for Conservation of Nature and Natural Resources (IUCN) Red List Classification (Wallace et al., 2013).

Subpopulation	*IUCN Red List Conservation Status*	*2010 IUCN Abundance Estimate/Nel (2012) (nests per year)*
East Pacific Ocean	Critically Endangered	926
Northeast Indian Ocean	Data Deficient	ND
Northwest Atlantic Ocean	Least Concern	50,842
Southeast Atlantic Ocean	Data Deficient	ND
Southwest Atlantic Ocean	Critically Endangered	53
Southwest Indian Ocean	Critically Endangered	259
West Pacific Ocean	Critically Endangered	2,182/5,067-9,176
Total		54,262 / 57,147-61,256

ND= No data

Wallace et al. (2013) estimated that the worldwide population of leatherback turtles has decreased by 40 percent over the past three generations. The Turtle Expert Working Group (2007) and the recent analysis by Wallace et al. (2013) reported stable to slightly increasing population trends for Atlantic Ocean leatherbacks, while Pacific and Indian Ocean leatherback populations are decreasing, with Pacific nesting numbers having dramatically decreased over the last three generations (NMFS and USFWS, 2013b).

Determining an exact worldwide population is complicated by lack of data and data reported in non-consistent population indicators (i.e., number nesting females vice number nests, which are not equivalent). Based on available published data on leatherback turtle nest abundances (average number of nests) through 2010, Wallace et al. (2013) estimated the current global population as 54,262 leatherback turtle nests per year. However, Nel (2012) reported the earlier documentation by Dutton et al. (2007) of 5,067 to 9,176 leatherback nests in the West Pacific Ocean population, which would increase the worldwide leatherback abundance to 57,147 to 61,256 nests annually (Table 3-5). The Northwest Atlantic Ocean subpopulation is the largest in the world, with an estimated 34,000 to 94,000 individuals (The Turtle Expert Working Group, 2007) and 50,842 nests per year (Wallace et al., 2013). The largest worldwide nesting location of leatherback turtles is in Gabon, Africa, where Witt et al. (2009) reported 5,865 to 20,499 nesting females annually, for an estimated total 15,730 to 41,373 breeding females. Leatherbacks are now essentially extinct in Malaysia, as only two nests were documented in the early 2000s, and numbers of Western Pacific leatherbacks have declined more than 80% over the last three generations, while the population of Eastern Pacific leatherbacks has declined by more than 97 percent over the last three generations (NMFS, 2018c). The Mexico nesting subpopulation of Eastern Pacific leatherback stock, which was once considered the world's largest, representing 65 percent of the worldwide population, is now less than one percent of its estimated 1980 size (NMFS, 2018c). In the Indian Ocean, the number of leatherback turtles is low, with the best available data indicating that 400 to 600 nesting females are estimated to occur annually in the Nicobar and Andaman islands area of the

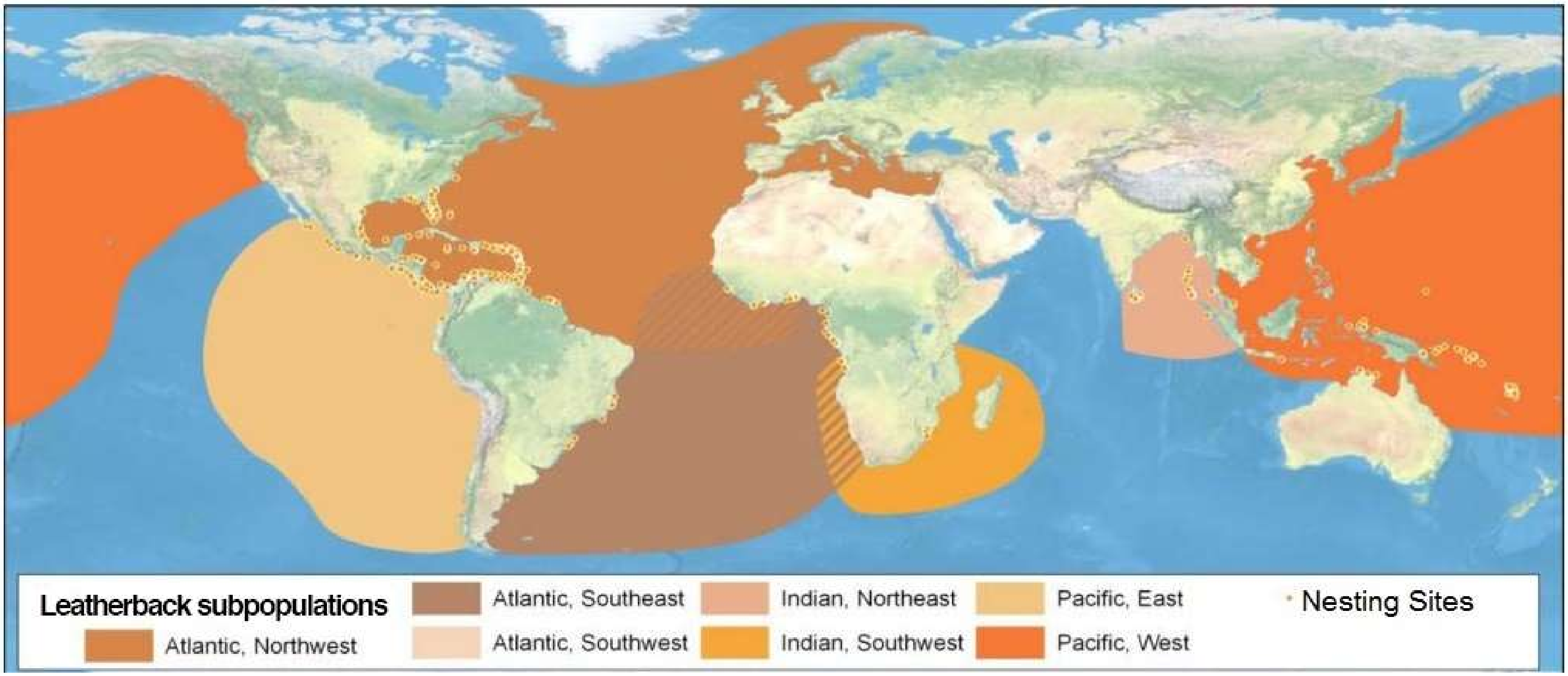

Figure 3-4. Location and Distribution of the Seven Worldwide Subpopulations of Leatherback Turtles and their Nesting Sites (Wallace et al., 2013).

Bay of Bengal/Andaman Sea, while only 100 to 200 leatherbacks are estimated to nest in Sri Lanka, and very low numbers (20 to 40 and <10 nesting females annually) are estimated for the southwestern and southeastern Indian Ocean, respectively (Andrews et al. 2006b; Nel, 2012).

Leatherbacks are the most pelagic and most widely distributed of any sea turtle and can be found circumglobally in temperate and tropical waters between 71°N and 47°S, including the Mediterranean Sea (Eckert et al., 2012; NMFS and USFWS, 2013b; Wallace et al., 2013). Leatherback turtles nest in all oceans around the world except in the Mediterranean Sea (Eckert et al., 2012). The largest Atlantic nesting sites are located in Gabon, Africa and Trinidad, Caribbean Sea, but other significant nesting colonies are found in French Guiana; Suriname; Panama; Equatorial Guinea; Florida, U.S.; and St. Croix, U.S. Virgin Islands (Wallace et al., 2013). The largest nesting grounds in the Pacific is located in Indonesia, but other important Pacific nesting sites are found in Costa Rica, Solomon Islands, and Papua New Guinea, with sparse nesting occurring in the Indian Ocean (Wallace et al., 2013). Leatherbacks are not resident to the waters Marianas Islands, CNMI, or Hawaiian Islands nor do they nest on these islands but are observed in offshore, pelagic waters surrounding the islands (DoN, 2017b; Hadpei, 2013).

Highly migratory, leatherback turtles make annual long-distance excursions between their nesting and feeding grounds. Although the most oceanic of all sea turtles, leatherback turtles also may be found seasonally in highly productive continental shelf and slope waters, where they may spend months foraging (Benson et al., 2011; Dodge et al., 2014). Benson et al. (2011) also found that the time of year when leatherback turtles nested in the western Pacific made a difference in the habitat used following nesting, with those turtles nesting in summer migrating into temperate waters of the North Pacific or the tropical waters of the South China Sea, but winter nesters migrated into temperate and tropical waters of the southern hemisphere. During their migratory phases, leatherbacks rarely stop swimming, and individuals have been documented to swim greater than 7,015 nmi (13,000 km) per year (Eckert, 1998; Eckert, 1999). In the western Atlantic, leatherbacks travel north in the spring, following the Gulf Stream and feeding opportunistically on the spring blooms of jellyfish they find en route. Continuing northward, arriving in waters corresponding to the continental slope by April, and finally, continuing on to leatherbacks arrive in continental shelf and coastal waters off New England and Atlantic Canada where they remain through October. In the fall, some leatherbacks move southward, essentially retracing their northward migration route offshore, while others cross the Atlantic to Great Britain and migrate south along the eastern Atlantic (James et al., 2005). Similarly, populations that nest in the eastern Atlantic and Indian oceans make annual transoceanic migrations between breeding grounds and feeding grounds, with turtles from the largest rookery in Gabon, West Africa migrating post-nesting to three foraging regions of the Atlantic: tropical waters of the equatorial Atlantic, temperate waters off South America, and temperate waters off southern Africa in the Benguela and Agulhas Currents (Witt et al., 2011).

Western Pacific Ocean leatherbacks engage in one of the greatest migrations of any air-breathing marine vertebrate, swimming from nesting beaches in the tropical western Pacific (primarily in Indonesia, Papua New Guinea, and the Solomon Islands) to foraging grounds in the eastern North Pacific Ocean off the Americas (Figure 3-5). This 6,083-nmi (11,265-km) trans-Pacific journey requires 10 to 12 months to complete (NMFS, 2016d). Eastern Pacific leatherbacks nest primarily in Mexico and Costa Rica (with isolated nesting sites in Panama and Nicaragua) and foraging grounds off Mexico, Central America, Chile, and Peru (NMFS, 2018c). Studies of leatherback turtle movements in the Pacific Ocean indicate that that there may be important migratory corridors and habitats used specifically by leatherbacks (Eckert, 1998; Eckert, 1999; Morreale et al., 1996). Shillinger et al. (2008) confirmed the existence of a persistent migration corridor for leatherbacks spanning the Pacific basin from the coast of Central America along the equator into the South Pacific.

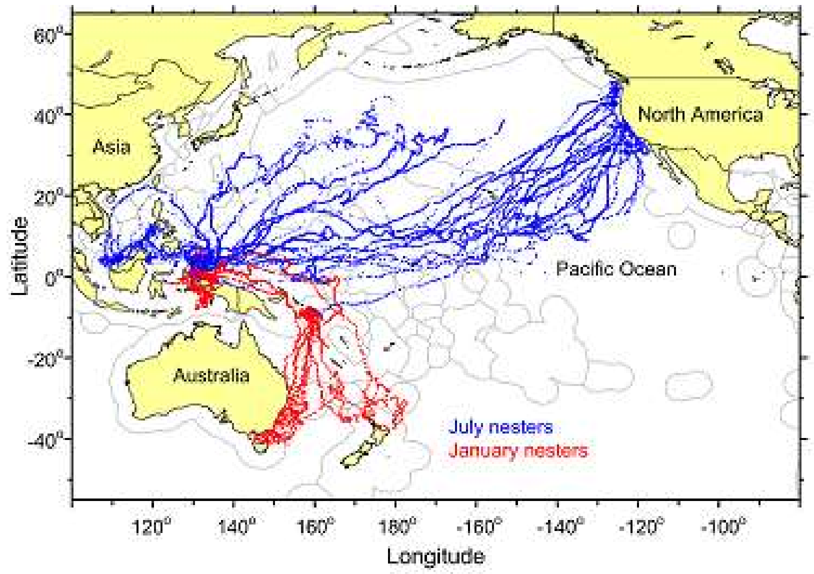

Figure 3-5. Trans-Pacific Seasonal Movements of Tagged Leatherback Turtles Showing Their 6,083 Nmi (11,265 Km) Journey from Nesting to Foraging Grounds (NMFS, 2016d).

Leatherback turtles make the deepest dives of any sea turtle, with the deepest dive recorded at 4,198 ft (1,280 m) (Doyle et al., 2008). Their longest duration dive was 86.5 min, but most dives are no more than 40 min (Byrne et al., 2009; López-Mendilaharsua et al., 2009; Sale et al., 2006). In their examination of nearly 10 years of satellite tag data on leatherback turtles in the North Atlantic Ocean, Hougthon et al. (2008) found that 99.6 percent of leatherback dives were to water depths less than 984 ft (300 m) while only a miniscule 0.4 percent were to deeper water depths, with the dives to waters >984 ft (300 m) occurring principally during the day and during migrational transit. Dives of 13 to 256 ft (4 to 78 m) and 256 to 827 ft (78 to 252 m) and of longer duration (28 to 48 min) characterize the migratory phases of the leatherback, while shallower dives (<164 ft (50 m]) and of shorter duration (<12 min) are more typical of foraging dives (James et al., 2005). Bradshaw et al. (2007) reported median dive depths and durations of over 17,618 dives of adult female leatherbacks as 174 ft (53 m) and 22 min, respectively. In the Atlantic, Hays et al. (2004) determined that migrating and foraging adult leatherbacks spent 71 to 94 percent of their diving time at depths from 230 to 361 ft (70 to 110 m). Wallace et al. (2015) noted that leatherback turtles in Nova Scotian (North Atlantic) waters dove and foraged almost continuously during the day, spending 61.5 percent of the time diving and making short (4.5 min), shallow (<98 ft [30 m]) dives and capturing prey at the bottom of their dives or on their ascent, and diving to forage in areas where prey were most abundant and dense. Eckert et al. (1996) also noted that interesting leatherbacks dove nearly continuously during the day and that daytime dives were longer and to deeper water depths than night dives. Salmon et al. (2004) noted that in their study of juvenile leatherback turtles that the majority of their dives were V-shaped with a minority of W-shaped dives, and that not surprisingly, older turtles dove deeper (up to 59 ft [18 m]) than younger turtles but diving frequency did not differ with age, indicating that as leatherbacks rapidly grow during the beginning of the pelagic lifestage, their diving ability also rapidly progresses. The modal speeds of swimming leatherback turtles ranged between 1.1 to 1.6 kt (2 to 3 kph) with absolute maximum speeds in the range of 3.5 to 5.4 kt (6.5 to 10 kph) (Eckert, 2002). Inter-nesting leatherback turtles swam at speeds ranging from 0.7 to 1.4 kt (1.25 to 2.5 kph) (Byrne et al., 2009).

3.4.3.3 Marine Mammals

Marine mammals are highly adapted aquatic animals, occurring in aquatic habitats ranging from freshwater rivers to the deep ocean. Most marine mammals are wholly aquatic, but some, such as pinnipeds, also depend partially upon the terrestrial environment for limited purposes that include birthing, molting, resting, and predator avoidance. Some pinnipeds spend part of each day hauled out on shore while others only go ashore once a year to give birth and molt. The distribution of marine mammals is difficult to predict, as these highly mobile animals are capable of traveling long distances, with some species undergoing lengthy seasonal migrations. Despite their mobility, however, the distribution of marine mammals is not typically random or homogeneous but is often characterized by irregular clusters (patches) of occurrence that frequently correlate with locations of high prey abundance.

Marine mammals are divided into four basic taxonomic groups: Mysticeti, Odontoceti, Pinnipedia, and Sirenia, which respectively are baleen whales; toothed whales (including dolphins and porpoises); seals, sea lions, and walruses; and manatees and dugongs. Collectively, mysticete and odontocete species of marine mammals are called cetaceans. Some of the marine mammal species that occur in the western or central North Pacific or Indian oceans do not meet the criteria for co-occurrence with SURTASS LFA sonar operations, as these species occur in inland or very shallow coastal waters where SURTASS LFA sonar activities would not occur. These neritic and inshore marine mammal species are excluded from further consideration:

- Shallow-water Porpoises—The distribution of porpoise species such as the Indo-Pacific finless porpoise (*Neophocaena phocaenoides)* and narrow-ridged finless porpoise (*Neophocaena asiaeorientalis)* is in riverine, nearshore, shallow waters where SURTASS LFA sonar is highly unlikely to be used.
- River Dolphins—Freshwater dolphin species, such as the Ganges River dolphin (*Platanista gangetica gangetica*), the endangered Indus River dolphin (*Platanista gangetica minor*), and the highly endangered baiji/Chinese river dolphin (*Lipotes vexillifer*) (which may possibly already be extinct) are restricted to riverine waters of the Ganges, Indus, and Yangzte rivers, respectively. These river dolphins today only occur in the main channels of these rivers, well inshore of where SURTASS LFA sonar would be used.
- Coastal Dolphins—Inshore and coastal delphinid species such as the Irrawaddy dolphin (*Oracella brevirostris*), Australian snubfin dolphin (*Oracella heinsohni*), Indian Ocean humpback dolphin (*Sousa plumbea*), Indo-Pacific humpbacked dolphin (*Sousa chinensis*), Australian humpback dolphin (*Sousa sahulesis*), and Taiwanese humpbacked dolphin (*Sousa chinensis taiwanensis)* all occur in shallow, coastal waters very near to shore. The Taiwanese humpbacked dolphin has been proposed for listing as endangered under the ESA. However, Taiwanese humpback dolphins have only been reported in shallow (<82 ft [25 m]) nearshore waters, no more than 1.6 nmi (3 km) from shore (Dares et al., 2014; Wang et al., 2016). Further, these coastal dolphin species are not known to hear sounds in the range at which the SURTASS LFA sonar system transmits (NMFS, 2016a).
- Sirenians—One sirenian species, the dugong (*Dugong dugon*) may occur in the shallow inshore and coastal waters of the Indo-West Pacific, where they are widely but discontinuously distributed in waters that are typically less than 16.4 ft (5 m) deep (Jefferson et al., 2015). Although dugongs have been sighted near reefs up to 43.2 nmi (80 km) from shore in waters up to 75 ft (23 m) deep (Marsh et al., 2002), such occurrences are very rare and considered atypical. Moreover, the water depths of the offshore reefs where dugongs have uncommonly been observed are so shallow to preclude the use of SURTASS LFA sonar in those types of environments.

Excluding these species leaves a remainder of 46 marine mammal species potentially occurring in the study area for SURTASS LFA sonar (Society for Marine Mammalogy [SMM], 2017). The 46 potentially occurring marine mammals include five pinniped species, 10 mysticete species, and 31 odontocete species (Table 3-6). All marine mammals are protected under the MMPA, while 11 of the marine mammals potentially occurring in the study area for SURTASS LFA sonar are listed under the ESA as either threatened or endangered. The populations of five of the ESA-listed species potentially occurring in the study area have been divided into DPSs. Only those DPSs occurring within the study area for SURTASS LFA sonar are included for assessment in this SEIS/SOEIS.

Although there are no direct measurements or data on auditory thresholds for any mysticete species, anatomical evidence strongly suggests that their inner ears are well adapted for LF hearing, suggestive of functional hearing from 15 Hz to 20 kHz, with good sensitivity from 20 Hz to 2 kHz (Ketten, 1998). Additionally, all baleen whales produce LF sounds. Odontocete species studied to date hear best in the mid- to high-frequency range, and as a consequence, are less likely to be affected by exposure to LF sounds than mysticetes. However, odontocetes depend upon acoustic perception and sound production for communication, prey location, and probably for navigation and orientation as well. Pinnipeds are taxonomically divided into three families: eared seals (family Otariidae), earless, or true seals (family Phocidae), and walruses (family Odobenidae). However, no polar occurring pinnipeds, such as the walrus, are considered herein. The functional hearing ranges of otariid and phocid pinniped species is 100 Hz to 40 kHz and 75 Hz to 100 kHz, respectively (NMFS, 2016b).

Since mysticete species are considered sensitive to LF sound, the 10 potentially occurring mysticete species in the study area for SURTASS LFA sonar are assessed in this SEIS/SOEIS. The potential exists for odontocetes to perceive and be affected by exposure to LFA sonar transmissions, so the 31 odontocete species that may occur in the study area for SURTASS LFA sonar are also assessed in this SEIS/SOEIS. The five pinniped species that potentially occur in the study area for SURTASS LFA sonar are capable of hearing SURTASS LFA sonar transmissions, and as such, merit consideration herein.

Information about the status, stocks, abundances, distribution, seasonality, diving, and swim speeds for each of the 46 potentially occurring species of marine mammals is presented herein. This information represents the best available on these species and stocks and is presented in taxonomic order (as organized in Table 3-6) and follows the taxonomy defined by the SMM (2017). Abundance and stock information is limited to those populations, stocks, or DPSs that are found in the study area for SURTASS LFA sonar.

3.4.3.3.1 Cetaceans

Cetaceans (whales, dolphins, and porpoises) are wholly aquatic and never purposefully return to land. They are ecologically diverse group that are classified in two suborders: Mysticeti or baleen whales and Odontoceti or toothed whales (which is also inclusive of dolphins and porpoises) (SMM, 2017). Considered in this SEIS/SOEIS are 41 cetacean species, 10 of which are mysticetes and 31 odontocetes. Six of the potentially occurring mysticete species or at least one of these species' DPSs, are listed as endangered under the ESA, as are two odontocete species that are likely to occur in the study area for SURTASS LFA sonar (Table 3-6).

Mysticetes are distinguished by their larger body size and specialized baleen feeding structures, which are keratinous plates that replace teeth and are used to filter zooplankton (e.g., krill) and small fishes from seawater. In contrast, odontocetes have teeth for feeding and exhibit greater foraging diversity.

Table 3-6. Marine Mammal Species and Stocks (or DPSs) Evaluated in this SEIS/SOEIS for Potential Effects Associated with Exposure to SURTASS LFA Sonar and their Status Under the ESA and MMPA. Taxonomy Follows that of the Society for Marine Mammalogy (2017), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
	Cetaceans—Mysticetes		
Balaenidae	North Pacific right whale (*Eubalaena japonica*)	Endangered	Depleted
Eschrichtiidae	Gray whale *(Eschrichtius robustus)*	Endangered—Western North Pacific DPS	Depleted—Western North Pacific DPS
Balaenopteridae	Antarctic minke whale (*Balaenoptera bonaerensis)*		
	Blue whale (*Balaenoptera musculus)* Pygmy: *Balaenoptera musculus brevicauda* Northern: *Balaenoptera musculus musculus* *Northern Indian: Balaenoptera musculus indica*	Endangered	Depleted
	Bryde's whale (*Balaenoptera edeni)*[22]		
	Common minke whale (*Balaenoptera acutorostrata)* *North Pacific: Balaenoptera acutorostrata scammoni*		
	Fin whale (*Balaenoptera physalus)* Northern: *Balaenoptera physalus physalus* Southern: *Balaenoptera physalus quoyi*	Endangered	Depleted
	Humpback whale (*Megaptera novaeangliae*) North Pacific: *Megaptera novaeangliae kuzira* Southern: *Megaptera novaeangliae australis*	Endangered—Western North Pacific DPS	Depleted
	Omura's whale (*Balaenoptera omurai*)		
	Sei whale (*Balaenoptera borealis*) Northern: *Balaenoptera borealis borealis* Southern: *Balaenoptera borealis schlegelii*	Endangered	Depleted
	Cetaceans—Odontocetes		
Physeteridae	Sperm whale (*Physeter macrocephalus*)	Endangered	Depleted
Kogiidae	Dwarf sperm whale (*Kogia sima*)		
	Pygmy sperm whale (*Kogia breviceps)*		

22 The Gulf of Mexico population of Bryde's whale has been proposed for listing as endangered under the ESA, but this DPS does not occur in the study area for SURTASS LFA sonar.

Table 3-6. Marine Mammal Species and Stocks (or DPSs) Evaluated in this SEIS/SOEIS for Potential Effects Associated with Exposure to SURTASS LFA Sonar and their Status Under the ESA and MMPA. Taxonomy Follows that of the Society for Marine Mammalogy (2017), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
Ziphiidae	Baird's beaked whale (*Berardius bairdii)*		
Ziphiidae (Continued)	Blainville's beaked whale (*Mesoplodon densirostris)*		
	Cuvier's beaked whale (*Ziphius cavirostris*)		
	Deraniyagala's beaked whale (*Mesoplodon hotaula)*		
	Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens)*		
	Hubbs' beaked whale (*Mesoplodon carlshubbsi*)		
	Longman's beaked whale (*Indopacetus pacificus*)		
	Southern bottlenose whale (*Hyperoodon planifrons)*		
	Spade-toothed beaked whale (*Mesoplodon traversii)*		
	Stejneger's beaked whale (*Mesoplodon stejnegeri)*		
Delphinidae	Common dolphin (*Delphinus delphis)* Indo-Pacific: *Delphinus delphis tropicalis*		
	Common bottlenose dolphin (*Tursiops truncatus truncatus*)		
	False killer whale (*Pseudorca crassidens*)	Endangered—Main Hawaiian Islands Insular DPS	Depleted—Main Hawaiian Islands Insular DPS
	Fraser's dolphin (*Lagenodelphis hosei*)		
	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)		
	Killer whale (*Orcinus orca)*[23]		
	Melon-headed whale (*Peponocephala electra*)		
	Northern right whale dolphin (*Lissodelphis borealis*)		
	Pacific white-sided dolphin (*Lagenorhynchus obliquidens)*		
	Pantropical spotted dolphin (*Stenella attenuata*)		
	Pygmy killer whale (*Feresa attenuata*)		

23 The Southern Resident killer whale DPS is listed as endangered, but this DPS occurs principally in U.S. and Canadian inland waters, which is not located in the study area for SURTASS LFA sonar.

Table 3-6. Marine Mammal Species and Stocks (or DPSs) Evaluated in this SEIS/SOEIS for Potential Effects Associated with Exposure to SURTASS LFA Sonar and their Status Under the ESA and MMPA. Taxonomy Follows that of the Society for Marine Mammalogy (2017), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
	Risso's dolphin (*Grampus griseus*)		
	Rough-toothed dolphin (*Steno bredanensis*)		
Delphinidae (Continued)	Short-finned pilot whale (*Globicephala macrorhynchus)*		
	Spinner dolphin (*Stenella longirostris)*		
	Striped dolphin (*Stenella coeruleoalba)*		
Phocoenidae	Dall's porpoise (*Phocoenoides dalli*) *dalli*-type*: Phocoenoides dalli dalli* *truei*-type: *Phocoenoides dalli truei*		
	Harbor porpoise (*Phocoena phocoena*)		
Pinnipeds			
Otariidae	Northern fur seal (*Callorhinus ursinus*)		
	Western Steller sea lion (*Eumetopias jubatus jubatus*)	Endangered—Western DPS/stock	Depleted
Phocidae	Hawaiian monk seal (*Neomonachus schauinslandi*)	Endangered	Depleted
	Ribbon seal (*Histriophoca fasciata)*		
	Spotted seal (*Phoca largha*)	Threatened—Southern DPS	Depleted—Southern DPS

Both cetacean groups are capable of emitting sound, but only odontocetes emit biosonar or echolocation signals that can be used for prey and object location and navigation.

Sound production and hearing are highly developed in all studied cetacean species. Of all mammals, cetaceans have the broadest acoustic range and fully specialized ears adapted for underwater hearing. Little information, however, is available on the hearing capabilities of most cetacean species (Ketten, 1994 and 2000). Although the hearing capability of no mysticete species has been directly measured, the scientific consensus is that mysticetes hear LF sound, from approximately 7Hz to 30 kHz, as estimated from observed vocalization frequencies, behavioral reactions to sound playback, and anatomical studies of mysticetes auditory systems (NMFS, 2016a). Odontocetes hear a broader range of sound frequencies, including mid- to high-frequencies that range from 150 Hz to 160 kHz, depending upon the species. Odontocete species such as the majority of dolphins and beaked, toothed, and bottlenose whales have greatest hearing sensitivity in the mid-frequency ranges of 150 Hz to 160 kHz, while the remainder of odontocetes including porpoises, cephalorhynchid and river dolphins, two species of *Lagenorhynchus* dolphins (hourglass and Peale's dolphins), and the two *Kogia* species have hearing sensitivity in the frequency range from 275 Hz to 160 kHz (NMFS, 2016a).

Sound production in cetaceans varies over a wide range of frequencies, sound types, and sound levels. While all functions of underwater sound production are not completely understood, vocalizations are likely used for echolocation, communication, navigation, sensing of the environment, prey detection, and orientation (Clark and Ellison, 2004; Ellison et al., 1987; George et al., 1989; Tyack, 2000). Some mysticetes such as humpback and blue whales produce songs, complex repetitions of patterned sequences, while most odontocetes produce click echolocation sounds as well as complicated sets of pulses and whistles (Frankel, 2018).

- ***Mysticetes (Baleen Whales): Balaenidae***

  - *North Pacific Right Whale (Eubalaena japonica)*

The North Pacific right whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as a species, is classified as endangered under the IUCN Red List of Threatened Species, although the Eastern North Pacific (ENP) stock is classified as critically endangered (Reilly et al., 2008i). Two stocks or populations of North Pacific right whales have been identified, with the ENP stock encompassing right whales found in the Gulf of Alaska and the Bering Sea while the Western North Pacific (WNP) stock consists of right whales occurring in the Commander Islands, off the coast of Kamchatka, the Kuril Islands, and in the Sea of Okhotsk (Brownell et al., 2001; LeDuc et al., 2012).). Critical habitat, comprising a total of 27,756 nmi^2 (95,200 km^2) in area for the North Pacific right whale has been designated in two areas of Alaska's marine waters: southeastern Bering Sea and the northwestern Gulf of Alaska where North Pacific right whales have been observed foraging (NOAA, 2008b). No overall population estimate for North Pacific right whales is available, but likely, less than 1,000 North Pacific right whales are currently living, as the population of ENP right whales is very small, with only 31 whales estimated (Wade et al, 2011; Muto et al., 2018). The WNP stock, which occurs within the study area for SURTASS LFA sonar, is estimated to include 922 individuals (Best et al., 2001).

Since so few North Pacific right whales exist, little information about the species is available. North Pacific right whales regularly occur only in the Sea of Okhotsk and the southeastern Bering Sea with very rare occurrences documented in the waters of the Gulf of Alaska, Sea of Japan (off South Korea), and North Pacific waters around the Ogasawara and Kuril islands; Hokkaido, Japan; and offshore Kamchatka (Jefferson et al., 2015; NMFS, 2018d; Sekiguchi et al., 2014). Since 2013, two North Pacific right whales have been reported off Hokkaido (one entangled) and one right whale was documented off South Korea, which was the first observation of this species in the Sea of Japan in 41 years (NMFS, 2018d). No swim speed information is available for the North Pacific right whale except that they are known to be slow swimmers. Thode et al. (2017) estimated the water depth of gunshot and upcall vocalizations to range from near the surface to 82 ft (25 m), which is consistent with the dive patterns of the North Atlantic right whale. Dive durations range from 41 to 726 sec (Crance, 2017).

There is no direct measurement of the hearing sensitivity of right whales (Ketten, 2000; Thewissen, 2002). However, thickness measurements of the basilar membrane of North Atlantic right whale suggests a hearing range from 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2007); this same range can be used as a proxy for North Pacific right whales. McDonald and Moore (2002) studied the vocalizations of North Pacific right whales in the eastern Bering Sea using autonomous seafloor-moored recorders and described five vocalization categories: up-calls, down-up calls, down calls, constant calls, and unclassified vocalizations. The up-call was the predominant type of vocalization and typically swept from 90 to 150 Hz, while the down-up call swept down in frequency for 10 to 20 Hz before it became a typical up call, and the down and constant calls were typically interspersed with up calls (McDonald and Moore, 2002). Constant calls were also subdivided into two categories: single frequency tonal or a frequency waver of up and down, which varied by approximately 10 Hz; the down and constant calls were lower in frequency than the up calls, averaging 118 Hz for the down call and 94 Hz for the constant call (McDonald and Moore, 2002). Munger et al. (2011) reported the SL of North Pacific right whale upcalls to be averaged from 176 to 178 dB re 1 μPa @ 1 m, with a frequency range of 90 to 170 Hz. Crance (2017) described a sixth type of North Pacific right whale vocalization as a gunshot, which is an impulsive signals that ranges from 50 Hz to 5.5 kHz, with an average duration of 0.3 sec.

- ***Mysticetes (Baleen Whales): Eschrichtiidae***

  - *Gray Whale (Eschrichtius robustus)*

Two genetically distinct stocks and DPSs, the WNP and Eastern North Pacific (ENP), of gray whales exist in the North Pacific Ocean (LeDuc et al., 2002). The ENP stock and DPS of gray whales was delisted from the ESA. The WNP DPS of gray whales is extremely small and remains listed as endangered under the ESA, depleted under the MMPA, and is considered critically endangered under the IUCN Red List of Threatened Species (Reilly et al., 2008a). The WNP stock/DPS was thought to be extinct, but a small group of 140 gray whales remains (Carretta et al., 2015).

Gray whales occur in shallow (16 to 49 ft [5 to 15 m]) coastal waters of the North Pacific Ocean and adjacent seas, occurring as far south as southern China in the western North Pacific and Mexico in the eastern North Pacific Ocean (Jefferson et al., 2015). Gray whales annually migrate north-south from high latitude feeding grounds to low latitude breeding grounds. Information about the WNP gray whale stock/DPS is not nearly as complete as is information about the eastern stock, but WNP gray whales summer in the Sea of Okhotsk, primarily near Sakhalin Island, and in Pacific waters off Kamchatka and eastern Japan and migrate southward via the Sea of Japan, East China, and South China seas (Meier et al., 2007; Weller et al., 2002). Reilly et al. (2018a) note that recent sightings in Pacific waters off Japan during the migrational period may suggest that WNP gray whales are using those waters as an additional or new migrational route. The breeding and calving grounds for the WNP gray whale are unknown, but Hainan Island in the South China Sea has been suggested as a possible location (Brownell and Chun, 1977). WNP gray whales have been satellite tracked traveling from Russia to America and sighted off

North America (Mate et al., 2015; Weller et al., 2012), which may suggest genetic interchange between the two populations of North Pacific gray whales and that at least some members of both populations may share a common winter ground (Swartz, 2018).

Gray whales generally are not deep or long-duration divers. Swartz (2018) noted the maximum dive depth known for gray whales as 557 ft (170 m), and Stewart et al. (2001) reported a maximum duration of 13.25 min for gray whales, although Swartz (2018) reported a longer maximum dive duration of 26 min. Typical dives are to water depths of < 98 ft (30 m), with dives to <33 ft (10 m) most common, and mean dive durations of 2.24 min (Stelle et al., 2008; Stewart et al., 2001). Würsig et al. (1986) noted that during summer, foraging gray whales exhibited dive times as long as 7 min, with a mean duration of 4 min. Swim speeds during migration average 2.4 to 4.9 kt (4.5 to 9 kph), with pursued gray whaled reaching speeds of 8.64 kt (16 kph) (Jones and Swartz, 2009). Gray whales migrating in Canadian waters moved with mean speeds of 2.5 to 3.2 kt (4.7 to 5.9 kph) (Ford et al., 2013).

Sparse data exist on the hearing sensitivity of gray whales. Ridgway and Carder (2001) attempted to measure hearing thresholds in a stranded gray whale but were not successful. Dahlheim and Ljungblad (1990) suggest that free-ranging gray whales are most sensitive to tones between 800 and 1,500 Hz. Migrating gray whales showed avoidance responses at ranges of several hundred meters to LF playback SLs of 170 to 178 dB when the source was placed within their migration path at about 1.1 nmi (2 km) from shore, but this response ceased when the source was moved out of their migration path even though the RLs remained similar to the earlier condition (Clark et al., 1999). Gray whales detected and responded to 21 kHz sonar signals, indicating that their hearing range extends at least that high in frequency (Frankel, 2005).

Gray whales produce a variety of sounds from about 100 Hz to 4 kHz (Swartz, 2018). The most common sounds recorded during foraging and breeding are knocks and pulses with frequencies from <100 Hz to 2 kHz, with most energy concentrated at 327 to 825 Hz (Richardson et al., 1995). Tonal moans are produced during migration in frequencies ranging between 100 and 200 Hz (Jones and Swartz, 2009). A combination of clicks and grunts has also been recorded from migrating gray whales in frequencies ranging below 100 Hz to above 10 kHz (Frankel, 2018). The SLs for sounds produced by gray whales range between 167 and 188 dB (Frankel, 2018).

- ***Mysticetes (Baleen Whales): Balaenopteridae***

  - *Antarctic Minke Whale (Balaenoptera bonaerensis)*

The Antarctic minke whale is listed by the IUCN Red List of Threatened Species as data deficient (Reilly et al., 2008b). Reilly et al. (2008b) suggested a corrected population estimated as 339,000 individuals (CV=0.079), while the International Whaling Commission (IWC) more recently estimated the entire population as 515,000 (IWC, 2013; Perrin et al. 2018). The population of Antarctic minke whales occurring off Western Australia has been estimated as 90,000 whales (Bannister et al., 1996).

Antarctic minke whales range from the waters of the Southern Ocean in Antarctica south of 60° S to the ice edge during austral summer to waters of the Pacific, Atlantic, and Indian oceans from about 10° to 30° S during austral winter, when they have been observed as far north as Brazil and Peru, with some whales having been reported to overwinter in Antarctic waters (Reilly et al., 2008b; Perrin et al., 2018). Antarctic minke whales are primarily oceanic, occurring in waters beyond the continental shelf break (Perrin et al., 2018).

Leatherwood et al., (1981) observed that Antarctic minke whales off Ross Island, Antarctica dove for durations between 9.7 to 10.8 min, and after making a series of shallow dives, the whales dove up to 14 min. Diving behavior has been recorded from foraging individuals, with three dive types identified: short and shallow, under ice, and long and deep (Friedlaender et al., 2014). The mean dive depth for short, shallow dives was 33 ft (10 m), 98 ft (30 m) for under ice dives, and 187 ft (57 m) for long, deep dives (Friedlaender et al., 2014). Dive times ranged from 1 to 6 min (Friedlaender et al., 2014). Risch et al. (2014) noted that Antarctic minke whales made shallow dives to <131 ft (40 m) at night and deeper dives to over 328 ft (100 m) during the day. The Antarctic minke whale can swim at speeds of up to 10.8 kt (20 kph).

Hearing sensitivity of Antarctic minke whales has not been measured (Ketten, 2000; Thewissen, 2002). However, models of minke whale middle ears predict their best hearing overlaps with their vocalization frequency range (Tubelli et al., 2012). Antarctic minke whales produce a variety of sounds, including whistles, clicks, screeches, grunts, downsweeps, calls that sound like clanging bell, and a sound called "bio-duck" (Leatherwood et al., 1981; Risch et al., 2014a). Downsweeps are intense, LF calls that sweep down from about 130 Hz to about 60 Hz, with a peak frequency of 83 Hz, and an average SL of about 147 dB re 1 µPa @ 1 m (Schevill and Watkins, 1972). The "bio-duck" sound was first described in the 1960s and resembles the quack of a duck. Bioduck signals consist of a series of pulse trains of short downswept signals with a peak frequency of 154 Hz, SL of 140 dB re 1 µPa @ 1 m, and sometimes include harmonics up to 1 kHz (Risch et al., 2014a). The bio-duck sound appears to be produced when whales are at the sea surface before foraging dives.

- *Blue Whale (Balaenoptera musculus) and Pygmy Blue Whale (Balaenoptera musculus brevicauda)*

Multiple subspecies and stocks exist worldwide but only the pygmy blue whale is typically differentiated as a species at-sea. The information available for the pygmy blue whale in the part of the study area in which it may occur is detailed herein; otherwise, information is presented on the blue whale as a species. The blue whale is listed as endangered under the ESA; depleted under the MMPA; protected under CITES; and as endangered (blue), data deficient (pygmy blue), and as critically endangered (Antarctic blue) by the IUCN Red List of Threatened Species (Reilly et al., 2008c). The global population of blue whales is estimated between 10,000 to 25,000 individuals (Reilly et al., 2008c). In the central North Pacific (CNP) stock of blue whales, 133 individuals (CV=1.09) are estimated to occur (Bradford et al., 2017), while 9,250 blue whales are estimated for the WNP stock (Tillman, 1977). The Northern Indian Ocean stock of blue whales has been estimated to include 3,432 whales (IWC, 2016), while 1,657 blue whales are estimated to occur in the Southern Indian Ocean stock (inclusive of both pygmy blue and blue whales) (Jenner et al., 2008; McCauley and Jenner, 2010).

Blue whales are distributed in oceanic subpolar to tropical waters of the world's oceans and some continental seas except the Mediterranean Sea and Gulf of Mexico (Jefferson et al., 2015). Occurring primarily in open ocean waters, they also may occur in neritic waters when foraging and possibly when breeding. Blue whales occur in lower numbers in the central and western North Pacific than in the eastern North Pacific Ocean, but blue whales are reported from Hawaiian waters and from Kamchatka and the Kuril Islands to offshore Japan (Sears and Perrin, 2018). Blue whales occur throughout the Indian Ocean, with at least some blue whales off Sri Lanka remaining at low-latitudes throughout the year, presumably, because oceanographic upwelling supports sufficient productivity and prey (de Vos et al., 2014). The pygmy blue whale occurs in the Southern Hemisphere, particularly in the Indian Ocean off the west coast of Australia and moves between ~42°S and the Molucca Sea near the equator (Double et al., 2014). Not all blue whales are migratory, as some remain resident and do not seasonally move from lower latitude calving and breeding grounds and higher latitude foraging grounds (Jefferson et al., 2015; Sears and Perrin, 2018).

The swimming and diving behavior of blue whales has been relatively well characterized. General blue whale dive durations and dive depths range from 5 to 15 min and 591 to 656 ft (180 to 200 m), respectively (Croll et al., 1998 and 2001a). Dives of 20 to 30 min are not unusual and the longest dive recorded was 36 min long (Jefferson et al., 2015; Sears and Perrin, 2018). Calambokidis et al. (2008a) reported a maximum dive depth of 961 ft (293 m). Foraging blue whales appear to dive more shallowly, with average foraging dives reaching only 223 ft (67.6 m) (Croll et al., 2001a). A migrating pygmy blue whale was observed consistently diving to 43 ft (13 m) (Owen et al., 2016). Dive descent swim rates of 2.4 kt (4.5 kph) have been recorded (Williams et al., 2000). The common surface swim speed for blue whales is 1.6 to 3.2 kt (3 to 6 kph), but travel speeds of 3.8 to 10.8 kt (7 to 20 kph) are not uncommon, and the maximum swim speed reported for a blue whale 18.9 kt (35 kph) (Sears and Perrin, 2018).

No hearing sensitivity has been measured for blue whales (Ketten, 2000; Nummela, 2009). Blue whales produce a variety of LF vocalizations ranging from 10 to 200 Hz throughout the year but with peaks in midsummer and winter (Alling and Payne, 1990; Clark and Fristrup, 1997; Edds, 1982; Rivers, 1997; Stafford et al., 1998, 1999a, 1999b, and 2001; Thompson and Friedl, 1982; Sears and Perrin, 2018). The majority of blue whale vocalizations are infrasonic sounds from 17 to 20 Hz with a SL of 188 dB re 1 µPa @ 1 m (Sears and Perrin, 2018), which makes their vocalizations amongst the loudest made by any animal (Aroyan et al., 2000; Cummings and Thompson, 1971). However, calls produced during foraging have been measured at lower SLs, ranging from 158 to 169 dB re 1 µPa @ 1 m (Akamatsu et al., 2014). Short sequences of rapid frequency modulated (FM) calls below 90 Hz are associated with animals in social groups (Mellinger and Clark, 2003; Moore et al., 1999). Off Australia, at least five types of pygmy blue whale calls were detected that consisted of amplitude modulated (AM) and FM components with frequencies ranging from 20 to 750 Hz, and durations between 0.9 and 4.4 seconds (Recalde-Salas et al., 2014). Calls produced by foraging blue whales off Iceland were FM downsweeps with a frequency range of 105 to 48 Hz and durations of 1to 2 sec (Akamatsu et al., 2014). Blue whales also produce a variety of transient sound (i.e., they do not occur in predictable patterns or have much interdependence of probability) in the 30 to 100 Hz band (sometimes referred to as "D" calls). These usually sweep down in frequency or are inflected (up-over-down), occur throughout the year, and are assumed to be associated with socializing when animals are in close proximity (Mellinger and Clark, 2003). Blue whales also produce long, patterned hierarchically organized sequences that are characterized as songs. Blue whales produce songs throughout most of the year with a peak period of singing overlapping with the general period of functional breeding.

The call characteristics of blue whales vary geographically and seasonally (Stafford et al., 2001). McDonald et al. (2006) have suggested that song characteristics could indicate population structure. In temperate waters, intense bouts of long, patterned sounds are common from fall through spring, but these also occur to a lesser extent during the summer in high-latitude feeding areas. Call rates during foraging may be very low, with a recent study recorded four calls during ~22 hours (Akamatsu et al., 2014).

- *Bryde's Whale (Balaenoptera edeni)*

The taxonomy of the Bryde's whale has not been completely resolved (SMM, 2017). Nevertheless, two forms of the Bryde's whale have been provisionally recognized: the larger, oceanic Bryde's whale (*B.*

edeni brydei) and the smaller, coastal Eden's whale (*B. edeni edeni*) (Kato and Perrin, 2018; Kershaw et al., 2013; Luksenberg et al., 2015; SMM, 2017). The offshore Bryde's whale occurs globally in pelagic waters, while the Eden's whale typically occurs in nearshore waters of the Pacific and Indian oceans (SMM, 2017). The examination of genetics samples from the Pacific and Indian oceans by Kershaw et al. (2013) clarified the existence of two forms of Bryde's whales, and the additional osteological and genetic analyses by Luksenberg et al. (2015) confirmed the conclusion of two Bryde's whale subspecies (Kato and Perrin, 2018). In the study area for SURTASS LFA sonar, both forms of Bryde's whales occur (de Boer et al., 2003; Martenstyn, 2016; Reilly et al., 2008d). However, due to the lack of resolution regarding the taxonomy and specific information about the Eden's whale in most areas, information is presented herein on the Bryde's whale at the species level.

The Bryde's whale is currently protected under CITES and is classified as a data deficient as a species by the IUCN Red List of Threatened Species (Reilly et al., 2008d). In December 2016, NMFS proposed listing the Gulf of Mexico (GOMx) Bryde's whale as endangered under the ESA (NOAA, 2016h). The GOMx Bryde's whale population includes those Bryde's whales that breed and feed solely in the GOMx. NMFS made the determination that the GOMx Bryde's whale is a unique evolutionary lineage, taxonomically distinct from other subspecies, and is thus classified as an unnamed subspecies rather than a DPS (NOAA, 2016h). The IWC recognizes four stocks of Bryde's whales in the North Pacific Ocean: Western North Pacific (WNP), Eastern Tropical, East China Sea, and Gulf of California (IWC, 1996) and the following stocks for the Southern Hemisphere: Western and Eastern South Pacific, Northern and Southern Indian Ocean, South African Inshore, and South Atlantic (IWC, 1980). NMFS additionally has identified a Hawaii stock of Bryde's whales in the central North Pacific Ocean. No global population estimates of Bryde's whales exist. In the western North Pacific Ocean, the population of Bryde's whales is estimated by the IWC as 20,501 whales (IWC, 2009). In the East China Sea, the stock of Bryde's whale is estimated as 137 individuals (IWC, 1996), and in Hawaiian waters, 1,751 Bryde's whales (CV=0.29) have been estimated (Bradford et al., 2017). In the Northern Indian Ocean, 9,176 Bryde's whales have been estimated (IWC, 2016; Wade and Gerrodette, 1993), while 13,854 Bryde's whales have been estimated for the Southern Indian Ocean (IWC, 1981).

Bryde's whales occur roughly between 40°N and 40°S throughout tropical and warm temperate (>61.3°F [16.3°C]) waters of the Atlantic, Pacific, and Indian oceans year round (Kato and Perrin, 2018; Omura, 1959). Bryde's whales occur in some semi-enclosed waters such as the Gulf of California, Gulf of Mexico, and East China Sea (Kato and Perrin, 2018). Recent sightings indicate that the range of Bryde's whales is expanding poleward (Kerosky et al., 2012). Bryde's whales are distributed in the subarctic-subtropical transition area of the western North Pacific Ocean (frontal boundary where subarctic waters intersect the warmer waters of the Kuroshio Current) throughout summer, which is thought to be a feeding area (Watanabe et al., 2012), although the foraging distribution in the western North Pacific is highly linked to the distribution of their prey (Sasaki et al., 2013). Most Bryde's whales are thought to migrate seasonally toward the lower latitudes near the equator in winter and to high latitudes in summer (Kato and Perrin, 2018). However, Bryde's whales remain resident in areas off South Africa, California, and the Gulf of Mexico throughout the year, migrating only short distances (Best, 1960; Tershy, 1992; Rosel et al., 2016). Foraging grounds are not well known for this species, although there is evidence that they feed on a wide range of food in both pelagic and nearshore areas (Niño-Torres et al., 2014). Murase et al. (2016) noted that two satellite-tagged Bryde's whales in the offshore waters of the western North Pacific Ocean did not remain in the northern, subarctic-tropical transition feeding area throughout the summer, but instead traveled southward to tropical waters between 20° and 30°N.

Bryde's whales can dive to a water depth of about 984 ft (300 m) (Kato and Perrin, 2018). The maximum dive time reported for two Bryde's whales off Madeira Island was 9.4 min, with more routine dives lasting 5 min, and mean dive durations of 0.4 to 6 min (Alves et al., 2010). Bryde's whales off Venezuela made dives in duration of 3 to 11 min (Notarbartolo di Sciara, 1983). Alves et al. (2010) also reported routine dives by Bryde's whales to water depths from 131 to 656 ft (40 to 200 m) and a dive to a maximum depth of 958 ft (292 m). Bryde's whales are relatively fast swimming whales. The maximum swim speed reached by a Bryde's whale was recorded at 10.8 to 13.5 kt (20 to 25 kph), with average swim speeds reported between 1.1 and 3.8 kt (2 and 7 kph) (Kato and Perrin, 2018; Murase et al., 2016). Bryde's whales tracked off Kauai, HI swam at speeds that ranged from 0.8 to 8.6 kt (0.15 to 16 kph), with an overall mean swim speed of 3.2 kt (6 kph) (Helble et al., 2016).

No direct measurements of Bryde's whales hearing sensitivity have been conducted (Ketten, 2000). Bryde's whales are known to produce a variety of LF sounds ranging from 20 to 900 Hz, with the higher frequencies being produced between cow-calf pairs (Cummings, 1985; Edds et al., 1993). Oleson et al. (2003) reported call types with fundamental frequencies below 240 Hz. These lower frequency call types have been recorded from Bryde's whales in the Caribbean, ETP, and off the coast of New Zealand. Additional call types have been recorded in the Gulf of Mexico (Širović et al., 2014). Calves produce discrete pulses at 700 to 900 Hz (Edds et al., 1993). SLs range between 152 and 174 dB re 1 µPa @ 1 m (Frankel, 2018). Pulsive, FM and AM calls with a frequency range of 50 to 900 Hz and 0.4 to 4.5 second duration were recorded off Brazil (Figueiredo, 2014).

- *Common Minke Whale (Balaenoptera acutorostrata)*

The taxonomy of the minke whale has been complex to unravel and is not yet fully resolved. The SMM (2017) has subdivided the common minke whale into three subspecies, with two subspecies representing the standard minke whales that are now known to occur only in the North Pacific (*B. acutorostrata scammoni*) and Atlantic *B. acutorostrata acutorostrata)* oceans, and a third unnamed subspecies representing the dwarf form that principally occurs in the waters of the Southern Hemisphere. Separation of the information and data about the standard and dwarf forms of the common minke whale is further complicated by a non-distinct boundary between the forms, with the dwarf form sometimes moving into waters of the Northern Hemisphere, and the two forms only being distinguishable at sea by subtle coloration differences (Jefferson et al., 2015). Little to no population-level data is available on the dwarf minke whale, so for purposes of this SEIS/SOEIS, information is presented on the common minke whale as a species, inclusive of the dwarf minke whale.

The common minke whale is protected under CITES as well as the MMPA and is classified by the IUCN Red List of Threatened Species as species of least concern (Reilly et al., 2008e). The IWC has recently re-evaluated the stock structure of common minke whales in the western North Pacific Ocean, and although not fully resolved given a lack of data for minke whales during winter on their reputed breeding grounds, the IWC has concluded that most likely five stocks of common minke whales occur in the western North Pacific Ocean (Wade and Baker, 2011). The IWC proposes the following stocks of common minke whales in the western North Pacific Ocean: Yellow Sea stock (Y stock), Sea of Japan stock (JW stock), Pacific-coast of Japan stock (JE stock), Pacific nearshore (<10 nmi [18.5 km] from coast) stock (OW stock), and Pacific offshore stock (OE stock) (Wade and Baker, 2011). These stock definitions are based on unique genetic characteristics (i.e., mitochondrial DNA and microsatellite DNA) and dates of conception of the common minke whales in each of the proposed stock areas. For example, common minke whales in the Y stock (Yellow Sea) all conceive in the autumn while common minke whales in the OW and OE stocks (Pacific nearshore and offshore) conceive only in winter (Wade and Baker, 2011). The

Navy considers these stock definitions to be the best available science to characterize the populations and stocks of common minke whales that occur in the western North Pacific Ocean region of the study area for SURTASS LFA sonar. Further, the SMM (2017) has differentiated a North Pacific subspecies of common minke whales. Thus, it is the North Pacific subspecies of the common minke whale (Table 3-6) that occurs in the western and central North Pacific Ocean region of the study area.

The IWC reported a 1992 to 2004 population estimate of minke whales in the Southern Hemisphere as 515,000 (IWC, 2016), while the population of common minke whales in the Northern Hemisphere has been estimated to include at least 180,000 individuals (Jefferson et al., 2015). The population of the WNP OE stock of common minke whales has been estimated as 25,049 individuals (Buckland et al., 1992; Miyashita and Okamura 2011), while the Y stock is estimated to include 4,492 whales (Hakamada and Hatanaka, 2010; Miyashita and Okamura, 2011), and the JW stock is estimated to include a population of 2,611 whales (Miyashita and Okamura, 2011). The Hawaii stock of common minke whales occurring in the central North Pacific Ocean has been estimated to include 25,049 individuals (Buckland et al., 1992). A single stock of common minke whales has been identified for the Indian Ocean, with an estimated abundance of 257,500 whales (IWC, 2016).

Minke whales occur most often in tropical to polar coastal/neritic and inshore waters of the Atlantic, Pacific, and Indian oceans but more infrequently also occur in pelagic waters. Common minke whales are considered rare in the northern Indian Ocean (Salm et al., 1993; Sathasivam, 2002), Gulf of Mexico, and Mediterranean Sea (Jefferson et al., 2015). Common minke whales are thought to be migratory, at least in some areas, but migratory pathways are not well known and populations in some area remain resident year-round (Reilly et al., 2008e). Likely, these whales migrate seasonally to higher latitudes to feed and move to lower latitudes to breed and calve (Víkingsson and Heide-Jørgensen, 2015).

Minke whales in the St. Lawrence River performed dives characterized as short and long dives, with short dives lasting between 2 and 3 min, while long dives ranged from 4 to 6 min (Christiansen et al., 2015). Stockin et al. (2001) observed dives of common minke whales averaging 1 to 1.4 min in length, while Stern (1992) noted dives of 4.4 min durations, and Joyce et al. (1989) measured dive durations off Norway of 1 to 6 min (Joyce et al., 1989). Kvadsheim et al. (2017) reported that the dives of four tagged minke whales could be characterized as long, deep; intermediate; and short, shallow dives, accounting for 14 percent, 29 percent, and 57 percent of all baseline dives, respectively. Tagged minke whales dove to a maximum depth of 492 ft (150 m), and rarely dove deeper than 394 ft (120 m) (Kvadsheim et al., 2017). The mean swim speed for minke whales in Monterey Bay was 4.5 kt (8.3 kph) (Stern, 1992), while Blix and Folkow (1995) reported a “cruising” speed of minkes as 6.3 kt (11.7 kph). Ford et al. (2005) reported that common minke whales being pursued by killer whales swim at speeds ranging from 8.1 to 16.2 kt (15 to 30 kph).

Hearing sensitivity of minke whales has not been directly measured (Ketten, 2000; Thewissen, 2002). However, models of minke whale middle ears predict their best hearing overlaps with their vocalization frequency range (Tubelli et al., 2012). Sounds produced by common minke whales encompass a wide frequency range and variety of call types (Frankel, 2018). Minke whales produce a variety of sounds, primarily moans, clicks, downsweeps, ratchets, thump trains, grunts, and “boings” in the 80 Hz to 20 kHz range (Edds-Walton, 2000; Frankel, 2018; Mellinger et al., 2000; Risch et al., 2014a; Thompson et al., 1979; Winn and Perkins, 1976). The signal features of their vocalizations consistently include LF, short-duration downsweeps from 250 to 50 Hz. The energy in thump trains is concentrated in the 100 to 400 Hz band (Winn and Perkins, 1976; Mellinger et al., 2000). Complex vocalizations recorded from Australian minke whales involved pulses ranging between 50 Hz and 9.4 kHz, followed by pulsed tones at 1.8 kHz and tonal calls shifting between 80 and 140 Hz (Gedamke et al., 2001). The minke whale was been identified as the elusive source of the North Pacific "boing" sound (Rankin and Barlow, 2005; Risch et al., 2014a). Boings begin with a brief pulse and then a longer AM and FM signal lasting 2 to 10 sec over frequencies from 1 to 5 kHz (Rankin and Barlow, 2005; Risch et al., 2014a). SLs of common minke whale calls ranged from 164 to 168 dB re 1μPa @ 1 m (Risch et al., 2014b). Both geographical and seasonal differences have been found among the sounds recorded from minke whales (Risch et al., 2013).

- *Fin Whale (Balaenoptera physalus)*

The fin whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered by the IUCN Red List of Threatened Species (Reilly et al., 2013). The SMM (2017) has differentiated Northern and Southern subspecies of fin whales (Table 3-8). Since these subspecies are not differentiated at sea or in available population data and information, hereafter all information about the fin whale will only be referenced as a single species. The global population is estimated as <100,000 whales (Reilly et al., 2013). The population of fin whales in the Hawaii stock is estimated as 154 fin whales (CV=1.05) (Bradford et al., 2017), while fin whales in the East China Sea stock are estimated to include 500 individuals (Mizroch et al., 2009; Tillman, 1977; Evans, 1987), and the abundance of the WNP stock has been estimated as 9,250 individuals (Mizroch et al., 2009; Tillman, 1977). The northern Indian Ocean population of fin whales has been estimated to include 1,716 individuals (IWC, 2016), while the Southern Indian Ocean stock of fin whales off western Australia is estimated as 38,185 whales (Branch and Butterworth, 2001b; Mori and Butterworth, 2006).

Fin whales are widely distributed in all oceans of the world, from tropical to polar oceanic waters, but appear to be absent from equatorial waters (Aguilar and García-Vernet, 2018). Fin whales are sometimes observed in neritic waters, but typically when deep water approaches near to land (Jefferson et al., 2015). Although fin whales have traditionally been considered migratory, acoustic data suggests no seasonality in the annual distribution of fin whales (Watkins, et al., 2000). Although fin whale calls have been reported from the central Pacific waters of Hawaii in all months except June and July, sightings of fin whales in these waters are rare (Muto et al., 2018). Specific breeding areas are unknown.

Fin whales dive for a mean duration of 4.2 min at depths averaging 197 ft (60 m) (Croll et al., 2001a; Panigada et al., 2004). The deepest dive recorded for a fin whale was to a depth of 1,542 ft (470 m) but dives to <328 ft (100 m) are more routine (Panigada et al., 1999). Fin whales forage at water depths between 328 to 656 ft (100 and 200 m), with foraging dives lasting from 3 to 10 min (Aguilar and García-Vernet, 2018; Witteveen et al., 2015). When traveling, fin whales have been recorded diving only to an average of 194 ft (59 m) (Croll et al., 2001a). Swimming speeds average between 5 to 8 kt (9.2 and 14.8 kph) (Aguilar, 2009). The average speed of descent during dives in the Mediterranean has been measured as 6.2 kt (11.5 kph), while the swim speed of ascending dives was recorded as 4.1 kt (7.6 kph) (Panigada et al., 1999). Watkins (1981) reported bursts of speed in fin whales up to 10.8 kt (20 kph). Singing fin whales swam at average speeds of 2.9 to 4.8 kt (5.3 to 8.8 kph) (Varga et al., 2018).

There is no direct measurement of fin whale hearing sensitivity (Ketten, 2000; Thewissen, 2002). Fin whales produce a variety of LF sounds that range from 10 to 200 Hz (Edds, 1988; Watkins, 1981; Watkins et al., 1987a). Short sequences of rapid FM calls from 20 to 70 Hz are associated with animals in social groups (Edds, 1988; McDonald et al., 1995; Watkins, 1981). The most common fin whale vocalization is what is referred to as the "20-Hz signal or call", which is a LF (18 to 35 Hz) loud and long (0.5 to 1.5 sec) patterned sequence signal centered at 20 Hz (Clark et al., 2002; Patterson and Hamilton, 1964; Watkins et al., 1987a). The pulse patterns of the 20-Hz signal vary only slightly geographically and with season (McDonald et al., 1995, Oleson et al., 2014; Širovic´ et al., 2007, 2013; Varga et al., 2018). The 20-Hz signal is common from fall through spring in most regions but also occurs to a lesser extent during the summer in high-latitude feeding areas (Clark and Charif, 1998; Clark et al., 2002). In the Atlantic, 20-Hz signals are produced regularly throughout the year, with Atlantic fin whales also producing higher frequency downsweeps ranging from 100 to 30 Hz (Frankel, 2018). Fin whales produce the 20-Hz call in two forms: songs and call-counter calls (Buccowich, 2014; McDonald and Fox, 1999; McDonald et al., 1995; Oleson et al., 2014; Širovic´ et al., 2013; Varga et al., 2018; Watkins et al., 1987a). 20-Hz songs are simply regular patterns of 20-Hz calls that are associated with reproductive behavior, and are only produced by males (Croll et al., 2002; Delarue et al., 2013; Širovic´ et al., 2013 and 2017; Thompson et al., 1992). 20-Hz call-counter calls are irregular patterns of 20-Hz signals that likely have a general communication function and are produced by single or multiple fin whales in an area (McDonald and Fox, 1999; McDonald et al., 1995; Širovic´ et al., 2013). Estimated SLs of the 20-Hz signal are as high as 180 to 190 dB re 1 µPa @ 1 m (Charif et al., 2002; Clark et al., 2002; Croll et al., 2002; Patterson and Hamilton, 1964; Thompson et al., 1992; Watkins et al., 1987a; Weirathmueller et al., 2013). Varga et al. (2018) reported the SLs of the 20-Hz songs off Southern California as 194.8 dB re 1 µPa @ 1 m (peak to peak) and 180.9 dB re 1 µPa @ 1 m (rms). Fin whales also produce 40 Hz downsweeps (Širović et al., 2012; Watkins, 1981).

- *Humpback Whale (Megaptera novaeangliae)*

The humpback whale is protected under CITES and is considered least concern as a species by the IUCN Red List of Threatened Species (Childerhouse et al., 2008; Reilly et al., 2008f). The worldwide ESA status of the humpback whale has been revised, with 14 worldwide DPSs identified (Figure 3-6). Of the 14 DPSs, only five are now listed under the ESA as threatened or endangered: the Arabian Sea, Cape Verde/Northwest Africa, WNP, and Central America DPSs are listed as endangered while the Mexico DPS is listed as threatened (NOAA, 2016a). Only one ESA-listed DPS, the WNP, occurs within the study area for SURTASS LFA sonar (Table 3-6). NMFS has determined that the remaining nine global DPSs do not currently warrant listing under the ESA and that the protections of the ESA no longer apply to these nine DPSs (NOAA, 2016a). No critical habitat has been established for the humpback whale. Further, the SMM (2017) has differentiated Northern and Southern subspecies of humpback whales (Table 3-6). However, since these subspecies are not differentiated at sea or in available population data and information, all information about the humpback whale that follows will be referenced at the species rather than subspecies level.

The humpback whale DPSs are based, among other factors, on the locations of humpback whale breeding grounds (Figure 3-6). In the North Pacific Ocean, four breeding grounds have been identified: Central America (Costa Rica, Panama, Guatemala, El Salvador, Honduras and Nicaragua), Mexico (mainland Mexico and Revillagigedos Islands), Hawaii, and the Western North Pacific (Okinawa, Philippines, and a third unknown breeding location in the western North Pacific) (Bettridge et al., 2015; NOAA, 2015b and 2016a). Three breeding areas have been identified in the Indian Ocean: Arabian Sea (where the population is non-migratory), southeast Africa/Madagascar (including the Seychelles Islands), and west Australia (NOAA, 2015b and 2016a). Contrastingly, stocks of humpback whales are identified by geographic areas that include discrete or multiple feeding areas. For instance, in the North Pacific Ocean, stocks of humpbacks include the California-Oregon-Washington (humpbacks that feed in the California-Oregon and Washington-British Columbia feeding areas), Central North Pacific (CNP) (with feeding areas from southeast Alaska to the Alaskan Peninsula), Western North Pacific (feeding

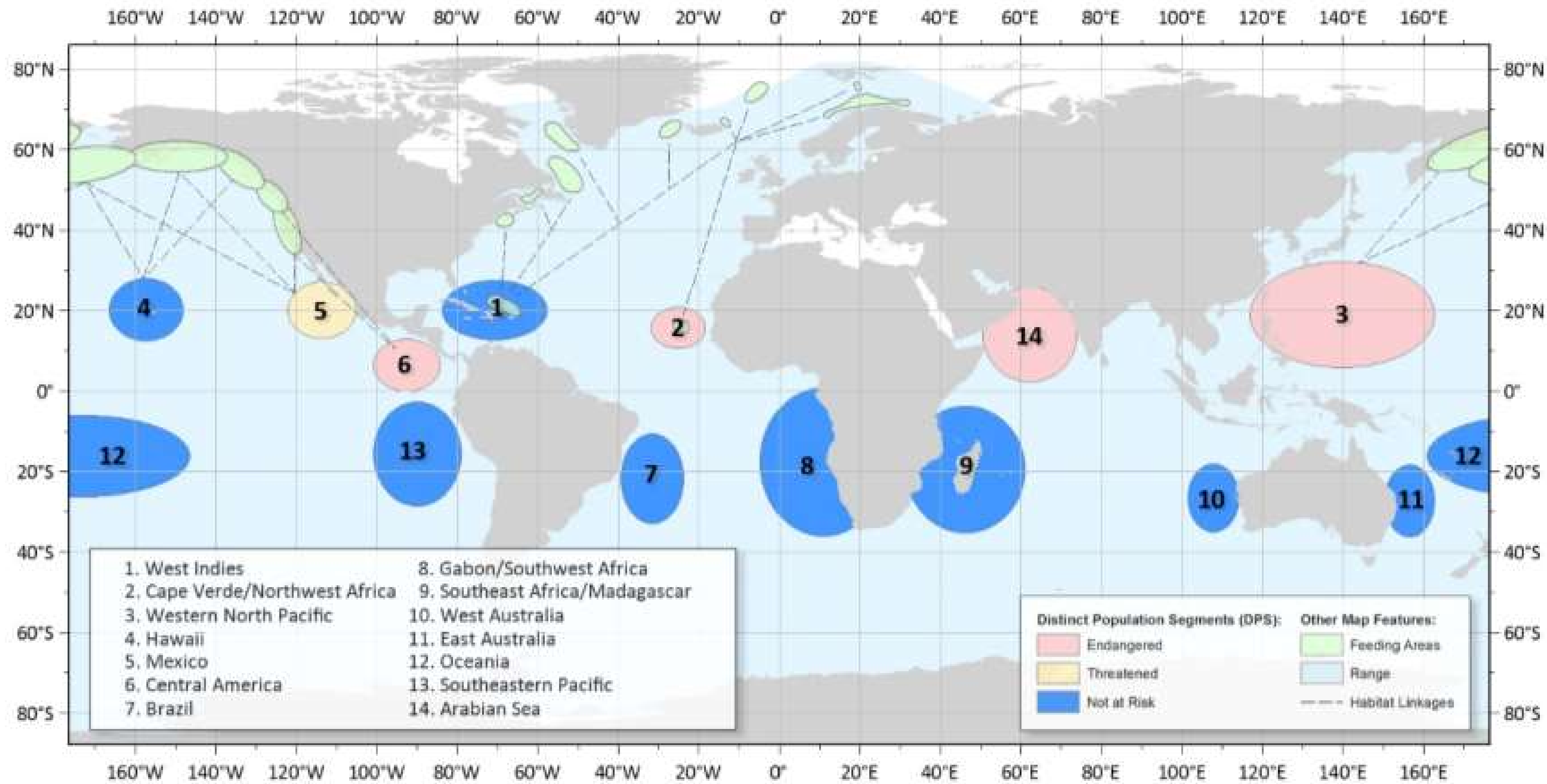

Figure 3-6. The Worldwide Distinct Population Segments (DPSs) of the Humpback Whale Listed Under the ESA. Four DPSs are Listed as Endangered (Arabian Sea, Cape Verde/Northwest Africa, Central America, and Western North Pacific), while One DPS (Mexico) is Listed as Threatened and all Other 10 DPSs not Listed Under the ESA. Image Courtesy of NMFS (2016c).

areas in the Aleutian Islands, the Bering Sea, and Russia), and America Samoa (which feeds in the Southern Ocean along the Antarctic Peninsula) (Carretta et al., 2016). Humpback whales from one DPS may migrate to feed in more than one feeding areas in varying numbers, meaning that animals from one DPS may occur in more than one stock. In the North Pacific Ocean, for example, whales in the Hawaii DPS and CNP stock forage in varying percentages of the DPS or stock in three feeding areas of Alaska during the summer (Figure 3-7).

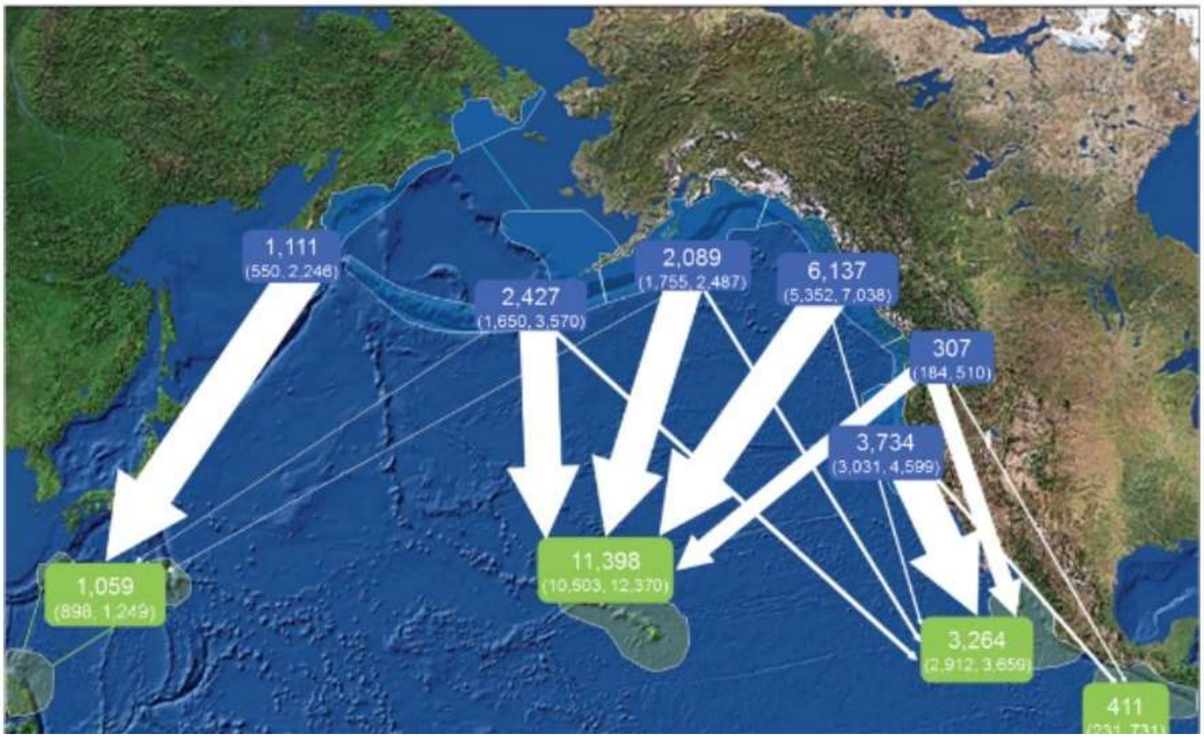

Figure 3-7. Seasonal Migrational Movements of Humpback Whales DPSs and Stocks in the North Pacific Ocean Between Summer Foraging Grounds (Blue) and Winter Breeding Grounds (Green). Estimated Humpback Whale Abundances are Presented by Area (95 Percent Log-Normal Confidence Intervals are given in Parentheses) (Wade et al., 2016).

The most current estimate of the humpback whale's global population is based on summing regional abundances, for an estimated total of 136,582 humpback whales worldwide (IWC, 2016). The population of humpback whales in the entire North Pacific Ocean is estimated as 21,808 (CV=0.04) whales (Barlow et al., 2011; Bettridge et al., 2015). In the western and central North Pacific Ocean portion of the study area for SURTASS LFA sonar, the population of the WNP DPS and stock of humpback whales is estimated to include 1,328 individuals (Bettridge et al., 2015), while the abundance of the CNP stock and Hawaii DPS is estimated as 10,103 whales (Calambokidis et al., 2008; Muto et al., 2018). In the eastern Indian Ocean, the population of humpback whales off Western Australia (Western Australia DPS and stock) is estimated to include 13,640 individuals (Bannister and Hedley, 2001).

Humpback whales are distributed throughout the world's oceans and are only absent from high Arctic and some equatorial waters, although they occur only rarely in some parts of their former Pacific range, such as the coastal waters of Korea, and have shown no signs of a recovery in those locations (Gregr, 2000; Gregr et al., 2000). Humpbacks occur both in neritic and pelagic waters, with neritic occurrences particularly during summer on foraging grounds and during winter when they may be found in waters close to islands and reef systems (Clapham, 2018). Humpback whales are a highly migratory species that have been documented traveling over 5,292 nmi (9,800 km) one way, which is the longest known migration of any mammal (Stevick et al., 2011). Humpback whales travel to high latitudes in the spring to begin feeding and to the warmer temperate and tropical waters in the winter to calve and breed. Despite this potential for long distance dispersal, there is considerable evidence that dispersal or interbreeding of individuals from different major ocean basins is extremely rare and that whales from the major ocean basins are differentiated by a number of characteristics. Data indicate that not all humpbacks migrate annually from summer feeding to winter breeding sites and that some whales remain in certain areas year-round (Barco et al., 2002; Christensen et al., 1992; Clapham et al., 1993; Murray et al., 2013; Straley, 1999). The small Arabian Sea population of humpback whales is non-migratory, breeding, and foraging in the same region (Bettridge et al., 2015; Pomilla et al., 2014).

Dive times of humpback whales have been recorded from 3 to 4 min in duration (Dolphin, 1987; Strong, 1990). Recently, Burrows et al. (2016) reported dive times that ranged from 7.5 to 9.6 min, with a mean of 6.0 min. Dive times on the wintering grounds can be much longer, with singing humpbacks typically diving between 10 and 25 min in duration (Chu, 1988). Humpback whales dove to depths from 131 to 512 ft (40 to 156 m) during foraging dives (Dolphin, 1988; Goldbogen et al., 2008). The deepest recorded humpback dive was 790 ft (240 m), with most dives ranging between 197 to 394 ft (60 and 120 m) (Hamilton et al., 1997). During their long-distance migrations, humpback whales swim at speeds ranging from 0.7 to 7.7 kt (1.3 to 14.2 kph) (Cerchio et al., 2016; Chaudry, 2006; Chittleborough, 1953; Gabriele et al., 1996; Guzman and Félix, 2017; Horton et al., 2011; Kennedy et al., 2014). Swim speeds of humpbacks during dive descent range from 2.4 to 3.9 kt (4.5 to 7.2 kph) while speeds on ascending dives were 2.9 to 4.9 kt (5.4 to 9 kph) (Dolphin, 1987).

No direct measurements of humpback whale hearing sensitivity exist (Ketten, 2000; Thewissen, 2002). Due to this lack of auditory sensitivity information, Houser et al. (2001) developed a mathematical function to describe the frequency sensitivity of humpbacks by integrating the humpback basilar membrane position with known mammalian data. The results predicted the typical U-shaped audiogram with sensitivity to frequencies from 700 Hz to 10 kHz with maximum sensitivity between 2 to 6 kHz (Houser et al., 2001).

Humpbacks produce a great variety of sounds that fall into three main groups: 1) sounds associated with feeding; 2) social sounds; and 3) songs associated with reproduction. These vocalizations range in frequency from 20 to 10,000 Hz. Feeding groups produce stereotyped feeding calls ranging from 20 to 2,000 Hz, with dominant frequencies near 500 Hz (Frankel, 2018; Thompson et al., 1986). Feeding calls were found to have SLs in excess of 175 dB re 1 μPa @ 1 m (Richardson et al., 1995’ Thompson, et al., 1986). Humpback whales in the Northwest Atlantic Ocean produce “megaclicks”, which are click trains and buzzes with most of their energy below 2 kHz, with relatively low SLs of 143 to 154 dB re 1 μPa @ 1 m (peak-peak) (Stimpert et al., 2007). “Whup” calls are composed of a short AM growl followed by a rapid upsweep from 56 to 187 Hz (Wild and Gabriele, 2014). Additional social sounds have been described that range from 70 Hz to 3.5 kHz, with a mean duration ranging from 0.8 to 16.7 sec (Fournet et al., 2015; Stimpert et al., 2011). Social sounds in the winter breeding areas are produced by males and range from 50 Hz to more than 10,000 Hz with most energy below 3,000 Hz (Silber, 1986). Calves produce short, LF sounds (Zoidis et al., 2008). Dunlop et al. (2007) reported 34 types of calls from migrating humpbacks ranging from 30 Hz to 2.4 kHz and between 0.2 and 2.5 sec in duration, with 21 of these call types being incorporated into songs; the median source level of these social sounds is 158 dB re 1 µPa (Dunlop et al., 2013).

During the breeding season, males sing long, complex songs with frequencies between 25 Hz and 5 kHz, with mean SLs of ~165 dB re 1 µPa @ 1 m (broadband) (Au et al., 2006; Frankel et al., 1995; Payne and McVay, 1971). The songs vary geographically among humpback populations and appear to have an effective range of approximately 5.4 to 10.8 nmi (10 to 20 km) (Au et al., 2000). Singing males are typically solitary and maintain spacing of 2.7 to 3.2 nmi (5 to 6 km) from one another (Frankel et al., 1995; Tyack, 1981). Songs have been recorded on the wintering ground, along migration routes, and less often on feeding grounds (Clapham and Mattila, 1990; Clark and Clapham, 2004; Gabriele and Frankel, 2002; Magnúsdóttir et al., 2014; Stanistreet et al., 2013; Van Opzeeland et al., 2013; Vu et al., 2012). Gabriele and Frankel (2002) reported that humpback whales sing more frequently in the late summer and early fall than previously observed.

- *<u>Omura's Whale (Balaenoptera omurai)</u>*

Omura's whales have only recently been described and were previously known as a small form of Bryde's whale (Wada et al., 2003). The Omura's whale is considered data deficient by the IUCN Red List of Threatened Species (Reilly et al., 2008g). The IWC recognizes the Omura's whale but has not yet defined stocks or estimated its population, and no global abundance of Omura's whales exists. The only abundance estimate that relates to Omura's whale is that derived by Ohsumi (1980) for what he characterized at the time as unusually small Bryde's whales in the Solomon Islands. At least part of the whales Ohsumi (1980) identified as small Bryde's whales in the Solomon Islands have now been shown through genetic analysis to have been Omura's whales (Sasaki et al., 2006; Wada et al., 2003). Thus, while not ideal, given the paucity of data currently available for this species, Ohsumi's (1980) estimate of 1,800 individuals is the only and best available estimate of Omura's whales in the WNP stock. The Northern Indian Ocean stock of Omura's whales that occurs in the Andaman Sea area has been estimated to include 9,176 individuals (IWC, 2016; Wade and Gerrodette, 1993), while the Southern Indian Ocean is estimated to number 13,854 individuals (IWC, 1981).

Omura's whales have a very limited Indo-Pacific distribution in tropical and subtropical neritic and oceanic waters, primarily occurring only in the western North Pacific Ocean from the Sea of Japan southward to eastern Australia, and in the Indian Ocean, primarily off Western Australia but with confirmed sightings off Sri Lanka and Madagascar (Aragones et al., 2010; Cerchio and Yamada, 2018; Cerchio et al., 2015; Reilly et al., 2008g; Wada et al., 2003), although the geographic range is not well established. No information is available on the migratory behavior of Omura's whales. The presence of mothers and calves in northwestern Madagascar waters suggested to Cerchio et al. (2015) that the area was a breeding and calving area. Swim speeds and dive behavior characteristics have not yet been documented for the Omura's whale.

Hearing has not been measured in the Omura's whale, but Omura's whales are classified as LF hearing specialists, presumably capable of hearing sound within the range of 7 Hz to 22 kHz (Southall et al., 2007). Omura's whales have been recorded producing long (mean duration = 9.2 sec), broadband, AM calls with energy concentrated in the 15 to 50 Hz band, with a rhythmic sequence with 2-3 min intervals between utterances (Cerchio et al., 2015). Cerchio and Yamada (2018) reported that the Omura's calls to be rhythmically repeated at 130 to 180 sec intervals, suggestive of a song display, with singing documented to last up to 12 hr without pause, and five to six singers being audible on single hydrophones.

- *Sei Whale (Balaenoptera borealis)*

The sei whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered by the IUCN Red List of Threatened Species (Reilly et al., 2008h). The SMM (2017) has differentiated Northern and Southern subspecies of sei whales (Table 3-6). While the Navy recognizes this taxonomy, the subspecies are not differentiated at sea or in the available population data and information. Accordingly, all subsequent information presented herein about the sei whale is referenced only to the species level. The global population for the sei whale has been estimated by the IUCN to include 31,600 individuals (Reilly et al., 2008h) while Jefferson et al. (2015) reported a population as large as 80,000 whales. The population of the Hawaii stock of sei whales is estimated as 391 whales (CV=0.9) (Bradford et al., 2017), while the the North Pacific stock is estimated to include 7,000 whales (Mizroch et al., 2015; Tillman, 1977). The Indian Ocean stock of sei whales is estimated as 13,854 whales (IWC, 1981).

Sei whales occur in temperate, oceanic waters of all world oceans, occurring very uncommonly in neritic waters, the Mediterranean Sea, and in equatorial waters (Horwood, 2018; Jefferson et al., 2015). The sei whale is migratory, seasonally traveling between low latitude calving grounds to high latitude foraging grounds, although these migrations may not be as extensive as that of other mysticetes (Jefferson et al., 2015). Specific breeding grounds are not known for this species, although the waters off northwest Africa have been suggested for the North Atlantic sei whales (Prieto et al., 2014).

Ishii et al. (2017) documented U- and V-shaped dives of foraging sei whales and noted that they dove no deeper than 187 ft (57 m) during the day and to no more than 40 ft (12.2 m) at night, with maximum durations of 12 min. Dive times of sei whales range from 0.75 to 15 min, with a mean duration of 1.5 min (Schilling et al., 1992). When foraging, sei whales make shallow dives of 65 to 100 ft (20 to 30 m), followed by a deep dive up to 15 min in duration (Gambell, 1985). Sei whales are fast swimmers, surpassed only by blue whales (Sears and Perrin, 2009). Swim speeds have been recorded at 2.5 kt (4.6 kph), with a maximum speed of 14.8 kt (27.4 kph) (Brown, 1977; Olsen et al.; 2009). Prieto et al. (2014) reported that the mean swim speeds of satellite-tagged sei whales during migration were 3.3 to 4 kt (6.2 to 7.4 kph) and an “off-migration” speed was measured as 3.2 kt (6 kph). Ishii et al. (2017) measured mean swimming speeds of 1.9 to 2.7 kt (3.6 to 5 kph) for two sei whales.

No direct measurements of sei whale hearing sensitivity exist (Ketten, 2000; Thewissen, 2002). Sei whale vocalizations are the least studied of all the rorquals. Rankin and Barlow (2007) recorded sei whale vocalizations in Hawaii and reported that all vocalizations were downsweeps, ranging from on average from 100.3 to 446 Hz for “high frequency” calls and from 39.4 to 21.0 Hz for “low frequency” calls. In another study, McDonald et al., (2005) recorded sei whales in Antarctica with an average call frequency of 433 Hz. A series of sei whales FM calls have been recorded south of New Zealand with a frequency range of 34 to 87 Hz and a duration of 0.4 to 1.7 sec (Calderan et al., 2014).

Odontocetes (Toothed Whales): Physeteridae

- *Sperm Whale (Physeter macrocephalus)*

The sperm whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and classified as vulnerable by the IUCN Red List of Threatened Species (Taylor et al., 2008). Jefferson et al. (2015) reported a putative global sperm whale population estimate of 360,000 individuals. The sperm whale stock in the North Pacific Ocean has been estimated to include 102,112 individuals (CV=0.155), while 4,559 sperm whales (CV=0.33) have been estimated for Hawaii stock (Bradford et al., 2017; Muto et al., 2018). The Indian Ocean stock of sperm whale is estimated as 24,446 individuals (IWC, 2016; Perry et al., 1999; Wade and Gerrodette, 1993).

With the largest distributional range of all cetaceans except killer whales, sperm whales are primarily found in deeper (>3,280 ft [1000 m]) polar, temperate, and tropical waters of the world's oceans and Mediterranean Sea (Reeves and Whitehead, 1997). Female sperm whales nearly always inhabit waters >3,281 ft (1,000 m) in depth far from land (Whitehead, 2018). The migration patterns of sperm whales are not well understood, as some whales show seasonal north-south migrations, and some whales show no clear seasonal migration pattern at all, especially in the equatorial waters (Whitehead, 2018). In ocean waters between 40° N and 45° N, female sperm whales with calves often remain on breeding grounds throughout the year, while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al., 2007; Rice, 1989; Whitehead, 2003). In the Northern Hemisphere, "bachelor" groups (males 15 to 21 yr old) generally leave warm waters at the beginning of summer to migrate to feeding grounds and in fall and winter, most bachelors return south, although some may remain in the colder northern waters during most of the year (Pierce et al., 2007). Specific breeding and foraging grounds are not well known for this species.

Sperm whales may make the longest and deepest dives of any mammal, with the maximum-recorded dive reaching 4,921 ft (1,500 m) (Davis et al., 2007), although examination of stomach contents of sperm whales suggests that sperm whales may dive as deep as 10,498 ft (3,200 m) (Clarke, 1976). Foraging dives to depths of 965 to 4,701 ft (294 to 1,433 m) and non-foraging dives to a water depth of 1,640 ft (500 m) were recently measured (Guerra et al., 2017; Joyce et al., 2017). In general, dive durations range between 18.2 to 65.3 min (Watkins et al., 2002). Foraging dives typically last about 30 to 65 min (Joyce et al, 2017; Papastavrou et al., 1989; Wahlberg, 2002), while non-foraging dives of about 30 min were measured (Joyce et al., 2017). Sperm whale's surface speeds generally average 0.7 to 2.2 kt (1.3 to 4 kph), with maximum speeds of about 5.1 kt (9.4 kph) (Jochens et al., 2008; Lockyer, 1997; Watkins et al., 2002; Whitehead, 2018). Dive swim rates range from 2.8 to 5.5 kt (5.2 to 10.1 kph) (Lockyer, 1997).

Audiograms measured from a sperm whale calf suggest a hearing range of 2.5 to 60 kHz, with best hearing sensitivity between 5 and 20 kHz (Ridgway and Carder, 2001). Measurements of evoked response data from one stranded sperm whale have shown a lower limit of hearing near 100 Hz (Gordon et al., 1996).

Sperm whales produce broadband echolocation clicks with energy from less than 100 Hz to 30 kHz (Goold and Jones, 1995; Madsen et al., 2002a; Møhl et al., 2000; Thode et al., 2002; Watkins and Schevill, 1977; Weilgart and Whitehead, 1997). Regular click trains and creaks have been recorded from foraging sperm whales and may be produced as a function of echolocation (Jaquet et al., 2001; Madsen et al., 2002b; Whitehead and Weilgart, 1991). A series of short clicks, termed "codas," have been associated with social interactions and are thought to play a role in communication (Pavan et al., 2000; Watkins and Schevill, 1977; Weilgart and Whitehead, 1993). Clicks are strongly directional, with SELs measured between 202 and 236 dB (Madsen and Møhl, 2000; Møhl et al., 2000; Møhl et al., 2003; Thode et al., 2002). Møhl (2003) reported that the maximum SL for sperm whale clicks was 236 dB with other calls ranging from 226 to 234 dB. Zimmer et al. (2005b) reported SL of the sperm whale's HF sonar component of clicks that are used to search for prey as 229 dB (peak value), while the LF component is apparently used to conveys sound to conspecifics at large ranges and peak frequencies that are depth dependent to over 1,640 ft (500 m). Sperm whales also produce sounds including creaks, squeals, and trumpets as well as codas, which are series of 3 to 20 clicks that last from 0.2 to 2 sec and are social vocalizations (Whitehead, 2003 and 2018).

➢ ***Odontocetes (Toothed Whales): Kogiidae***

- *Pygmy Sperm Whale (Kogia breviceps) and Dwarf Sperm Whale (Kogia sima)*

Both the pygmy sperm whale and dwarf sperm whale are listed as data deficient under the IUCN Red List of Threatened Species (Taylor et al., 2012a and 2012b). Abundance estimates of the global population sizes for these species are unknown. Population estimation by species is difficult as due to difficulty in distinguishing these species at sea, data for both species are typically combined. Where possible, population data by species are presented herein. The population of both species (*Kogia* spp.) combined and individually in the WNP stocks has been estimated as 350,553 whales (Ferguson and Barlow, 2001 and 2003). The Hawaii stocks of the dwarf sperm whale and pygmy sperm whale are estimated as 17,519 individuals and 7,138 individuals, respectively (Barlow, 2006; Carretta et al., 2014). The Indian Ocean stocks of pygmy and dwarf sperm whales are estimated to number 10,541 individuals (Wade and Gerrodette, 1993).

Pygmy and dwarf sperm whales are distributed worldwide, primarily in temperate to tropical deep waters, and are especially common in waters along continental shelf breaks (Evans, 1987; Jefferson et al., 2008). Dwarf sperm whales seem to prefer warmer water than the pygmy sperm whale (Caldwell and Caldwell, 1989). Little evidence exists for seasonal movements in either species (McAlpine, 2009).

In the Gulf of California, *Kogia* spp. have been recorded with an average dive time of 8.6 min, while dwarf sperm whales exhibited a maximum dive time of 43 min (Breese and Tershy, 1993). Swim speeds vary and were found to reach up to 5.9 kt (11 kph) (Scott et al., 2001).

Sparse data exist on the hearing sensitivity of pygmy sperm whales and no data on the hearing sensitivity of the dwarf sperm whale have been measured. An ABR study on a rehabilitating pygmy sperm whale indicated an underwater hearing range with greatest sensitive between 90 and 150 kHz (Carder et al., 1995; Ridgway and Carder, 2001).

Recordings of captive pygmy sperm whales show they produce sounds between 60 and 200 kHz with peak frequencies at 120 to 130 kHz (Carder et al., 1995; Ridgway and Carder, 2001; Santoro et al., 1989). Echolocation pulses of pygmy sperm whales were documented with peak frequencies at 125 to 130 kHz (Ridgway and Carder, 2001). Thomas et al. (1990a) recorded an LF swept signal between 1.3 to 1.5 kHz from a captive pygmy sperm whale in Hawaii. Jérémie et al. (2006) reported frequencies ranging from 13 to 33 kHz for dwarf sperm whale clicks with durations of 0.3 to 0.5 sec. Merkens et al. (2018) recently reported that the sounds produced by captive and free-ranging dwarf sperm whales were very similar to those of pygmy sperm whales, and were characterized as narrow-band, HF clicks with mean frequencies from 127 to 129 kHz and inter-click intervals of 110 to 164 msec.

➢ ***Odontocetes (Toothed Whales): Ziphiidae***

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

The Baird's beaked whale is currently classified as data deficient under the IUCN Red List of Threatened Species (Taylor et al., 2008a). While the abundance of the global population size is unknown, the abundance of Baird's beaked whale in the WNP stock has been estimated as 5,688 individuals (Kasuya and Perrin, 2017; Miyashita, 1986 and 1990).

Baird's beaked whales occur in the North Pacific, including the Bering and Okhotsk seas (Kasuya, 1986; Kasuya, 2009) and off California (Yack et al., 2013). These whales inhabit deep water and appear to be most abundant at areas of steep topographic relief such as shelf breaks and seamounts (Dohl et al., 1983; Kasuya, 1986; Leatherwood et al., 1988). Baird's beaked whales were documented as having an inshore-offshore movement off California beginning in July and ending in September to October (Dohl et al., 1983). Ohizumi et al. (2003) reported that Baird's beaked whales migrate to the coastal waters of the western North Pacific and the southern Sea of Okhotsk in the summer.

Baird's beaked whales were recorded diving between 15 and 20 min, with a maximum dive duration of 67 min (Barlow, 1999; Kasuya, 2009). In a recent study, a Baird's beaked whale in the western North Pacific had a maximum dive time of 64.4 min and a maximum depth of 5,830 ft (1,777 m). Minamikawa et al. (2007) reported that Baird's beaked whales dive deeply (>3,280 ft [>1,000 m]), followed by several subsequent intermediate dives (328 to 3,280 ft [100 to 1,000 m]). Few swim speed data are available for any beaked whale species.

Direct measurements of Baird's beaked whale hearing sensitivity have not been measured (Ketten, 2000; Thewissen, 2002). Baird's beaked whales have been recorded producing HF sounds between 12 and 134 kHz with dominant frequencies between 23 to 24.6 kHz and 35 to 45 kHz (Dawson et al., 1998). This species produces a variety of sounds, mainly burst-pulse clicks, and FM whistles. The functions of these signal types are unknown. Clicks and click trains were heard sporadically throughout the recorded data, which may suggest that these beaked whales possess echolocation abilities. There is no available data regarding seasonal or geographical variation in the sound production of these species and no estimated SLs have been documented.

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

Cuvier's beaked whale is currently classified as a least concern (lower risk) species by the IUCN Red List of Threatened Specie (Taylor et al., 2008b). No global population estimate for this species is known. Abundances of Cuvier's beaked whales are estimated as 90,725 whales in the WNP stock (Ferguson and Barlow, 2001 and 2003) and as 723 individuals (CV=0.69) for the Hawaii stock (Bradford et al., 2017). The population of Cuvier's beaked whales in the Southern Hemisphere is estimated as 76,500 individuals (Dalebout et al., 2005), of which 27,222 individuals are estimated to occur off Western Australia (Wade and Gerrodette, 1993).

The Cuvier's beaked whale is the most cosmopolitan of all beaked whale species. Except for the high Arctic and Antarctic waters, Cuvier's beaked whales are widely distributed in tropical to polar oceanic waters of all oceans and major seas, including the Gulf of Mexico, Gulf of California, Caribbean Sea, Mediterranean Sea, Sea of Japan, and Sea of Okhotsk (Heyning and Mead, 2009; Jefferson et al., 2008; Omura et al., 1955). No data on breeding and calving grounds are available.

Dive durations range between 20 and 87 min with an average dive time near 30 min (Baird et al., 2004; Heyning, 1989; Jefferson et al., 1993). This species is a deep diving species) (Heyning and Mead, 2009). Schorr et al. (2014) reported a maximum dive depth of 9,816 ft (2,992 m) that lasted 137.5 min. In the Caribbean Sea, Cuvier's beaked whales performed dives to a mean depth of 3,868 ft (1,179 m) and mean dive duration of 65.4 min, with non-foraging dives as deep as ~ 1,640 ft (500 m) over 40 min, and foraging dives ranging between 2,297 to 6,234 ft (700 and 1900 m) over 3- to 100 min (Joyce et al., 2017). Joyce et al. (2017) also reported that Cuvier's beaked whales exhibited long recovery times (or inter-dive intervals) with a median of 68 min at the surface between dive bouts (Joyce et al. 2017). Shallow and deep dive times for Cuvier's beaked whales in the waters of southern California waters were reported to have durations of ~ 20 min and ~ 60 min, respectively (Falcone et al., 2017). Swim speeds of Cuvier's beaked whale have been recorded between 2.7 and 3.3 kt (5 and 6 kph) (Houston, 1991).

Hearing sensitivity of Cuvier's beaked whales has not been measured (Ketten, 2000; Thewissen, 2002). Cuvier's beaked whales were recorded producing HF clicks between 13 and 17 kHz; since these sounds were recorded during diving activity, the clicks were assumed to be associated with echolocation (Frantzis et al., 2002). Johnson et al. (2004) recorded frequencies of Cuvier's clicks ranging from about 12 to 40 kHz with associated SLs of 200 to 220 dB re 1 µPa @ 1 m (peak-to-peak). Johnson et al. (2004) also found that Cuvier's beaked whales do not vocalize when within 656 ft (200 m) of the surface and only started clicking at an average depth of 1,558 ft (475 m) and stopped clicking on the ascent at an average depth of 2,789 ft (850 m) with click intervals of approximately 0.4 sec. Zimmer et al. (2005a) also studied the echolocation clicks of Cuvier's beaked whales and recorded a SL of 214 dB re 1 µPa @ 1 m (peak-to-peak). There are no available data regarding seasonal or geographical variation in the sound production of Cuvier's beaked whales.

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

Longman's beaked whale, also known as the Indo-Pacific beaked whale, is currently classified as data deficient by IUCN. Very few population data are available for this little known beaked whale. Although no global abundance estimate of this species is available, 7,619 Longman's beaked whales (CV=0.66) are estimated to occur in the Hawaii and WNP stocks (Bradford et al., 2017), while 16,867 whales are estimated to occur in the Indian Ocean stock (Wade and Gerrodette, 1993).

The distribution of this rarely occurring beaked whale is oceanic tropical waters of the Indo-Pacific oceans (Leatherwood and Reeves, 1983; Jefferson et al., 2008; Pitman, 2018). Longman's beaked whales appear to be rare in the eastern Pacific and Indian oceans but occur more commonly in the western Pacific and western Indian oceans, suggesting to Pitman (2018) that this species prefers the warmer waters typically found in western ocean basins. Nothing is known about possible seasonal movements of this beaked whale.

Only a small number of dive times have been recorded for the Longman's beaked whale. Two dive duration periods were reported by Anderson et al. (2006) for Longman's beaked whales: short durations lasting from 11 to 18 min and long durations ranging from 20 to 33 min, although one beaked whale possibly was submerged as long as 45 min. No data are available on swim speeds.

No direct measurements of hearing sensitivity are available for the Longman's beaked whales (Ketten, 2000; Thewissen, 2002). Longman's beaked whales produce burst-pulse, echolocation click, and pulse vocalizations. Echolocation clicks have a frequency range between 15 and 25 kHz, while pulses exhibit a 25 kHz FM upswept frequency signal, and burst-pulses are a long sequence of clicks lasting ~ 0.5 seconds (Rankin et al., 2011).

- *Mesoplodon Beaked Whales*

Six species of *Mesoplodon* beaked whales may occur in the SURTASS LFA sonar study area. These species include: Blainville's, Deraniyagala's, ginkgo-toothed, Hubbs', spade-toothed, and Stejneger's beaked whales (Table 3-6). The *Mesoplodon* species are not well known, are difficult to identify to the species at sea, and so little about their behavior has been documented that much of the available characterization for beaked whales is to genus level only; for this reason, information on the *Mesoplodon* beaked whale species is presented together.

Species in the genus *Mesoplodon* are currently classified with a data deficient status by IUCN. The worldwide population sizes for all species of *Mesoplodon* spp. are unknown. The population of Blainville's beaked whales in the Hawaii stock was reported as 2,105 whales (CV=1.13) (Bradford et al., 2017), while 8,032 Blainville's beaked whales have been estimated for the WNP stock (Carretta et al., 2011; Ferguson and Barlow, 2001 and 2003; LGL, 2011). In the North Pacific stocks, populations of 22,799 whales have been estimated for Deraniyagala, ginkgo-toothed, and Hubbs' beaked whales (Ferguson and Barlow, 2001 and 2003). In the Indian Ocean stock, populations each of 16,687 whales are estimated for Blainville's, Deraniyagala, ginkgo-toothed, and spade-toothed beaked whales (Wade and Gerrodette, 1993). The population of Stejneger's beaked whales is estimated to include 8,000 individuals in the WNP stock (Kasuya, 1986).

With the exception of cold, polar waters, *Mesoplodon* beaked whales are distributed in all of the world's oceans in deep (>6,562 ft [2,000 m]) pelagic waters. The distribution of ginkgo-toothed beaked whales is restricted to the tropical and warm-temperate waters of the North Pacific and Indian oceans. In the North Pacific Ocean, Stejneger's beaked whales occur in temperate to subarctic waters, while Hubbs' beaked whale occurs only in temperate waters (Olson, 2018). Spade-toothed beaked whales have a very restricted distributional range in the southern Pacific Ocean and the southeastern most Indian Ocean, ranging from Australia and New Zealand to Chile. Blainville's beaked whales are the most cosmopolitan of the beaked whales and can be found in the Atlantic, Pacific, and Indian oceans in warm temperate and tropical waters (Pitman, 2009b). The little known Deraniyagala beaked whale ranges throughout the tropical waters of the equatorial Indo-Pacific (Dalebout et al., 2014).

Dives of Blainville's beaked whales average 7.5 min during social interactions (Baird et al., 2004). Dives over 45 min have been recorded for some species in this genus (Jefferson et al., 1993). Dive depths are variable among *Mesoplodon* species and are not well documented. In Hawaii, a Blainville's beaked whale was observed to dive to a maximum water depth of 4,619 ft (1,408 m), with the dive duration ranging from 48 to 68 min (Pitman, 2009b). Blainville's beaked whales in the Caribbean Sea performed dives with a mean depth of 3,704 ft (1,129 m) and mean duration of 46.1 min, with the whale's non-foraging dives reaching ~1,148 ft (350 m) and lasting 40 min, while foraging dives ranged between 1,969 to 6,234 ft (600 and 1,900 m) with a duration between 30 and 70 min (Joyce et al., 2017). Few swim speed data are available for any beaked whale species. Schorr et al. (2009) reported a horizontal swim speed of 0.4 to 0.8 kt (0.8 to 1.5 kph) for a Blainville's beaked whales in Hawaii with a maximum rate of 4.4 kt (8.1 kph).

The hearing sensitivity of a stranded Blainville's beaked whale was measured at 5.6 and 160 kHz, with the best hearing response ranging between 40 and 50 kHz, with AEP thresholds less than 50 dB re 1 μPa (Pacini et al., 2011). In a study of echolocation clicks in Blainville's beaked whales, Johnson et al. (2006) found that the whales make various types of clicks while foraging. The whales have a distinct search click that is in the form of an FM upsweep with a minus 10 dB bandwidth from 26 to 51 kHz (Johnson et al., 2006). Blainville's beaked whales also produce a buzz click during the final stage of prey capture that has no FM structure but exhibits a minus 10 dB bandwidth from 25 to 80 kHz or higher (Johnson et al., 2006). Johnson et al. (2004) studied Blainville's beaked whales and concluded that no vocalizations were detected from any tagged beaked whales when they were within 656 ft (200 m) of the surface. The Blainville's beaked whale started clicking at an average depth of 1,312 ft (400 m), ranging from 200 to 570 m (656 to 1,870 ft), and stopped clicking when they started their ascent at an average depth of 2,362 ft (720 m), with a range of 1,640 to 2,591 ft (500 to 790 m). The intervals between regular clicks were approximately 0.4 second, and trains of clicks often ended in a buzz. Blainville's beaked whales have a somewhat flat spectrum that was accurately sampled between 30 and 48 kHz, with a slight decrease in the spectrum above 40 kHz, although the 96 kHz sampling rate was not sufficient to sample the full frequency range of clicks from either of the species (Johnson et al., 2004).

- *Southern Bottlenose Whale (Hyperoodon planifrons)*

The IUCN classifies the status of the southern bottlenose whales as least concern (lower risk). The population of southern bottlenose whales south of the Antarctic Convergence has been estimated as 500,000 whales, which makes this species the most commonly observed beaked whale in Antarctic waters (Jefferson et al., 2008). In the Indian Ocean, an estimated 599,300 southern bottlenose whales occur (Kasamatsu and Joyce, 1995).

Southern bottlenose whales are found south of 20°S, with a circumpolar distribution (Leatherwood and Reeves, 1983; Jefferson et al., 2008). Evidence of seasonal migration shows a northward movement near South Africa in February and southward movement toward the Antarctic in October (Sekiguchi et al., 1993). Calving and breeding grounds are unknown.

Hooker and Baird (1999) documented dives for the closely related northern bottlenose whales, reporting regular dives between 394 ft (120 m) and 2,625 ft (800 m), with a maximum recorded dive depth to 4,770 ft (1,453 m). The deeper dives of northern bottlenose whales have been associated with foraging behavior (Hooker and Baird, 1999). Martin Lopez et al. (2015) reported a mean dive depth of 5,158 ft (1,572 m) and a mean dive duration of 49 min. Dive durations have been recorded close to 70 min. Southern bottlenose whales have been observed diving from 11 to 46 min, with an average duration of 25.3 min (Sekiguchi et al., 1993). General swim speeds for ziphiids average 2.7 kt (5 kph) (Kastelein and Gerrits, 1991).

There is no direct measurement of hearing sensitivity for bottlenose whales (Ketten, 2000; Thewissen, 2002). Off Nova Scotia, diving northern bottlenose whales produced regular click series (consistent inter-click intervals) at depth with peak frequencies of 6 to 8 kHz and 16 to 20 kHz (Hooker and Whitehead, 1998). Click trains produced during social interactions at the surface ranged in peak intensity from 2 to 4 kHz and 10 to 12 kHz. Additional measurements report that the whales produce FM sweeps from 20 to 55 kHz, with rms source levels between 175 and 202 dB re 1μPa @ 1 m (Wahlberg et al., 2011a). There is no seasonal or geographical variation documented for the northern bottlenose whale. There are no available data for the sound production of southern bottlenose whales.

➢ ***Odontocetes (Toothed Whales): Delphinidae***

- *Common Dolphin (Delphinus delphis delphis) and Indo-Pacific Common Dolphin (Delphinus delphis tropicalis)*

The SMM (2017) has recently resolved and revised the complex taxonomy of the common dolphin, which it had formerly divided into multiple subspecies. Although the Indo-Pacific common dolphin is retained as a subspecies, the SMM no longer recognizes the long-beaked and short-beaked subspecies of common dolphins—these species are now simply the common dolphin. Thus, in this SEIS/SOEIS, we include two species of common dolphins: the common dolphin and the Indo-Pacific common dolphin. The Indo-Pacific common dolphin is essentially a long-beaked variant that occurs in the Indian Ocean (SMM, 2017). However, the characterizations that define the two species are difficult to assess at sea, and until recently, at-sea observations only reported “common” dolphins generically. Since little information is known to the species level, information that follows refers to both subspecies of common dolphins.

The common dolphin is classified as a least concern (lower risk) species by the IUCN. The global population for all common dolphin species is unknown. In the WNP stock, 3,286,163 common dolphins are estimated (Ferguson and Barlow, 2001 and 2003), while 1,819,882 common and Indo-Pacific common dolphins are estimated to occur in the Indian Ocean (Wade and Gerrodette, 1993).

Common dolphins are widely distributed worldwide in temperate, tropical, and subtropical oceans, primarily in neritic waters of the continental shelf and steep bank regions where upwelling occurs (Jefferson et al. 2015; Perrin, 2009b). These dolphins seem to be most common in the coastal waters of the Pacific Ocean, often occurring within 97.2 nmi (180 km) of land (Jefferson et al., 2015

Dive depths range between 30 and 656 ft (9 and 200 m), with a majority of dives 30 to 164 ft (9 to 50 m) (Evans, 1994). The deepest dive recorded for these species was 850 ft (260 m) (Evans, 1971). The maximum dive duration has been documented at 5 min (Heyning and Perrin, 1994). Swim speeds for *Delphinus* spp. have been measured at 3.1 kt (5.8 kph) with maximum speeds of 8.7 kt (16.2 kph); but in other studies, common dolphins have been recorded at swimming up to 20 kt (37.1 kph) (Croll et al., 1999; Hui, 1987). Common dolphins tracked off California swum at an average speed of 4.9 kt (9 kph) {Wiggins et al., 2013).

Very little is known about hearing in common dolphins. Popov and Klishin (1998) measured the hearing threshold of a common dolphin by auditory brainstem response and discovered an U-shaped audiogram with a steeper high-frequency branch and an auditory range from 10 to 150 kHz, with greatest sensitivity between 60 and 70 kHz; it should be noted that the dolphin was ill, died while in captivity, and testing appears to have been conducted on the dead animal. Aroyan (2001) modeled three-dimensional hearing in the common dolphin to elucidate the hearing processes and reported tissue-borne sound reception channels in the head of the common dolphin with the suggestion that the lower jaw exhibits strongly directional reception. Common dolphins produce sounds as low as 0.2 kHz and as high as 150 kHz, with dominant frequencies at 0.5 to 18 kHz and 30 to 60 kHz (Au, 1993; Moore and Ridgway, 1995; Popper, 1980]; Watkins, 1967). Signal types consist of clicks, squeals, whistles, and creaks (Evans, 1994). Whistles of short-beaked common dolphins range between 3.5 and 23.5 kHz (Ansmann et al., 2007), while the whistles of long-beaked common dolphins ranges from 7.7 to 15.5 kHz (Oswald et al., 2003). Most of the energy of echolocation clicks is concentrated between 15 and 100 kHz (Croll et al., 1999). The maximum peak-to-peak SL of common dolphins is 180 dB. In the North Atlantic, the mean SL was approximately 143 dB with a maximum of 154 (Croll et al., 1999). There are no available data regarding seasonal or geographical variation in the sound production of common dolphins.

- *Common Bottlenose Dolphin (Tursiops truncatus)*

Overall, the common bottlenose dolphin is classified as least concern (lower risk) by the IUCN. The global population for the bottlenose dolphin is unknown. The abundance of common bottlenose dolphins in the WNP Northern Offshore stock, which includes bottlenose dolphins in the area of the WNP bounded by 30° N, 145°E to 180°E, is estimated as 100,281 dolphins (Kasuya and Perrin, 2017; Miyashita, 1993). The population of the WNP Southern Offshore stock of bottlenose dolphins, found in the area between 23° to 30° N, 127°to 180° E, has been estimated to include 40,769 dolphins (Kanaji et al., 2018). Common bottlenose dolphins occurring in Pacific coastal waters of Japan are part of the Japanese Coastal stock, which is estimated to include 3,516 dolphins (Kanaji et al., 2018). The Inshore Archipelago stock of common bottlenose dolphins that occurs in the Asian continental seas includes 105,138 dolphins (Miyashita, 1986 and 1993). The Hawaii population of pelagic common bottlenose dolphins includes 21,815 individuals (CV=0.57) (Bradford et al., 2017); while the insular Hawaiian stocks of common bottlenose dolphins include an estimated 184 dolphins in the Kauai/Niihau stock, 743 individuals in the Oahu stock, 191 dolphins in the 4-Island stock, and 128 individuals in the Hawaii Island stock (Baird et al., 2009; Carretta et al., 2014). The population of common bottlenose dolphins in the Indian Ocean stock is estimated as 785,585 dolphins (Wade and Gerrodette, 1993), while 3,000 common bottlenose dolphins may occur in the waters off Western Australia (Preen et al., 1997).

The bottlenose dolphin is distributed worldwide in temperate to tropical waters. In North America, they inhabit waters with temperatures ranging from 50 to 89°F (10 to 32°C) (Wells and Scott, 2009). Common bottlenose dolphins are primarily found in coastal waters, but they also occur in diverse habitats ranging from rivers and protected bays to oceanic islands and the open ocean, over the continental shelf, and along the shelf break (Scott and Chivers, 1990; Sudara and Mahakunayanakul, 1998; Wells and Scott, 2009). Seasonal movements vary between inshore and offshore locations and year-round home ranges (Croll et al., 1999; Wells and Scott, 2009). Calving season is generally year-round with peaks occurring from early spring to early fall (Scott and Chivers, 1990). There are no known breeding grounds.

Dive times for bottlenose dolphins range from 38 sec to 1.2 min, with dives having been recorded to last as long as 10 min (Croll et al., 1999; Mate et al., 1995). The dive depth of a bottlenose dolphin in Tampa Bay, Florida, was measured at 322 ft (98 m) (Mate et al., 1995). Wild offshore bottlenose dolphins were reported to dive to depths greater than 1,476 ft (450 m) (Klatsky et al., 2007). The deepest dive recorded for a bottlenose dolphin is 1,755 ft (535 m) by a trained individual (Ridgway, 1986). Sustained swim speeds for bottlenose dolphins range between 2.2 and 10.8 kt (4 and 20 kph) and may reach speeds as high as 29 kt (54 kph) (Lockyer and Morris, 1987).

Bottlenose dolphins hear underwater sounds in the range of 150 Hz to 135 kHz (Johnson, 1967; Ljungblad et al., 1982). Their best underwater hearing occurs between 15 and 110 kHz, where the threshold level range is 42 to 52 dB RL (Au, 1993). Nachtigall et al. (2000) more recently measured the range of highest sensitivity as between 25 and 70 kHz, with peaks in sensitivity at 25 and 50 kHz (). Bottlenose dolphins also have good sound location abilities and are most sensitive when sounds arrive directly towards the head (Richardson et al., 1995). Bottlenose dolphins are able to voluntarily reduce their hearing sensitivity to loud sounds (Nachtigall and Supin, 2015).

Bottlenose dolphins produce sounds as low as 50 Hz and as high as 150 kHz with dominant frequencies at 0.3 to 14.5 kHz, 25 to 30 kHz, and 95 to 130 kHz (Croll et al., 1999; dos Santos et al., 1990; Johnson, 1967; McCowan and Reiss, 1995; Oswald et al., 2003; Popper, 1980; Schultz et al., 1995). The maximum SL reported is 228 dB (Croll et al., 1999). Bottlenose dolphins produce a variety of whistles, echolocation clicks, low-frequency narrow, “bray” and burst-pulse sounds. Echolocation clicks with peak frequencies from 40 to 130 kHz are hypothesized to be used in navigation, foraging, and predator detection (Au, 1993; Houser et al., 1999; Jones and Sayigh, 2002). According to Au (1993), sonar clicks are broadband, ranging in frequency from a few kilohertz to more than 150 kHz, with a 3 dB bandwidth of 30 to 60 kHz (Croll et al., 1999). The echolocation signals usually have a 50 to 100 msec duration with peak frequencies ranging from 30 to 100 kHz and fractional bandwidths between 10 and 90 percent of the peak frequency (Houser et al., 1999). Burst-pulses, or squawks, are commonly produced during social interactions. These sounds are broadband vocalizations that consist of rapid sequences of clicks. Inter-click intervals (ICIs) vary to form different types of click patterns such as 1) low-frequency clicks that have no regular repeating interval; 2) train clicks (ICI = 35-143 msec); 3) Packed clicks (ICI = 2-6 msec); and 4) Burst, with an ICI of 1.7 to 4.9 msec, with more clicks than a packed click train (Buscaino et al., 2015). Burst-pulse sounds are typically used during escalations of aggression (Croll et al., 1999). Whistles range in frequency from 1.5 to 23 kHz and have durations up to 4 seconds (Díaz López, 2011; Gridley et al., 2015). Each individual bottlenose dolphin has a fixed, unique FM pattern, or contour whistle called a signature whistle. These signal types have been well studied and are used for recognition, but may have other social contexts (Janik et al., 2013; Jones and Sayigh, 2002; Kuczaj et al., 2015). Signature whistles have a narrow-band sound with the frequency commonly between 4 and 20 kHz, duration between 0.1 and 3.6 seconds, and an SL of 125 to 140 dB (Croll et al., 1999).

- *False Killer Whale (Pseudorca crassidens)*

False killer whales are classified as least concern (lower risk) by the IUCN. Three populations of false killer whales have been identified in Hawaiian waters, but only the Main Hawaiian Island Insular DPS of false killer whales is listed under the ESA as endangered and depleted under the MMPA (NOAA, 2012b). The populations of false killer whales occurring in the insular waters of the Hawaiian Islands have been shown to be genetically and behaviorally distinct from false killer whales found in oceanic or offshore waters (Chivers et al., 2010; Martien et al., 2011; NOAA, 2012b). The boundaries between the Hawaiian Island populations of false killer whales are complex and overlapping. The areal extent of the Main Hawaiian Island Insular DPS of false killer whales is a 39-nmi (72-km) radius around the Main Hawaiian Islands, with the offshore extent of the DPS' outer boundary connected on the leeward sides of Hawaii Island and Niihau to encompass the offshore movements of Main Hawaiian Islands Insular DPS false killer whales within that region (Carretta et al., 2015). In comparison to other populations of false killer whales, the Main Hawaiian Islands Insular DPS is characterized by a very low abundance and very high density, suggesting that either the nearshore habitat used by these whales is highly productive or these whales employ an unique habitat-use strategy that supports a high density of false killer whales (Oleson et al., 2010; Wearmouth and Sims, 2008). Critical habitat has been designated for the Main Hawaiian Island Insular DPS of the false killer whale (NOAA, 2018c). The critical habitat for the Main Hawaiian Islands DPS of false killer whales includes waters from the 148- to 10,499-ft (45-to 3,200-m) depth contours around the Main Hawaiian Islands from Niihau east to Hawaii (Figure 3-8); some Navy and other federal agency areas, such as the Pacific Missile Range Facility offshore ranges, are excluded from the proposed critical habitat designation (NOAA, 2017).

The global population for the false killer whale is unknown. Estimates of 16,668 whales have been documented in the northwestern Pacific (Miyashita, 1993) and 9,777 whales have been estimated in the Inshore Archipelago stock of the Asian continental seas (Miyashita, 1986). In Hawaiian waters, false killer whale populations have been estimated as 1,540 whales (CV=0.66) in the Hawaii pelagic population, 617 whales (CV=1.11) in the Northwestern Hawaiian Islands DPS, and 167 whales in the Main Hawaiian Islands Insular DPS (Bradford et al., in review; Muto et al., 2018). The population of false killer whales in the Indian Ocean has been estimated as 144,188 whales (Wade and Gerrodette, 1993).

False killer whales are found worldwide in tropical to warm temperate zones in deep (> 3,300 ft (1,000 m) waters (Baird, 2009a; Odell and McClune, 1999; Stacey et al., 1994). Although typically a pelagic species, they approach close to the shores of oceanic islands and regularly mass strand (Baird, 2009a). In the North Pacific Ocean, false killer whales are well documented in the waters of southern Japan, Hawaii, ETP, and off the U.S. West Coast. In the waters of the Hawaiian Archipelago, false killer whales occur in nearshore (Baird et al. 2008, 2013) and pelagic waters, including waters surrounding Palmyra and Johnston Atolls (Barlow et al., 2008, Bradford and Forney, 2013). False killer whales have a poorly known ecology. Breeding grounds and seasonality in breeding are unknown; however, one population does have a breeding peak in late winter (Jefferson et al., 2015). These whales do not have specific feeding grounds but feed opportunistically (Jefferson et al., 2015).

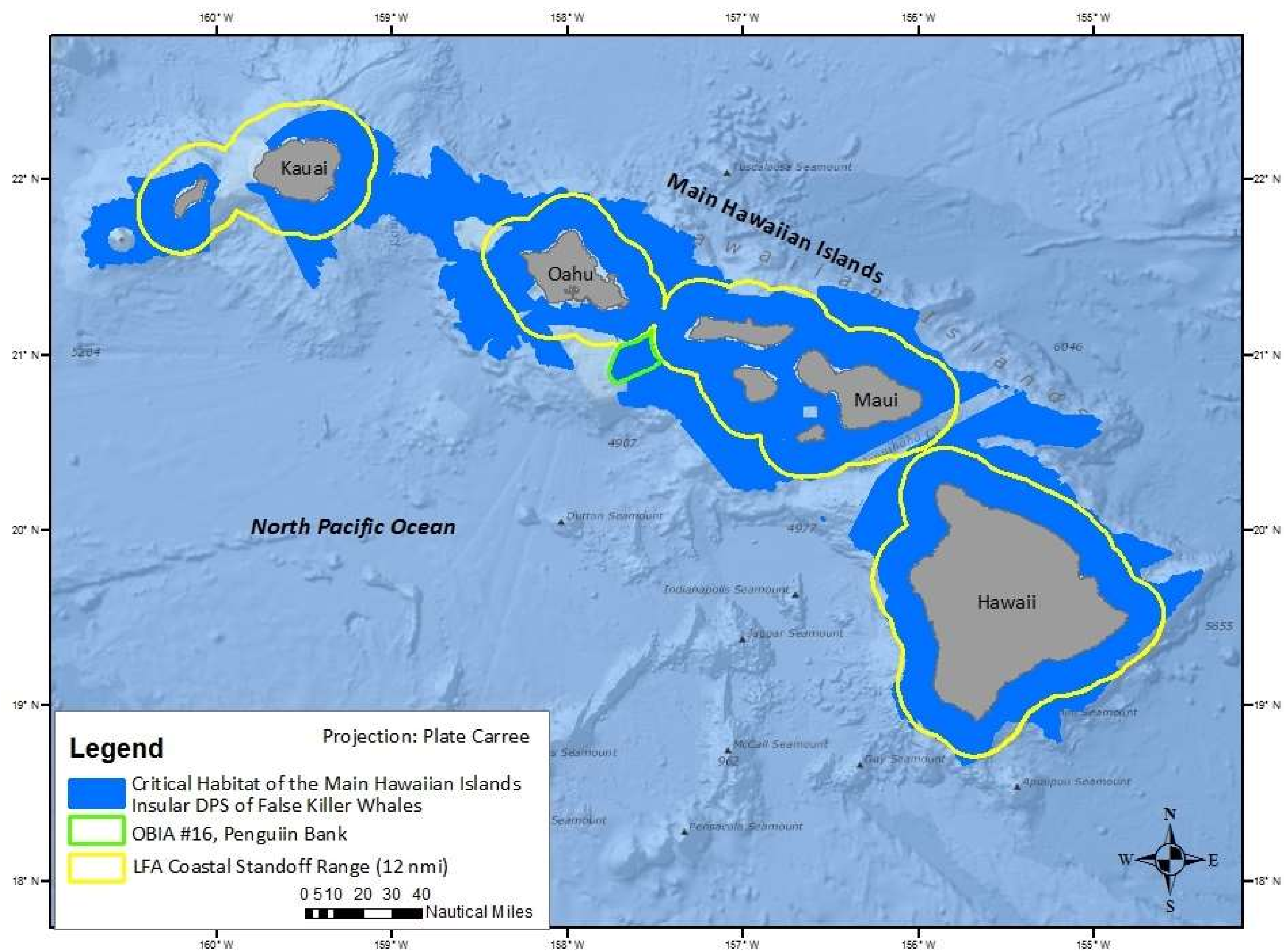

Figure 3-8. Critical Habitat Designated for the Main Hawaiian Islands Insular Distinct Population Segment of False Killer Whales in Hawaiian Waters (NOAA, 2018d).

False killer whales tagged in the western North Pacific performed both shallow and deep dives. Shallow dives had a mean duration of 103 sec and a mean maximum depth of 56 ft (17 m), while deep dives had a mean duration of 269 sec (SD = 189) and a mean maximum depth of 424 ft (129 m) (SD = 185) (Minamikawa et al., 2013), while the longest dives lasted 15 min and the deepest went to 2,133 ft (650 m). Dives were deeper during the day, suggesting that the whales are feeding on the deep scattering layer during the day (Minamikawa et al., 2013). False killer whales have an approximate swim speed of 1.6 kt (3 kph), although a maximum swim speed has been documented at 14.5 kt (26.9 kph) (Brown et al., 1966; Rohr et al., 2002).

False killer whales hear underwater sounds in the range of less than 1 to 115 kHz (Au, 1993; Johnson, 1967). Their best underwater hearing occurs at 17 kHz, where the threshold level ranges between 39 to 49 dB RL. In a study by Yuen et al. (2005), false killer whales' hearing was measured using both behavioral and AEP audiograms. The behavioral data show that this species is most sensitive between 16 and 24 kHz, with peak sensitivity at 20 kHz. The AEP data show that this species best hearing sensitivity is from 16 to 22.5 kHz, with peak sensitivity at 22.5 kHz. Au et al. (1997) studied the effects of the Acoustic Thermometry of Ocean Climate (ATOC) program on false killer whales. The ATOC source transmitted 75-Hz, 195 dB SL signals. The hearing thresholds for false killer whales were 140.7 dB RL ± 1.2 dB for the 75-Hz pure tone and 139.0 dB RL ±1.1 dB for the ATOC signal. False killer whales have the ability to reduce their hearing sensitivity in response to loud sounds (Nachtigall and Supin, 2013).

False killer whales produce a wide variety of sounds from 4 to 130 kHz, with dominant frequencies between 25 to 30 kHz and 95 to 130 kHz (Busnel and Dziedzic, 1968; Kamminga and Van Velden, 1987; Murray et al., 1998; Thomas and Turl, 1990). Most signal types vary among whistles, burst-pulse sounds and click trains (Murray et al. 1998). Whistles generally range between 4.7 and 6.1 kHz. Echolocation clicks of false killer whales are highly directional and range between 20 and 60 kHz and 100 and 130 kHz (Kamminga and van Velden, 1987; Madsen et al., 2004a; Thomas and Turl, 1990). There are no available data regarding seasonal or geographical variation in the sound production of false killer whales. Estimated peak-to-peak SL of captive animal clicks is near 228 dB re 1 μPa @ 1 m (Madsen et al., 2004a; Thomas and Turl, 1990).

- *Fraser's Dolphin (Lagenodelphis hosei)*

Fraser's dolphin is classified as a data deficient species by the IUCN. The global population for this species is unknown. Abundances or densities of Fraser's dolphins only exist for a limited number of regions. In the WNP stock, 220,789 Fraser's dolphins are estimated; while in the Central North Pacific stock, which includes Hawaii, 51,491 dolphins (CV=0.66) have been estimated (Bradford et al., 2017). The Indian Ocean population is estimated to include 151,554 dolphins (Wade and Gerrodette, 1993).

Fraser's dolphins occur primarily in tropical and subtropical waters of the Atlantic, Pacific, and Indian oceans (Croll et al., 1999; Dolar, 2009). This oceanic species is most commonly found in deep waters (4,921 to 6,562 ft [1,500 to 2,000 m]) usually 8.1 to 11 nmi (15 to 20 km) from shore or where deepwater approaches the shore, as occurs in the Philippines, Taiwan, some Caribbean islands, and the Indonesian-Malay archipelago (Jefferson et al., 2015). Breeding areas and seasonal movements of this species have not been confirmed. However, in Japan, calving appears to peak in the spring and fall. There is some evidence that calving occurs in the summer in South Africa (Dolar, 2009).

Little information on the diving ability of the Fraser's dolphin is available. Based on prey composition, it is believed that Fraser's dolphins feed at two depth horizons in the ETP: the shallowest depth in this region is no less than 820 ft (250 m) and the deepest is no less than 1,640 ft (500 m). In the Sulu Sea, these dolphins appear to feed from near the surface to at least 1,968 ft (600 m). Off South Africa and in the Caribbean Sea, Fraser's dolphins were observed feeding near the surface (Dolar et al., 2003). According to Watkins et al. (1994), Fraser's dolphins herd when they feed, swimming rapidly to an area, diving for 15 sec or more, surfacing and splashing in a coordinated effort to surround the school of fish. Swim speeds of Fraser's dolphin have been recorded between 2.2 and 3.8 kt (4 and 7 kph) with swim speeds up to 15 kt (28 kph) when escaping predators (Croll et al., 1999).

Hearing sensitivity of Fraser's dolphins has not been measured (Ketten, 2000; Thewissen, 2002). Fraser's dolphins produce sounds ranging from 4.3 to over 40 kHz (Leatherwood et al., 1993; Watkins et al., 1994). Echolocation clicks are described as short broadband sounds without emphasis at frequencies below 40 kHz, while whistles were frequency-modulated tones concentrated between 4.3 and 24 kHz. Whistles have been suggested as communicative signals during social activity (Watkins et al., 1994). There are no available data regarding seasonal or geographical variation in the sound production of Fraser's dolphins. Source levels were not available.

- *Indo-Pacific Bottlenose Dolphin (Tursiops aduncus)*

Only recently has this species' taxonomy been clearly differentiated from that of the common bottlenose dolphin. Indo-Pacific bottlenose dolphins are considered data deficient by the IUCN. No global abundance estimates exist for the species and even regional abundance estimates are few, even though it is the most commonly observed marine mammal species in some coastal regions of the world. Estimates of Indo-Pacific bottlenose dolphins include 218 animals in Japanese waters and 1,634 to 1,934 dolphins in Australian waters (Wang and Yang, 2009). The population includes more than 24 dolphins off Taiwan and 44 dolphins in the northeast Philippines (Jefferson et al., 2015). In the Indian Ocean, the population has been numbered at 7,850 dolphins (Wade and Gerrodette, 1993).

Indo-Pacific bottlenose dolphins occur in warm temperate to tropical waters of the Indian Ocean and southwestern Pacific Ocean, from South Africa and the Red Sea and Persian Gulf to southern Japan, Indonesia, Malaysia, and central Australia (Jefferson et al., 2015). Considered principally a coastal species, the Indo-Pacific bottlenose dolphin occurs predominantly in continental shelf and insular shelf waters, usually in shallow coastal and inshore waters (Cribb et al., 2013; Jefferson et al., 2015). However, movements across deep, oceanic waters have been reported (Wang and Yang, 2009).

Little information is known about the diving ability of the Indo-Pacific bottlenose dolphin, but dive depths and durations are thought be less than 656 ft (200 m) and from 5 to 10 min (Wang and Yang, 2009). Swimming speeds range from 0.8 to 2.2 kt (1.5 to 4.1 kph), but bursts of higher speeds can reach 8.6 to 10.3 kt (16 to 19 kph) (Wang and Yang, 2009).

Although much is known about hearing in the common bottlenose dolphin, specific hearing data are not yet available for the Indo-Pacific bottlenose dolphin. These dolphins produce whistle and pulsed call vocalizations. Whistles range in frequency from 4 to 12 kHz (Gridley et al., 2012; Morisaka et al., 2005a). Morisaka et al. (2005a) found variations in whistles between populations of Indo-Pacific bottlenose dolphins and determined that ambient noise levels were likely responsible for the whistle variability (Morisaka et al., 2005b). Variability in whistle structure has been documented between both nearby and distant groups, although a few whistle types were shared, suggesting that their repertoire is driven by social functions such as group identity (Hawkins, 2010). Preliminary analyses suggest that Info-Pacific bottlenose dolphins use signature whistles like the common bottlenose dolphin (Gridley et al., 2014). Indo-Pacific bottlenose dolphin echolocation clicks have peak-to-peak source levels that range between

177 to 219 dB, with a duration of 8-48 μsec, and peak frequencies that range from 45 to 141 kHz (de Freitas et al., 2015; Wahlberg et al., 2011b).

- *Killer Whale (Orcinus orca)*

The killer whale is classified as a data deficient species under the IUCN. In 2005, NMFS listed the Southern Resident killer whale DPS as endangered under the ESA (NOAA, 2005c). Both the Southern Resident and AT1 Transient stocks of killer whales are listed as depleted under the MMPA. Critical habitat has been designated for the Southern Resident killer whales in the inland marine waters of Washington (Puget Sound, Strait of Juan de Fuca, and Haro Strait) (NOAA, 2006).

Generally, three major ecotypes of killer whales have been identified: the coastal (fish-eating) residents, the coastal (mammal-eating) transients, and the offshore types of killer whales. The basic social unit for all of these ecotypes is the matrilineal group (Ford, 2009). In resident killer whales, pods are formed from multiple matrilines and related pods form clans. Resident killer whales in the North Pacific consist of the southern, northern, southern Alaska (which includes southeast Alaska and Prince William Sound whales), western Alaska, and western North Pacific groups (NOAA, 2005c).

Although no current global population estimates are available, Jefferson et al. (2015) estimated the killer whale worldwide abundance near 50,000 individuals. An abundance of 146 killer whales (CV=0.96) are currently estimated in the Hawaii stock (Bradford et al., 2017; Carretta et al., 2014), while 12,256 whales estimated to occur in the WNP stock (Ferguson and Barlow, 2001 and 2003). In the Indian Ocean, killer whales number 12,593 individuals (Wade and Gerrodette, 1993).

The killer whale is perhaps the most cosmopolitan of all marine mammals, found in all the world's oceans from about 80°N to 77°S, especially in areas of high productivity and in high latitude coastal areas (Ford, 2009; Leatherwood and Dalheim, 1978). However, killer whales appear to be more common within 430 nmi (800 km) of major continents in cold-temperate to subpolar waters (Mitchell, 1975). Individual populations are known to migrate between high and low latitude waters (Dahlheim et al., 2008; Durban and Pitman, 2012; Matthews et al., 2011).

The diving behavior of killer whales differs between fish-eating and mammal-eating types. Baird et al. (2005) reported that southern resident (fish-eating) killer whales in Washington State had a mean maximum dive depth of 463 ft (141 m [SD = 62 m]), with a maximum dive depth of 807 ft (246 m). Males dove more often and remained submerged longer than females and dove more during the day than at night. Fish-eating killer whales in Antarctica dove to depths ranging from about 656 to 2,625 ft (200 to 800 m) (Reisinger et al., 2015); these killer whales also dove significantly deeper during the day than the night. Miller et al. (2010) reported on the diving behavior of transient (mammal-eating) killer whales in Alaska. Dives were categorized as short and shallow or long and deep. Short dives lasted less than one minute to water depths <16 ft (5 m), while deep dives ranged between 39 to 164 ft (12 and 50 m) in depth and lasted from 4 to 6 min. The mammal-easting killer whales dove much less deeply than the fish-eating whales, reflecting the distribution of their prey. Swimming speeds usually range between 3.2 to 5.4 kt (6 to 10 kph) but short bursts of speeds up to 20 kt (37 kph) have been documented (Lang, 1966; LeDuc, 2009).

Killer whales hear underwater sounds in the range of <500 Hz to 120 kHz (Bain et al., 1993; Szymanski et al., 1999). Their best underwater hearing occurs between 15 and 42 kHz, where the threshold level is near 34 to 36 dB RL (Hall and Johnson, 1972; Szymanski et al., 1999). Killer whales produce sounds as low as 80 Hz and as high as 85 kHz with dominant frequencies at 1 to 20 kHz (Awbrey, 1982; Diercks et al., 1973; Diercks et al., 1971; Evans, 1973; Ford, 1989; Ford and Fisher, 1982; Miller and Bain, 2000; Schevill and Watkins, 1966). An average of 12 different call types (range 7 to 17)—mostly repetitive discrete calls—exist for some pods of killer whales (Ford, 2009). Pulsed vocalizations tend to be in the range between 500 Hz and 10 kHz and may be used for group cohesion and identity (Ford, 2009; Frankel, 2018). Whistles range in frequency up to at least 75 kHz (Filatova et al., 2012; Samarra et al., 2015; Simonis et al., 2012). Echolocation clicks are also included in killer whale repertoires but are not a dominant signal type in comparison to pulsed calls (Miller and Bain, 2000). Erbe (2002) recorded received broadband SPLs of killer whale's burst-pulse calls that ranged between 105 and 124 dB RL at an estimated distance of 328 ft (100 m). Offshore killer whales tracked in the Southern California Bight had SLs for echolocation clicks of 170 to 205 dB re 1μPa @ 1 m (peak-peak) (Gassmann et al., 2013). Whistle source levels ranged between 185 and 193 dB re 1 μPa @ 1 m. Pulse call source levels ranged between 146-158 dB re 1μPa @ 1 m. While the basic structure of killer whale vocalizations are similar within all populations, geographic variation between populations does exist (Samarra et al., 2015).

All pods within a clan have similar dialects of pulsed calls and whistles. Killer whales engaged in different activities produce different proportion of calls, suggesting that high-frequency and biphonic calls are used for long range communication, and LF monophonic calls are used for intra-pod signaling (Filatova et al., 2013). Intense LF pulsed calls (683 Hz, 169 to 192 dB re 1 μPa @ 1 m (peak-peak) appear to be used to manipulate herring prey, increasing foraging efficiency (Simon et al., 2006).

- *Melon-headed Whale (Peponocephala electra)*

Melon-headed whales are classified as a lower risk (least concern) species by the IUCN. The global population for this species is unknown. Kanaji et al. (2018) estimated the population of the WNP to include 56, 213 individuals. Two populations have been documented in Hawaiian waters: the Hawaiian Islands stock with an estimated 8,666 whales (CV=1.00) (Bradford et al., 2017), and the Kohala resident population with an estimated 447 whales (CV=0.12) (Aschettino, 2010; Carretta et al., 2014; Oleson et al., 2013). In the Indian Ocean, the melon-headed whale population has been estimated as 64,600 whales (Wade and Gerrodette, 1993).

The melon-headed whale occurs in pelagic tropical and subtropical waters worldwide (Jefferson and Barros, 1997). Breeding areas and seasonal movements of this species have not been confirmed.

Few data are available on diving or swim speed for the melon-headed whale. Melon-headed whales feed on mesopelagic squid found down to 4,920 ft (1,500 m) deep, so they appear to feed deep in the water column (Jefferson and Barros, 1997). Mooney et al. (2012) reported in preliminary research findings that a tagged melon-headed whale in Hawaiian waters dove deeply to near the seafloor, >984 ft (300 m), at night but stayed near the sea surface during the day, with no dives >67 ft (20 m). Melon-headed whales in the Caribbean appeared to have two modes of foraging diving, with a small percentage of foraging dives descending less than 328 ft (100 m), while most of the foraging dives ranged from 492 to 1,640 ft (150 to 500 m) (Joyce et al., 2017). Dive durations were as long as 18 min (Joyce et al., 2017). No swim speeds for are available for this species.

There is no direct measurement of hearing sensitivity for melon-headed whales (Ketten, 2000; Thewissen, 2002). The first confirmed description of melon-headed whale vocalizations was reported by Frankel and Yin (2010). Melon-headed whale's clicks have frequency emphases beginning at 13 kHz and extending to at least 100 kHz (Baumann-Pickering et al., 2015a; Frankel and Yin, 2010). Dominant frequencies of whistles are 1 to 24 kHz, with both upsweeps and downsweeps in frequency modulation. Burst-pulse sounds had a mean duration of 586 msec. No available data exist regarding seasonal or geographical variation in the sound production of this species. Changes in vocalization activity patterns suggest that melon-headed whales may forage at night and rest during the day (Baumann-Pickering et al., 2015a).

- *Northern Right Whale Dolphin (Lissodelphis borealis)*

The northern right whale dolphin is classified as a least concern (lower risk) species by the IUCN. The global population in the North Pacific Ocean of the northern right whale dolphin is estimated as 68,000 animals (Jefferson et al., 2015).

This oceanic species is only found in temperate to subarctic regions of the North Pacific from roughly 34° to 54° N and 118° to 145° W (Jefferson et al., 2015; Lipsky, 2009). This range extends from the Kuril Islands (Russia) south to Japan and from the Gulf of Alaska to southern California. Northern right whale dolphins have been most often observed in waters ranging in temperature from 46.4 to 66.2°F (8 and 19°C) (Leatherwood and Walker, 1979). Northern right whale dolphins can occur near to shore when submarine canyons or other such topographic features cause deep water to be located close to the coast. Seasonally the northern right whale dolphin exhibits inshore-offshore movements in some areas, such as off southern California (Lipsky, 2009).

The maximum recorded dive duration for northern right whale dolphins is 6.25 min with a maximum dive depth of 656 ft (200 m) (Fitch and Brownell, 1968; Leatherwood and Walker, 1979). Swim speeds for northern right whale dolphins can reach 18.3 to 21.6 kt (34 to 40 kph) (Leatherwood and Reeves, 1983; Leatherwood and Walker, 1979).

There is no direct measurement of the hearing sensitivity of the northern right whale dolphin (Ketten, 2000; Thewissen, 2002). These dolphins0000 produce sounds as low as 1 kHz and as high as 40 kHz or more, with dominant frequencies at 1.8 and 3 kHz (Fish and Turl, 1976; Leatherwood and Walker, 1979). Echolocation clicks have peak frequencies that range from 23 to 41 kHz (Rankin et al., 2007). The maximum known peak-to-peak SL of northern right whale dolphins is 170 dB (Fish and Turl, 1976). Northern right whale dolphins also produce burst-pulse sounds that are lower in frequency and shorter in duration than echolocation click sequences. The peak frequencies of burst-pulses signals range from 6 to 37 kHz with durations from 1 to 178 msec (Rankin et al., 2007). Northern right whale dolphins do not produce whistles (Oswald et al., 2008).

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

Pacific white-sided dolphins are listed as least concern under the IUCN. In the North Pacific Ocean, an abundance of 931,000 Pacific white-sided dolphins has been estimated (Buckland et al., 1993; Jefferson et al., 2015).

Pacific white-sided dolphins are mostly pelagic and have a primarily cold temperate distribution across the North Pacific; in the western North Pacific, this species occurs from Taiwan north to the Commander and Kuril Islands while in the eastern North Pacific, it occurs from southern Gulf of California to the Aleutian Islands (Black, 2009; Jefferson et al., 2015). Pacific white-sided dolphins are distributed in continental shelf and slope waters generally within 100 nmi (185 km) of shore and often move into coastal and even inshore waters. No breeding grounds are known for this species.

From studies of the ecology of their prey, Pacific white-sided dolphins are presumed to dive from 393.7 to 656 ft (120 to 200 m), with most of their foraging dives lasting a mean of 27 sec (Black, 1994). Captive

Pacific white-sided dolphins were recorded swimming as fast as 15.0 kt (27.7 kph) for 2 sec intervals (Fish and Hui, 1991), with a mean travel speed of 4.1 kt (7.6 kph) (Black, 1994).

Pacific white-sided dolphins hear in the frequency range of 2 to 125 kHz when the sounds are equal to or softer than 90 dB RL (Tremel et al., 1998). This species is not sensitive to LF sounds (i.e., 100 Hz to 1 kHz) (Tremel et al., 1998). Pacific white-sided dolphins produce broad-band clicks in the frequency range of 60 to 80 kHz with a SL at 180 dB re 1 µPa @ 1 m (Richardson et al., 1995). These clicks have spectral peaks at 22.2, 26.6, 33.7, and 37.3 kHz with spectral notches at 19.0, 24.5, and 29.7 kHz. These spectral characteristics can be used to identify the species from recordings (Soldevilla et al., 2008). There are no available data regarding seasonal or geographical variation in the sound production of *Lagenorhynchus* dolphins.

- *Pantropical Spotted Dolphin (Stenella attenuata)*

The pantropical spotted dolphin is one of the most abundant dolphin species in the world. This species is listed as a least concern (lower risk) species by the IUCN. The WNP population of pantropical spotted dolphins is estimated to include 130,002 individuals (Kanaji et al., 2018). Pantropical dolphins in the Central North Pacific stock, which encompasses the Hawaiian Islands, are comprised of four stocks: the pelagic stock, estimated as 55,795 dolphins (CV=0.55) (Bradford et al., 2017), as well as the Hawaii Island, Oahu, and 4-Islands stocks, which have each been estimated to include 220 individuals (Courbis et al., 2014). As many as 736,575 pantropical spotted dolphins have been estimated to occur in the Indian Ocean (Wade and Gerrodette, 1993).

Pantropical spotted dolphins occur throughout tropical and sub-tropical waters from roughly 40°N to 40°S in the Atlantic, Pacific, and Indian Oceans (Perrin, 2009c). These dolphins typically are oceanic but are found close to shore in areas where deep water approaches the coast, as occurs in Taiwan, Hawaii, and the western coast of Central America (Jefferson et al., 2015). Pantropical spotted dolphins also occur in the Persian Gulf and Red Sea.

Pantropical spotted dolphins dive to at least 557.7 ft (170 m), with most of their dives to between 164 and 328 ft (50 and 100 m) for 2 to 4 min, and most foraging occurs at night (Stewart, 2009). Off Hawaii, pantropical spotted dolphins have been recorded to dive to a maximum depth of 400 ft (122 m) during the day and 700 ft (213 m) during the night (Baird et al., 2001). The average dive duration for the pantropical spotted dolphins is 1.95 min to water depths as deep as 328 ft (100 m) (Scott et al., 1993). Dives of up to 3.4 min have been recorded (Perrin, 2009c). Pantropical spotted dolphins have been recorded swimming at speeds of 2.2 to 10.3 kt (4 to 19 kph), with bursts up to 12 kt (22 kph) (Perrin, 2009c).

Greenhow et al. (2016) studied the hearing thresholds of a pantropical spotted dolphin using AEP and behavioral methods, and found the peak hearing sensitivity at 10 kHz, with a cutoff frequency between 14 and 20 kHz. Pantropical spotted dolphins produce whistles with a frequency range of 3.1 to 21.4 kHz (Richardson et al., 1995). They also produce click sounds that are typically bimodal in frequency with peaks at 40 to 60 kHz and 120 to 140 kHz with SLs up to 220 dB re 1 µPa (Schotten et al., 2004).

- *Pygmy Killer Whale (Feresa attenuata)*

Pygmy killer whales are one of the least known cetacean species. They are classified as data deficient by the IUCN. The global population for this species is unknown. Estimates of the Hawaiian population include 10,640 whales (CV=0.53) (Bradford et al., 2017), and 30,214 whales are included in the WNP population (Ferguson and Barlow, 2001 and 2003). An estimated 22,029 pygmy killer whales have been estimated in the Indian Ocean (Wade and Gerrodette, 1993).

Pygmy killer whales have been recorded in oceanic tropical and subtropical waters of all oceans (Caldwell, 1971; Donahue and Perryman, 2009). These whales are sighted relatively frequently in the ETP, the Hawaiian archipelago, and off Japan (Donahue and Perryman, 2009; Leatherwood et al., 1988). The population in Hawaiian waters shows high site fidelity and is considered to represent a resident population (McSweeney et al., 2009). No data are available to confirm seasonal migration patterns for pygmy killer whales. No data on breeding and calving grounds are available.

No dive data are available. Baird et al. (2011) reported that tagged pygmy killer whales in Hawaiian waters swam at speeds from 1.5 to 1.7 kt (2.7 to 3.1 kph).

Little information is available on the hearing sensitivity of pygmy killer whales. Recently, AEP-derived audiograms were obtained on two live-stranded pygmy killer whales during rehabilitation. The U-shaped audiograms of these pygmy killer whales showed that best hearing sensitivity occurred at 40 kHz with lowest hearing thresholds having occurred between 20 and 60 kHz (Montie et al., 2011). These stranded animals did not hear well at higher frequencies (90 and 96 dB at 100 kHz) (Montie et al., 2011). The peak frequencies of wild pygmy killer whale clicks ranged from 45 to 117 kHz, with peak-to-peak source levels that ranged from 197 to 223 dB (Madsen et al., 2004b). Pryor et al. (1965) described the LF "growl" sounds produced by pygmy killer whales.

- *Risso's Dolphin (Grampus griseus)*

Risso's dolphins are classified as a least concern (lower risk) species by the IUCN. No global population abundance exists for the Risso's dolphin. The WNP and Inshore Archipelago stocks of Risso's dolphins are each estimated to include 143,374 individuals (Kanaji et al. 2018); the Inshore Archipelago stock occurs in the Asian continental seas. In the Hawaii stock, 11,613 Risso's dolphins (CV=0.43) have been estimated (Bradford et al., 2017). The population of Risso's dolphins in the Indian Ocean is estimated to include 452,125 individuals (Wade and Gerrodette, 1993).

Risso's dolphin inhabits deep oceanic and continental slope waters from the tropics through the temperate regions (Baird, 2009b; Jefferson et al., 1993; Leatherwood et al., 1980). These dolphins occur predominantly at steep shelf-edge habitats, in waters between 1,300 and 3,281 ft (400 and 1,000 m) deep and temperatures ranging from 59° to 68° F (15° and 20°C) and rarely below 50° F (10°C) (Baird, 2009b). Seasonal migrations of Risso's dolphins in Japanese and North Atlantic populations have been apparent, although seasonal variation in their movement patterns elsewhere have not been studied (Kasuya, 1971; Mitchell 1975). No data on breeding grounds are available, and Risso's dolphins have been known to calve year round, but peak breeding times differ by habitat. In the North Atlantic, breeding peaks in the summer, while in Japan breeding peaks in summer-fall, and in California, breeding peaks in fall-winter (Jefferson et al., 2015).

Dive times up to 30 min have been reported for Risso's dolphins (Jefferson et al. 2015). Arranz et al. (2018) reported that Risso's dolphins spend 1 to 3 min at the surface between foraging dives; echolocate throughout foraging dives, a behavior atypical of deep-diving odontocetes; and often continue to forage during ascent. Out of 37 foraging dives observed from tagged Risso's dolphins, 57 percent were to shallow water depths (<295 ft [90 m]) while only 12 percent were to deep water depths (1,148 to 1,476 ft [350 to 450 m]) (Arranz et al., 2018). Typical Risso's dolphin swimming speeds are 3.2 to 3.8 kt (6 to 7 kph) (Kruse et al., 1999). Risso's dolphins studied in the Ligurian Sea also swam at speeds from 3.2 to 3.8

kt (6 to 7 kph), remained at the surface for about 7 to 15 sec between dives that lasted 5 to 7 min and occasionally longer (Bearzi et al., 2011). Swim speeds from Risso's dolphins were recorded at 1.1 to 6.5 kt (2 to 12 kph) off Santa Catalina Island (Shane, 1995). Tag data from a rehabilitated and released Risso's dolphin in the Gulf of Mexico indicate that the Risso's dolphin swam on average at 3.9 kt (7.19 kph) and the majority (95 percent) of the dives were within 50 m of the sea surface, with the deepest to 1,312 to 1,640 ft (400 to 500 m) (Wells et al., 2009).

Audiograms for Risso's dolphins indicate that their hearing RLs equal to or less than approximately 125 dB in frequencies ranging from 1.6 to 110 kHz (Nachtigall et al., 1995). Philips et al. (2003) reported that Risso's dolphins are capable of hearing frequencies up to 80 kHz. Optimal underwater hearing occurs between 4 and 80 kHz, with hearing threshold levels from 63.6 to 74.3 dB RL. Other audiograms obtained on Risso's dolphin (Au et al., 1997) confirm previous measurements and demonstrate hearing thresholds of 140 dB RL for a 1-second 75 Hz signal (Croll et al., 1999). Au et al. (1997) estimated the effects of the ATOC source on false killer whales and on Risso's dolphins. The ATOC source transmitted 75-Hz, 195 dB SL acoustic signal to study ocean temperatures. The hearing sensitivity was measured for Risso's dolphins and their thresholds were found to be 142.2 dB RL $\pm$ 1.7 dB for the 75 Hz pure tone signal and 140.8 dB RL $\pm$ 1.1 dB for the ATOC signal (Au et al., 1997). Another individual had best hearing at 11 kHz, and between 40 and 80 kHz, a response threshold of about 60 dB re 1μPa (Mooney et al., 2015). These values are comparable to those previously reported by (Nachtigall et al., 1995; Nachtigall et al., 2005). Risso's dolphins are able to reduce their hearing sensitivity while echolocating (Nachtigall and Supin, 2008).

Risso's dolphins produce sounds as low as 0.1 kHz and as high as 65 kHz. Their dominant frequencies are between 2 to 5 kHz and at 65 kHz (Au, 1993; Corkeron and Van Parijs, 2001; Croll et al., 1999; Watkins, 1967). Risso's dolphins produce tonal whistles, burst-pulse sounds, echolocation clicks and a hybrid burst-pulse tonal signal (Corkeron and Van Parijs, 2001). Echolocation clicks have peak frequencies around 50 kHz, centroid frequencies of 60-90 kHz with peak-to-peak source levels of 202-222 dB re 1 µPa at 1 m (Madsen et al., 2004a). In one experiment conducted by Phillips et al. (2003), clicks were found to have a peak frequency of 65 kHz, with 3 dB bandwidths of 72 kHz and durations ranging from 40 to 100 msec. In a second experiment, Phillips et al. (2003) recorded clicks with peak frequencies up to 50 kHz, with a 3 dB bandwidth of 35 kHz. Click durations ranging from 35 to 75 msec. Estimated SLs of echolocation clicks can reach up to 216 dB (Phillips et al., 2003). Bark vocalizations consisted of highly variable burst pulses and have a frequency range of 2 to 20 kHz. Buzzes consisted of a short burst pulse of sound around 2 seconds in duration with a frequency range of 2.1 to 22 kHz. Low frequency, narrowband grunt vocalizations ranged from 400 to 800 Hz. Chirp vocalizations were slightly higher in frequency than the grunt vocalizations, ranging in frequency from 2 to 4 kHz. There are no available data regarding seasonal or geographical variation in the sound production of Risso's dolphin.

- *Rough-toothed Dolphin (Steno bredanensis)*

The rough-toothed dolphin is classified as least concern by the IUCN. Globally, few population estimates are available. The populations of rough-toothed dolphins in the WNP stock is estimated to include 5,002dolphins (Kanaji et al., 2018), while the Hawaii stock was estimated to include 72,528 individuals (CV=0.39) (Bradford et al., 2017). In the Indian Ocean, the population of rough-toothed dolphins was estimated at 156,690 individuals (Wade and Gerrodette, 1993).

Rough-toothed dolphins occur in oceanic tropical and warm-temperate waters around the world and appear to be relatively abundant in certain areas; these dolphins are also found in continental shelf waters in some locations, such as Brazil (Jefferson, 2009b). In the Pacific, rough-toothed dolphins inhabit waters from central Japan to northern Australia and from Baja California, Mexico, south to Peru. Rough toothed dolphins are also found in the Indian Ocean, from the southern tip of Africa to Australia (Jefferson et al., 2015). Seasonal movements and breeding areas for this species have not been confirmed.

Rough-toothed dolphins can dive to 98 to 230 ft (30 to 70 m) with dive durations ranging from 0.5 to 3.5 min (Ritter, 2002; Watkins et al., 1987b). Dives up to 15 min have been recorded for groups of dolphins (Miyazaki and Perrin, 1994). Rough-toothed dolphins are not known to be fast swimmers, often skimming the surface at a moderate speed (Jefferson, 2009b). Swim speeds of this species vary from 3.0 to 8.6 kt (5.6 to 16 kph) (Ritter, 2002; Watkins et al., 1987b).

Very little information is available on the hearing sensitivity of rough-toothed dolphins. Cook et al. (2005a) performed AEPs on five live-stranded rough-toothed dolphins and found that these dolphins could detect sounds between 5 and 80 kHz; the authors believe that rough-toothed dolphins are likely capable of detecting frequencies much higher than 80 kHz. Rough-toothed dolphins produce sounds ranging from 0.1 kHz up to 200 kHz (Miyazaki and Perrin, 1994; Popper, 1980; Thomson and Richardson, 1995). Clicks have peak energy at 25 kHz, while whistles have a maximum energy between 2 to 14 kHz (Lima et al., 2012; Norris, 1969; Norris and Evans, 1967; Oswald et al., 2007; Popper, 1980). There are no available data regarding seasonal or geographical variation in the sound production of this species.

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

Two ecotypes of short-finned pilot whales occur in the western North Pacific Ocean off Japan, the northern (Shiho) and southern (Naisa) ecotypes, which are distinguishable by pigmentation, morphological, genetic, acoustic, and geographical characteristics (Kanaji et al. 2018; Kasuya, 1998; Kasuya and Perrin, 2017; Olson, 2018; Van Cise et al., 2016 and 2017a). The northern ecotype is distinguished at sea by a saddle-patch near the dorsal fin, and the two forms are restricted to the waters off northern and southern Japan, respectively, by the Kuroshio Front; the northern ecotype of the short-finned pilot whale is located in the area roughly between 35° and 43° N latitude while the southern ecotype is found from about 23° to 35° N latitude (Miyashita, 1993; Kasuya and Perrin, 2017). Recent research on short-finned pilot whales in Hawaiian waters indicates that genetically, the Hawaiian area pilot whales are similar to the southern ecotype found off Japan (Van Cise et al., 2016). The short-finned pilot whale is classified as data deficient by the IUCN. A global population estimate of short-finned pilot whales is unknown. The population of short-finned pilot whales in the Indian Ocean has been estimated at 268,751 individuals (Wade and Gerrodette, 1993). In the North Pacific Ocean, an abundance of 19,503 whales (CV=0.49) is estimated for the Hawaii stock of short-finned pilot whales (Bradford et al., 2017). In the WNP Ocean, two stocks of short-finned pilot whales are recognized, the WNP Northern and WNP Southern, with respective abundances estimated as 20,884 and 31,396 individuals (Kanaji et al., 2018).

Short-finned pilot whales occur in nearshore to pelagic, tropical to warm-temperate waters of the Atlantic, Pacific, and Indian oceans (Olson, 2018). Little seasonal movement has been documented in this species but most occur in oceanic waters annually, only moving inshore to follow the movements of their prey (Croll et al., 1999). Short-finned pilot whales are considered nomadic, although resident populations are known to occur in California’s Channel Islands, Madiera Islands, Hawaiian Islands, and in the Strait of Gibraltar (Olson, 2018). Additionally, two short-finned pilot whale populations are likely in Hawaiian waters, particularly in the Main Hawaiian Islands: an insular, inshore population as well as a pelagic, offshore population (Carretta et al. 2018; Van Cise et al., 2017b).

Both long- and short-finned pilot whales are considered deep divers, feeding primarily on fish and squid (Croll et al., 1999). Short-finned pilot whales off Tenerife showed a bimodal dive behavior with a large number of dives to 984 ft (300 m), very few between 984 to 1,640 ft (300 and 500 m), and many dives with a maximum depth between 1,640 to 3,343 ft (500 and 1,019 m) (Aguilar Soto et al., 2008). Generally, dive times increased with dive depth, to a maximum duration of 21 min. (Ridgway, 1986). Data from Madeira Island show that dives can last as long as 20 min to as deep as 3,281 ft (1,000 m) (Alves et al., 2013), although the majority of recorded dives were much shorter and shallower, and almost all of these were recorded during the daytime. Two whales that had stranded were equipped with satellite tags and were tracked for 16 and 67 days, with 93 percent of their dives to less than 328 ft (100 m) (Wells, 2013). Short-finned pilot whales have swim speeds ranging between (3.8 and 4.6 kt (7 and 9 kph) (Norris and Prescott, 1961). Short-finned pilot whale perform underwater 'sprints', with velocities ranging up to 17.5 kt (32.4 kph) that are associated with foraging attempts (Aguilar Soto et al., 2008).

AEPs were used to measure the hearing sensitivity of two short-finned pilot whales, one captive and one stranded (Schlundt et al., 2011). The region of best hearing sensitivity for the captive whale was between 40 and 56 kHz (thresholds of 78 and 79 dB re 1 µPa, respectively) with the upper limit of functional hearing between 80 and 100 kHz (Schlundt et al., 2011). The only measurable detection threshold for the stranded pilot whale was 108 dB re 1 µPa at 10 kHz, which suggested severe hearing loss above 10 kHz (Schlundt et al., 2011). The hearing range of the captive short-finned pilot whale was similar to other odontocete species, particularly of larger toothed whales. Another four stranded short-finned pilot whales were tested with AEP, and their greatest sensitivity was measured between 20 to 40 kHz for all whales, with thresholds between 70 and 80 dB re 1µPa, with higher thresholds (25 to 61 dB) measured at 80 kHz measured for the adults than the juveniles (Greenhow et al., 2014).

Short-finned pilot whales produce sounds as low as 280 Hz and as high as 100 kHz, with dominant frequencies between 2 to 14 kHz and 30 to 60 kHz (Caldwell and Caldwell, 1969; Fish and Turl, 1976; Scheer et al., 1998). The mean call frequency produced by short-finned pilot whales is 7.87 kHz, much higher than the mean call frequency produced by long-finned pilot whales (Rendell et al., 1999). The frequency content of tonal calls extends to at least 30 kHz (Sayigh et al., 2013). Echolocation abilities have been demonstrated during click production (Evans, 1973). Pilot whales' echolocate with a precision similar to bottlenose dolphins and vocalize with other school members (Olson, 2018). SLs of clicks have been measured as high as 180 dB (Fish and Turl, 1976). The center frequency of their clicks is 25 kHz, with a mean 10 dB bandwidth of 10 kHz (Baumann-Pickering et al., 2015b), and a mean click duration was 545 milliseconds (msec). There are little available data regarding seasonal or geographical variation in the sound production of the short-finned pilot whale, although there is evidence of group specific call repertoires (Olson, 2018) and specific call types can be repeated (Sayigh et al., 2013).

- *Spinner Dolphin (Stenella longirostris)*

Spinner dolphins are classified overall as a data deficient species by the IUCN. Spinner dolphins are one of the most abundant dolphin species in the world. In the western North Pacific, 1,015,059 spinner dolphins have been estimated (Ferguson and Barlow, 2001 and 2003). In Hawaiian waters, the Hawaii pelagic stock includes 3,351 dolphins (Barlow, 2006), while the island associated populations include the Kauai and Niihau stock of 601 individuals, the Hawaii Island stock that number 631 dolphins, the Oahu/4-Islands stock with 355 spinner dolphins, the Kure/Midway Atoll stock of 260 dolphins, and the Pearl and Hermes Reef stock of 300 spinner dolphins (Andrews et al., 2006; Carretta et al., 2014; Hoos, 2013). The spinner dolphin population in the Indian Ocean is estimated as 634,108 individuals (Wade and Gerrodette, 1993).

Spinner dolphins are pantropical, occurring in tropical and most subtropical oceanic waters from about 40°S to 40°N, except in the Mediterranean Sea (Jefferson et al. 2015). Spinner dolphins are found in coastal regions of Hawaii, the eastern Pacific, Indian Ocean, and off Southeast Asia, usually resting in the shallow waters of bays of oceanic islands and atolls (Perrin, 2009d). The dwarf species occurs only in the shallow waters of Southeast Asia and northern Australia is found in shallower waters in the Gulf of Thailand, Timor Sea, and Arafura Sea (Jefferson et al., 2015).

Based on where their prey is located in the water column, spinner dolphins likely dive as deep as 1,969 ft (600 m) (Perrin, 2009d). Dive durations are unknown for this species. Spinner dolphins are known for their aerial behavior, spinning up to seven times during one aerial leap from the water, reaching heights of 9 ft (3 m) above the water surface with an airborne time of 1.25 sec (Fish et al., 2006). Hawaiian spinner dolphins have swim speeds ranging from 1.4 to 3.2 kt (2.6 to 6 kph) (Norris et al., 1994).

Greenhow et al. (2016) measured the hearing threshold of a spinner dolphin using AEP methods, and reported a peak sensitivity at 40 kHz and functional hearing up to 128 kHz; these sensitivities are similar to those of other measured dolphins. Spinner dolphins produce burst pulse calls, echolocation clicks, whistles, and screams (Bazua-Duran and Au, 2002; Norris et al., 1994). The results of a study on spotted and spinner dolphins conducted by Lammers et al. (2003) revealed that the whistles and burst pulses of the two species span a broader frequency range than is traditionally reported for delphinids. The fundamental frequency contours of whistles occur in the human hearing range, but the harmonics typically reach 50 kHz and beyond. The whistle contours of near shore spinner dolphins in Hawaiʻi show geographic variation between groups (Bazua-Duran and Au, 2004), correlating with the Island associated populations. Additionally, the burst pulse signals are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al., 2003). Echolocation clicks show the typical delphinid broadband character, with center frequencies ranging from 34 to 58 kHz, peak frequencies from 27 to 41 kHz, and durations of 140 to 620 μs (Baumann-Pickering et al., 2010).

- *Striped Dolphin (Stenella coeruleoalba)*

Striped dolphins are a lower risk (least concern) species classified by the IUCN. In the Hawaii stock, 61,201 striped dolphins (CV=0.38) are estimated (Bradford et al., 2017). The WNP population of striped dolphins is divided into Northern, Southern, and Japanese Coastal stocks, with 497,725; 52,682; and 19,631 whales, respectively, estimated for each stock (Miyashita, 1993; Kasuya and Perrin, 2017). The Indian Ocean striped dolphin population is estimated to include 674,578 individuals (Wade and Gerrodette, 1993).

Striped dolphins are common in tropical and warm-temperate oceanic waters of the Atlantic, Pacific, and Indian oceans and adjacent seas between roughly 50° N and 40° S (Jefferson et al., 2015). Striped dolphins may be found in coastal waters in areas with very narrow continental shelves or where deep waters are found close to shore. Their occurrence appears to be associated with oceanographic fronts or circulation features in many regions, such as the ETP. Striped dolphins occur further north than other *Stenella* species, although in the western North Pacific Ocean, striped dolphins only very rarely occur in the Sea of Japan, East China Sea, Yellow Sea, or Sea of Okhotsk, even though the water temperatures appear to be in the range the species prefers (Kasuya and Perrin, 2017). In the western North Pacific Ocean, striped dolphins are divided into three stocks in the Pacific waters east of Japan. The oceanic Northern and Southern stocks of striped dolphins are latitudinally separated at about 35° N, while the

Japanese Coastal stock is located west of the Northern and Southern stocks in the Pacific waters southeast of the main Japanese Islands of Honshu, Kyushu, and Shikoku (Kasuya and Perrin, 2017).

Dive times are unknown for this species. Based on stomach contents, it is predicted that striped dolphins may be diving down 656 to 2,297 ft (200 to 700 m) to feed (Archer, 2009). Average swim speeds of 5.9 kt (11 kph) were measured from striped dolphins in the Mediterranean (Archer and Perrin, 1999).

The behavioral audiogram developed by Kastelein et al. (2003) shows hearing capabilities from 0.5 to 160 kHz. The best underwater hearing of the species appears to be at from 29 to 123 kHz (Kastelein et al., 2003). Striped dolphins produce whistle vocalizations lasting up to three seconds, with frequencies ranging from 1.5 to >24 kHz, with peak frequencies ranging from 8 to 12.5 kHz (Azzolin et al., 2013; Thomson and Richardson, 1995). An examination of whistle structure within the Mediterranean Sea found geographic variation between different sub-populations (Azzolin et al., 2013).

- ***Odontocetes (Toothed Whales): Phocoenidae***

  - *Dall's Porpoise (Phocoenoides dalli)*

Dall's porpoises are separated taxonomically into two subspecies: the *truei*-type and the *dalli*-type, with both subspecies occurring in the study area for SURTASS LFA sonar. Dall's porpoise is considered least concern under the IUCN. The total population of Dall's porpoise is estimated at 1.2 million (Jefferson et al., 2015). The population of the WNP *truei* subspecies of the Dall's porpoise is estimated as 178,157 individuals (Kasuya and Perrin, 2017; Miyashita et al., 2007), while the Sea of Japan and WNP *dalli* populations are estimated to include 173,638 porpoises (IWC, 2008) and 162,000 porpoises (Kasuya and Perrin, 2017; Miyashita et al., 2007), respectively.

The Dall's porpoise is found exclusively in the North Pacific Ocean and adjacent seas (Bering Sea, Okhotsk Sea, and Sea of Japan) from about Baja California to Japan in the south and Bering Sea to the north (Jefferson et al., 2015). Although this oceanic species is primarily found in deep oceanic waters from 30°N to 62°N, or in areas where deepwater occurs close to shore, it has been observed in the inshore waters of Washington, British Columbia, and Alaska (Jefferson et al., 2015). Distribution in most areas is very poorly defined (Jefferson, 2009a).

Dall's porpoises are relatively deep divers, diving to 900 ft (275 m) for as long as 8 min (Hanson et al., 1998; Ridgway, 1986). Thought to be one of the fastest swimming of the small cetaceans (Croll et al., 1999; Jefferson, 2009b), Dall's porpoise's average swim speeds between 1.3 and 11.7 kt (2.4 and 21.6 kph). Swim speeds are dependent on the type of swimming behavior (slow rolling, fast rolling, or rooster-tailing) (Croll et al., 1999), but Dall's porpoises may reach speeds of 29.7 kt (55 kph) for quick bursts (Leatherwood and Reeves, 1983).

Although there is no direct measurement of the hearing sensitivity of Dall's porpoises (Ketten, 2000; Thewissen, 2002), the reaction thresholds of Dall's porpoise for pulses at 20 to 100 kHz are estimated to be about 116 to 130 dB RL or higher for pulses shorter than one millisecond or for pulses higher than 100 kHz (Hatakeyama et al., 1994).

Dall's porpoises produce sounds as low as 40 Hz and as high as 160 kHz (Awbrey et al., 1979; Evans and Awbrey, 1984; Evans and Maderson, 1973; Hatakeyama et al., 1994; Hatakeyama and Soeda, 1990; Ridgway, 1966) and can emit LF clicks in the range of 40 Hz to 12 kHz (Awbrey et al., 1979; Evans, 1973). Narrow band high frequency clicks are also produced with energy concentrated around 120 to 141 kHz with a duration of 35 to 251 μsec (Au, 1993; Kyhn et al., 2013). Their maximum peak-to-peak SL is 175 dB (Evans, 1973; Evans and Awbrey, 1984). Dall's porpoise do not whistle very often.

- *Harbor Porpoise (Phocoena phocoena)*

Harbor porpoises are classified overall as least concern under IUCN. Three major residential isolated populations exist: 1) the North Pacific; 2) North Atlantic; and 3) the Black Sea (Bjorge and Tolley, 2009; Jefferson et al., 2008). However, morphological and genetic data indicate different populations exist within these three regions (Jefferson et al., 2015). The global population for the harbor porpoise estimated to be at least 675,000 (Jefferson et al., 2015). The WNP population of harbor porpoises consists of an estimated 31,046 individuals (Allen and Angliss, 2014; Hobbs and Waite, 2010).

Harbor porpoises are found in cold temperate and sub-arctic neritic waters of the Northern hemisphere (Bjørge and Tolley, 2009; Gaskin, 1992; Jefferson et al., 1993). They are typically found in waters of about 41 to 61° F (5 to 16° C) with only a small percentage appearing in more polar waters (32° to 39° F [0° to 4° C]) (Gaskin, 1992). Harbor porpoises are most frequently found in coastal waters, but do occur in adjacent offshore shallows and, at times, in deep water (Croll et al., 1999; Gaskin, 1992). Harbor porpoises show seasonal movement in northwestern European waters that may be related to oceanographic changes seasonally (Gaskin, 1992; Heimlich-Boarn et al., 1998; Read and Westgate, 1997). Although migration patterns have been inferred for the harbor porpoise, data suggest that seasonal movements of individuals are discrete and not temporally coordinated migrations (Gaskin, 1992; Read and Westgate, 1997).

Dive times of harbor porpoises range between 0.7 and 1.7 min with a maximum dive duration of 9 min (Westgate et al., 1995). Recently, van Beest et al. (2018) reported mean dive durations of tagged harbor porpoises of 53 sec and mean dive depths of 50.9 ft (15.5 m). The majority of dives range in depth from 65.6 to 426.5 ft (20 to 130 m), although the maximum dive depth recorded is 741.5 ft (226 m) (Westgate et al., 1995). Three tagged porpoises in shallow Danish waters had an average dive rate of 45 dives per hour, with maximum dive depth of 82 ft (25 m) (Linnenschmidt et al., 2013). Maximum swim speeds for harbor porpoises range from 9.0 to 12.0 kt (16.6 and 22.2 kph) (Gaskin et al., 1974). A mean horizontal/surface swim speed of 1.26 kt (2.3 kph) was reported for free-ranging harbor porpoises (van Beest et al., 2018).

Harbor porpoises can hear frequencies in the range of 100 Hz to 140 kHz (Kastelein et al., 2002; Kastelein et al., 2015; Villadsgaard et al., 2007). Kastelein et al. (2002) determined the best range of hearing for a two-year-old male was 16 to 140 kHz; this harbor porpoise also demonstrated the highest upper frequency hearing of all odontocetes presently known (Kastelein et al., 2002). In a series of experiments designed to investigate harbor porpoise hearing with respect to naval sonar, the hearing threshold for 1 to 2 kHz FM signals was 75 dB, without the presence of harmonics. When harmonics were present, the threshold dropped to 59 dB, and the thresholds for LF sonars were higher than for MF sonars; the measured threshold for 6-7 kHz signals was 67 dB (Kastelein et al., 2011).

Harbor porpoises produce click and whistle vocalizations that cover a wide frequency range, from 40 Hz to at least 150 kHz (Verboom and Kastelein, 1995). The click vocalizations consist of four major frequency components: lower frequency component (1.4 to 2.5 kHz) of high amplitude that are may be used for long-range detection; two middle frequency components consisting of a low amplitude (30 to 60 kHz) and a broadband component (10 to 100 kHz); and a higher frequency component (110 to 150 kHz) that is used for bearing and classification of objects (Verboom and Kastelein, 1995). Vocalization peak frequencies are similar for wild and captive harbor porpoises, with the peak frequencies reported to range from 129 to 145 kHz and 128 to 135 kHz, respectively (Villadsgaard et al., 2007). Maximum SLs vary, apparently, between captive and wild dolphins, with maximum SLs of 172 dB re 1 µPa at 1 m in captive dolphins but range from 178 to 205 dB re 1 µPa at 1 m in wild dolphins (Villadsgaard et al., 2007). Variations in click trains apparently represent different functions based on the frequency ranges associated with each activity.

3.4.3.3.2 Pinnipeds

Pinnipeds (sea lions, seals, and walruses) are globally distributed amphibious marine mammals with varying degrees of aquatic specialization (Berta, 2009; Goebel, 1998). Five pinniped species are considered in this SEIS/SOEIS, including two otariid and three phocid species (Table 3-6). Of these species, three are listed under the ESA with DPSs that occur in the study area for SURTASS LFA sonar. Otariid and phocid pinnipeds differ morphologically, ecologically, and physiologically; Berta (2018) provides a good overview of otariid and phocid pinnipeds.

Pinnipeds are able to hear both in air and water and are sensitive to a wide range of frequencies (from about 75 Hz to 180 kHz) and can detect sounds at low pressure levels, with their lowest hearing thresholds at about 55 to 58 dB (Berta, 2018; Cunningham, 2015; Reichmuth et al., 2013; Kastak and Schusterman, 1998). Phocids exhibit the more extensive hearing range of the two groups of pinnipeds, particularly in high frequency ranges, as their ears appear to be better adapted to underwater hearing (NMFS, 2016b). Most pinnipeds produce sounds, often both in-air and underwater, with most sounds associated with some type of behavior.

- ***Otariidae***

  - *Northern Fur Seal (Callorhinus ursinus)*

Northern fur seals are currently classified as vulnerable under IUCN Red List of Threatened Species (Gelatt et al., 2015). The Pribilof Island/Eastern Pacific stock, which does not coincide with the study area for SURTASS LFA sonar, is considered depleted under the MMPA. The global population of northern fur seals in 2014 was estimated as 1.29 million seals, which represented a population decline of about 30 percent since 1976 (Gelatt et al., 2015). The Western Pacific stock of northern fur seals is estimated to include 503,609 individuals (Gelatt et al., 2015; Kuzin, 2014).

Northern fur seals are widely distributed in pelagic waters across the North Pacific Ocean from about 35° N northward to the Bering Sea, including the Sea of Okhotsk and the Sea of Japan (Jefferson et al., 2015). Primary breeding sites include the Commander Islands, Kuril Islands, Pribilof Islands, Robben Island, Bogoslof Island, Tyuleny Island, Farallon Islands, and San Miguel Island (Gentry, 2009b). Northern fur seals are one of the most pelagic pinnipeds, with adults only coming ashore for about 40 days during the breeding season and not hauling out on land except during that period. In late autumn, northern fur seals leave their rookeries and migrate southward for the winter to foraging areas. Northern fur seals from the Bering Sea and Aleutian Islands rookeries migrate into the northeastern Pacific through the Aleutian passes, while seals from Tyuleny Island, the Commander Islands, and Kuril Islands migrate southward into the Sea of Japan and in the Pacific waters off Japan (Gentry, 2009b; Horimoto et al., 2016 and 2017). In the Sea of Japan, adult male northern fur seals predominate and forage in waters over the narrow continental shelf that drops steeply into 6,562 ft (2,000 m) deep waters (Horimoto et al., 2016), while in Pacific waters of northern Japan, adult female and juvenile northern fur seals dominate (Horimoto et al., 2017).

Maximum recorded dive depths of breeding female northern fur seals are 680 ft (207 m) in the Bering Sea and 755 ft (230 m) in Pacific waters off southern California (Goebel, 1998). Juvenile fur seals in the Bering Sea had an average dive time of 1.24 min at an average depth of 57.4 ft (17.5 m) (Sterling and

Ream, 2004). Kooyman et al. (1976) measured shallow dives (to 66 ft [20 m]) of northern fur seals to last 1 min, while deeper dives (to 459 ft [140 m]) were from 2 to 5 min in duration, and the average interval between dives was 17 min. Goebel et al. (1991) calculated average dive durations of 4.1 min for shallow dives and 7.3 min for deep dives, which were similar to the measured modal durations of <2 min for shallow dives and 3 to 5 min for deep dives that Ponganis et al. (1992) reported. Ream et al. (2005) and Sterling et al. (2014) noted that the preponderance of deeper dives occur at night during the full moon, likely related to the vertical migration of prey. Routine migration swim speeds are 1.54 kt (2.85 kph), while during foraging, swim speeds averaged between 0.48 and 1.23 kt (0.89 and 2.28 kph) (Ream et al., 2005). Lactating female northern fur seals swam 2.7 kt (5 kph) during foraging forays in the Bering Sea (Battaile et al., 2015).

The northern fur seal can hear sounds in the range of 500 Hz to 40 kHz (Babushina et al., 1991; Moore and Schusterman, 1987), with best hearing ranging from 2 and 12 kHz (Gentry, 2009a). Moore and Schusterman (1987) measured the in-air hearing sensitivity of the northern fur seal as 500 Hz to 32 kHz and the in-water hearing sensitivity from 2 to 32 kHz. Babushina et al. (1991) reported that underwater hearing sensitivity of the northern fur seal is 15 to 20 dB better than in-air hearing sensitivity. Northern fur seals are known to produce clicks and high-frequency bleating sounds under water (Frankel, 2018). On land during breeding season, males make low growls and roars (Antonelis and York, 1985). Female northern fur seals emit calls when returning from foraging trips to attract and locate their pups (Bartholomew, 1959).

- *Western Steller Sea Lion (Eumetopias jubatus jubatus)*

The Steller sea lion is divided taxonomically into two species that effectively represent the Western and Eastern stocks and DPSs of Steller sea lions (SMM, 2017). The Western Steller sea lion occurs west of Cape Suckling, Alaska (Loughlin and Gelatt, 2018). As a species, the Steller sea lion is classified as near threatened under the IUCN Red List of Threatened Species, with the Western Steller sea lion classified as endangered (Gelatt and Sweeney, 2016). Under the ESA, only the Western DPS of is listed as endangered under the ESA and depleted under the MMPA. The Western stock/DPS and Asian stock of the Western Steller sea lion occur within the study area for SURTASS LFA sonar. Critical habitat for both species (stocks/DPSs) of Steller sea lions is designated under the ESA in three geographic locations in the North Pacific Ocean, Gulf of Alaska, and the Bering Sea including: 1) Alaska rookeries, haulouts, and associated areas; 2) California and Oregon rookeries and associated areas; and 3) special aquatic areas in Alaska (Shelikof Strait area, Bogoslof area, and Seguam Pass area). Critical habitat designations include terrestrial, aerial, and aquatic habitat zones (NOAA, 1993a). The worldwide population size of Steller sea lions is estimated to be 160,867 (Gelatt and Sweeney, 2016). The Western U.S. stock and DPS (west of Cape Suckling, Alaska) is estimated at 53,303 sea lions (Muto et al., 2018), and the Western Asian stock (Russia to Japan) stock of Steller sea lions has been estimated to include 17,918 individuals (Burkanov, 2017; Muto et al., 2018), for a total Western Steller sea lion population of 71,221 individuals.

Steller sea lions are found in temperate to sub-polar waters and are widely distributed throughout the North Pacific Ocean from Japan/Korea and central California to the southern Bering Sea, including the Sea of Japan and Sea of Okhotsk (Jefferson et al., 2015). The northernmost rookery is found at Seal Rocks in Prince William Sound, Alaska, and the southernmost rookeries are found at Año Nuevo Island in California and Medny Island, in the Commander Islands, Kamchatka (Burkanov and Loughlin, 2007; Loughlin, 2009). Steller sea lions typically occur in coastal to outer continental shelf waters but cross deep oceanic waters in parts of their range (Jefferson et al., 2015; Loughlin and Gelatt, 2016). Steller sea lions are not migratory, but often disperse widely over the North Pacific after the breeding season.

Most dives by pup and juvenile Steller sea lions are of short duration (<1 min) and to shallow water depths (<33 ft [10 m]), although they are capable of diving to the same depths and dive durations as adults (Pitcher et al., 2005). Juvenile and sub-adult Steller sea lions dove to the maximum depth of 1,184 ft (361 m), which was the deepest measurable depth, and for the maximum durations of 4.9 min and 13.2 min, respectively (Rehberg and Burns, 2008). Female Steller sea lions on foraging trips during the breeding season dove to the maximum dive depth of 774 ft (236 m), while the longest dive was longer than 16 min; the average dive depth for foraging females was 97.1 ft (29.6 m) and the average dive time was recorded at 1.8 min (Rehberg et al., 2009). The deepest dive depth to which a Steller sea lion has been recorded diving is 1,391 ft (424 m). Swim speed has been estimated at 1.5 kt (2.82 kph), with a range of 0.2 to 3.3 kt (0.4 to 6.05 kph) (Raum-Suryan et al., 2004). A swim speed measured during dives was 2.7 kt (5 kph) (Merrick et al., 1994). Hindle et al. (2010) measured three adult Steller sea lions swimming at transit speeds from 3.5 to 4.5 kt (6.5 to 8.3 kph) and noted that these transit speeds were associated with minimal energetic costs.

Using behavioral methods, Kastelein et al. (2005) measured the underwater audiograms of a male and a female Steller sea lion. Maximum hearing sensitivity in the male Steller sea lion was at 1 kHz for 77 dB RL signals, with the range of best hearing between 1 and 16 kHz, at 10 dB from the maximum sensitivity; the average pre-stimulus responses occurred at low frequency signals (Kastelein et al., 2005). The maximum hearing sensitivity of the female Steller sea lion was 25 kHz for a RL signal of 73 dB RL (Kastelein et al., 2005). The reasons for the differences in hearing capability between the male and female adult Steller sea lions was not known.

Steller sea lions produce sounds both in air and underwater. The underwater sounds produced by Steller sea lions have been described as clicks and growls (Frankel, 2009; Poulter, 1968). The in-air sounds produced by male Steller sea lions, described as belches, growls, snorts, scolds, hisses, and LF roars appear to be part of territorial demonstrations during the breeding season (Kastelein et al., 2005). Females and their pups make in-air communication sounds that are described as bellows and bleats (Loughlin, 2009). No available data exist on seasonal or geographical variation in the sound production of this species.

- ***Phocidae***

  - *Hawaiian Monk Seal (Neomonachus schauinslandi)*

Hawaiian monk seals are listed as endangered under the ESA throughout its range, as endangered under the IUCN Red List of Threatened Species (Littnan et al., 2015), as depleted under the MMPA, and are protected under CITES. Critical habitat for the Hawaiian monk seal has been established from the shore to 121 ft (37 m) of water depth in 10 areas of the Northwest Hawaiian Islands (NWHI) (NOAA, 1988). In 2015, revisions to the Hawaiian monk seal's critical habitat were established (NOAA, 2015a). The critical habitat now includes all of Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, Nihoa, Kaula Island and Niihau and Lehua Islands to the 628-ft (200-m) isobath It also includes selected portions of the remaining main Hawaiian Islands and all waters to the 656-ft (200-m) isobath (excluding National Security Exclusion zones off Kauai, Oahu and Kahoolawe) (NOAA, 2015a). The Hawaii stock of Hawaiian monk seals consists of two subpopulations: Northwest Hawaiian Islands (NWHI) and the Main Hawaiian Islands (MHI) (NMFS, 2018). Since the early 1990s, a small but increasing number of monk seals and an increasing number of annual births have been documented in the MHI (NMFS, 2018). The two subpopulations of Hawaiian monk seals are not isolated from one another, with seals moving between the two subpopulations and island groups (NMFS, 2018e). The subpopulation of Hawaiian monk seals that occurs in the NWHI, which encompasses 80 percent of the overall population, is currently considered stable and is possibly increasing while the MHI subpopulation continues to expand (NMFS, 2018 and 2018d). Six breeding groups within the NWHI subpopulation have been identified: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Islands, and French Frigate Shoals (Littnan et al., 2015). The best available, most current population estimate for the Hawaii stock of Hawaiian monk seals is 1,427 individuals (95 percent confidence limit=1,542) (NMFS, 2018).

Hawaiian monk seals only occur throughout the subtropical waters of the Hawaiian Archipelago and Johnson Atoll (NOAA, 2011), and may be found in water depths ranging from 3 to 984 ft (1 to 300 m) in shelf, slope, and bank habitats. Hawaiian monk seals come ashore (haul out) daily on a variety of substrates, including sandy beaches, rocky shores, rock ledges, and emergent reefs. Hawaiian monk seals from Kure Atoll, the westernmost atoll in the NWHI, may forage on Hancock Banks, NW of Kure Atoll. Although not a migratory species, Abernathy (1999) and Parrish et al. (2002) reported that Hawaiian monk seals may travel a distance of as much as 216 nmi (400 km) to forage. Hancock Banks are approximately 162 nmi (300 km) northwest of Kure Atoll and are characterized by a single pinnacle that is shallower than 1,476 ft (450 m), which is within the known foraging range for foraging Hawaiian monk seals. In this SEIS/SOEIS, Hawaiian monk seals are considered to potentially range and forage as far west as Hancock Banks, which is located within the Offshore Japan (25 to 40° N) modeling area (Model Area #8) for SURTASS LFA sonar. Hawaiian monk seals exhibit high site fidelity to their natal island (Gilmartin and Forcada, 2009), and pupping only occurs on sandy beaches.

Hawaiian monk seals spend a greater proportion of their time at sea; Wilson et al. (2017a) noted that on average, Hawaiian monk seals spent 49 percent of their time diving, 19 percent on the sea surface, and 32 percent of their time hauled out on land. Hawaiian monk seals appear to exhibit a single dive type, which is a square-shaped, benthic dive pattern that indicates more than 50 percent of the dive time is spent foraging along the seafloor in deeper more offshore waters; most dives (70 percent) occurred during daylight hours (Wilson et al., 2017). This species commonly dives to water depths less than 328 ft (100 m), but dives have been recorded as deep as 984 to 1,805 ft (300 to 550 m) (Parrish et al., 2002; Stewart et al., 2006). Wilson et al. (2017a) reported that Hawaiian monk seals in the MHI dove to water depths from 66 to 98 ft (20 to 50 m). The Hawaiian monk seal can also dive for up to 20 min and perhaps longer (Parrish et al., 2002). Routine dives range from 3 to 6 min in primarily shallow water depths from 33 to 131 ft (10 to 40 m) are typical (Stewart, 2009; Wilson, 2015). Kiraç et al. (2002) reported mean dive times of 6.4 min, while Wilson et al. (2017a) reported mean dive durations of 5.9 min. Swim speed data on the Hawaiian monk seal are sparse. Hawaiian monk seals swim near the bottom almost exclusively while at sea (Parrish et al., 2005 and 2008; Wilson, 2015). Parrish and Abernathy (2006) reported Hawaiian monk seals swimming with a velocity of 3.9 kt (7.2 kph).

Only one audiogram has been recorded for the Hawaiian monk seal, which indicated relatively poor hearing sensitivity, a narrow range of best hearing sensitivity (12 to 28 kHz), and a relatively low upper frequency limit (Thomas et al., 1990b); it should be noted that this information may not be representative, as the Hawaiian monk seal tested was an older, captive animal. Above 30 kHz, high-frequency hearing sensitivity dropped markedly (Thomas et al., 1990b). No underwater sound production has been reported for this species. Recorded in-air vocalizations of Hawaiian monk seals consist of a variety of sounds, including a liquid bubble sound (100 to 400 Hz), a guttural expiration (about 800 Hz) produced during short-distance agonistic encounters, a roar (<800 Hz) for long-distance threats, a belch-cough made by males when patrolling (<1 kHz), and sneeze/snorts/coughs of variable frequencies that are <4 kHz (Miller and Job, 1992).

- *Ribbon Seal (Histriophoca fasciata)*

Ribbon seals are classified as least concern by the IUCN Red List of Threatened Species (Lowry, 2016). The most recent population of ribbon seals occurring in the Sea of Okhotsk, Russia was estimated as 181,179 individuals (95 percent CI=118,392 to 316,995) (Chernook et al., 2015), while the Alaska, Bering Sea population of ribbon seals was estimated to include 184,000 seals (95 percent CI=146,000 to230,000) (Conn et al, 2014; Muto et al., 2017). Lowry (2016) combined these Bering Sea and Sea of Okhotsk estimates for a total North Pacific population estimate of 365,000 ribbon seals, which is close to the approximated estimate of 500,000 seals that Boveng and Lowry (2018) recommended.

The ribbon seal is a pagophilic or ice-loving species, with a distribution limited to the northernmost Pacific Ocean and Arctic Ocean including the Chukchi Sea, with predominant occurrence in the Bering Sea and Sea of Okhotsk (Fedoseev, 2009; Jefferson et al., 2015). Ribbon seals are associated with the southern edge of the pack ice from winter through early summer, where they pup and molt on the ice that is commonly found along the continental shelf where there is high water circulation (Fedoseev, 2009). During the summer months, ribbon seals have a pelagic distribution that likely encompasses a broader distributional range than the time of year when the seals are dependent upon sea ice (Jefferson et al., 2015).

Few dive data and no swim speed data are known for the ribbon seal. Boveng et al. (2013) noted that ribbon seal diving patterns are tied to season, with a tendency for the dive depths to increase as the ice edge expands south, nearer to the continental shelf break. When ribbon seals on are on the sea ice in shallow water during spring, they dive to the sea floor, typically to depths of 233 to 328 ft (71 to 100 m), but when not tied to sea ice, ribbon seals dive deeper, up to 1640 ft (500 m) and rarely to 1,969 ft (600 m) (Boveng et al., 2013). London et al. (2014) reported that ribbon seals often dove to water depths of 656 ft (200 m) with some dives exceeding 1,969 ft (600 m). No dive duration data are available (Ponganis, 2015).

There is no direct measurement of auditory threshold for the hearing sensitivity of the ribbon seal (Thewissen, 2002). Ribbon seals produce two types of underwater vocalizations with frequencies between 100 Hz and 7.1 kHz and an estimated SEL recorded at 160 dB (Watkins and Ray, 1977). Ribbon seals produce short, broadband puffing noises and downward-frequency swept sounds that are long and intense, include harmonics, vary in duration, and do not waver; puffs last less than 1 sec and are below 5 kHz while sweeps are diverse and range from 100 Hz to 7.1 kHz (Watkins and Ray, 1977). Watkins and Ray (1977) hypothesized that the sounds of ribbon seals produce are associated with social interactions during the mating season and may be part of territorial displays. Ribbon seals also produce grunts, roars, growls, and hisses (Jones et al., 2014; Miksis-Olds and Parks, 2011). Miksis-Olds and Parks (2011) noted that the ribbon seal vocalizations were only recorded when ice covered was >80 percent, typically during the winter to spring breeding season.

- *Spotted Seal (Phoca largha)*

Spotted or largha seals are classified as a least concern by the IUCN Red List of Threatened Species (Boveng, 2016). The Southern DPS of spotted seals, which consists of breeding concentrations in the Yellow Sea and Peter the Great Bay in the Sea of Japan, is listed as threatened under the ESA and depleted under the MMPA. The global population of the spotted seal is estimated to include 640,000 individuals (Boveng, 2016; Frost and Burns, 2018). Fedoseev (2000) reported that 180,000 seals occur in the Sea of Okhotsk stock/DPS, while Mizuno et al. (2002) reported an average abundance of 10,099 seals in the southern Sea of Okhotsk off Hokkaido, Japan during March and April 2000. Conn et al. (2014) and Muto et al. (2018) estimated 461,625 spotted seals (95 percent CI: 388,732 to 560,348) in the Alaska stock/Bering Sea DPS. Additionally, Trukhin and Mizuno (2002) reported 1,000 spotted seals in Peter the Great Bay and that this population had maintained this stable number of seals for at least 10 years. The total population in the Southern DPS/stock of spotted seals is estimated as 3,500 individuals (Boveng, 2016; Han et al., 2010; Nesterenko and Katin, 2008).

Spotted seals occur in cold temperate to Arctic waters of the North Pacific and Arctic oceans, including the Yellow Sea, East China Sea, Sea of Japan, Sea of Okhotsk, Bering Sea, and Chukchi Sea; spotted seals occur as far east in the Arctic Ocean as the Mackenzie River Delta and as far west as about 170° E (Boveng, 2016; Jefferson et al., 2015). Spotted seals are found either in open-ocean or in pack-ice habitats throughout the year, including the ice over continental shelves during the winter and spring (Burns, 2009). This species hauls out on sea ice but also comes ashore on land during the ice-free seasons of the year (Boveng, 2016). The range of spotted seals contracts and expands in association with ice cover, and their distribution is most concentrated during the period of maximum ice cover (Burns, 2009). When the ice cover recedes in the Bering Sea, some spotted seals migrate northward into the Chukchi and Beaufort seas. As the ice cover increases in the northern waters of their range, spotted seals migrate southward through the Chukchi and Bering seas to maintain association with drifting ice. Peak haul-out time is during molting and pupping from February to May (Burns, 2009).

Dives as deep as 984 to 1,312 ft (300 to 400 m) have been reported for adult spotted seals, with pups diving to 263 ft (80 m) (Bigg, 1981). London et al. (2014) noted that most spotted seal dives were to depths <230 ft (70 m) but dives from 230 to 656 ft (70 to 200 m) were observed primarily during the late winter and spring. Lowry et al. (1994) reported that spotted seals in the Chukchi Sea dove to waters <328 ft (100 m) in depth and that no dives exceeded <10 min in duration. Swim speeds range from 0.2 to 2.8 kt (0.4 to 5.2 kph), with an average speed of 1.2 kt (2.2 kph) have been observed (Lowry et al., 1998).

Spotted seals can hear underwater from 300 Hz to 56 kHz, with best sensitivity between 2 and 30 kHz at a threshold of ~ 55 dB, while in air, spotted seal's hearing sensitivity ranges from 6 Hz to 11 kHz (Sills et al., 2014). Underwater hearing sensitivity in a spotted seal has been measured to 72.4 kHz (Reichmuth et al., 2013). Recently, Cunningham and Reichmuth (2017) tested the ability of several pinniped species to hear high frequency (HF) sounds underwater; the ability of a 4-year old spotted seal to hear underwater sounds from 50 to 180 kHz was measured, with the spotted seal able to detect sounds up to 180 kHz, which was well beyond the limit of their presumed HF hearing capability. Adult spotted seals vocalize in the air and underwater (Frost and Burns, 2018). Underwater vocalization of captive spotted seals increased 1 to 2 weeks before mating and was higher in males than females, with the sounds produced including growls, drums, snorts, chirps, and barks that ranged in frequency from 500 Hz to 3.5 kHz (Richardson et al., 1995).

3.4.3.3.3 Occurrence and Population Estimates of Marine Mammals in the Study Area for SURTASS LFA Sonar

As the previous species-specific sections have illustrated, marine mammals are not homogeneously distributed throughout the study area for SURTASS LFA sonar. However, to effectively assess impacts to marine mammals potentially associated with SURTASS LFA sonar activities, information is not only needed about which marine mammals occur in all regions of the vast study area for SURTASS LFA sonar but also about when and how many occur in all areas of the LFA sonar study area. A temporal and spatial framework is needed to divide the study area and effective period into manageable components.

Since the behavioral ecology of most marine mammal species is mediated by seasonally driven changes in light, temperature, and associated prey availability, standard seasons have been used as the temporal framework. For this SEIS/SOEIS and associated documentation, four seasons defined according to the following monthly breakdown are used:

- Winter: December, January, and February
- Spring: March, April, and May
- Summer: June, July, and August
- Fall: September, October, and November.

This seasonality is based on the Northern Hemisphere. For the part of the study area for SURTASS LFA sonar that lies in the Southern Hemisphere, austral seasons pertain, which are the reverse of this standard timeframe. Austral winter occurs from June through August while austral summer lasts from December through February.

Deriving a spatial framework for the impact analysis required consideration of the geographic usage constraints (i.e., coastal standoff range) of SURTASS LFA sonar, the Navy's national security purpose for conducting SURTASS LFA sonar testing and training activities, and appropriate acoustic and environmental conditions. The Navy devised a spatial framework of 15 representative areas to model SURTASS LFA sonar activities in the study area of the central and western North Pacific and eastern Indian oceans that represent the acoustic regimes and marine mammal species potentially encountered during SURTASS LFA sonar training and testing activities (Table 3-7).

With this spatial and temporal framework in place, deriving the associated marine mammal species and associated population numbers for each model area in each season was required. Since the MMPA mandates protection of marine mammal stocks, stocks of each of the potentially occurring marine mammal species in each of the SURTASS LFA model areas had to also be identified. The potentially occurring marine mammal species and stocks for each modeling area were verified with distributional information and data from published scientific literature; government reports, including NMFS's stock assessment reports (SARs) for U.S. waters; and information from international organizations such as the IUCN and IWC.

Compiling population data and information is challenging for such a vast area as the study area for SURTASS LFA sonar. Yet, density and abundance estimates are a critical component of the analysis to estimate risk to marine mammal populations from activities occurring in the marine environment. Population estimates of marine mammals are difficult to collect since these marine species spend much of their time submerged beneath the sea surface and are not easily observed. To collect sufficient sighting data to derive reasonable abundance or density estimates, however, multiple observations are required, often in areas that are not easily accessible (e.g., far offshore). For most cetacean species, abundances and densities are estimated using line-transect surveys or mark-recapture studies (e.g., Barlow, 2010; Barlow and Forney, 2007; Calambokidis et al., 2008), which usually provide a single abundance or density estimate for each species observed across broad geographic areas, such as waters within the U.S. EEZ off Hawaii. Though the single abundance or density provides a good average estimate of the total number of individuals in a specified area, it does not provide information on the

Table 3-7. Locations of the 15 Representative Modeling Areas for Covered SURTASS LFA Sonar Training and Testing Activities.

Modeling Area	*Modeling Area Name*	*Location of Modeling Area Center*	*Notes*
1	East of Japan	38°N, 148°E	
2	North Philippine Sea	29°N, 136°E	
3	West Philippine Sea	22°N/124°E	
4	Offshore Guam	11°N, 145°E	Navy Mariana Islands Testing and Training Area
5	Sea of Japan	39°N, 132°E	
6	East China Sea	26°N, 125°E	
7	South China Sea	14°N, 114°E	
8	Offshore Japan 25° to 40°N	30°N, 165°E	
9	Offshore Japan 10° to 25°N	15°N, 165°E	
10	Hawaii North	25°N, 158°W	Navy Hawaii-Southern California Testing and Training Area; Hawaii Operating Area
11	Hawaii South	19.5°N, 158.5°W	Navy Hawaii-Southern California Testing and Training Area; Hawaii Operating Area
12	Offshore Sri Lanka	5°N, 85°E	
13	Andaman Sea	7.5°N, 96°E	
14	Northwest of Australia	18°S, 110°E	
15	Northeast of Japan	52°N, 163°E	

species distribution or concentrations outside that limited area nor does it provide abundance or density estimate for other seasons that were not surveyed.

Abundance estimates are typically more available than are density estimates, which require more sophisticated sampling and analysis and are not always available for each species/stock in all model areas or seasons. Despite the greater availability of abundance data, population-level data on potentially occurring marine mammals are very scarce for some of the 15 modeling areas, particularly in the Indian Ocean. Overall, no single source of abundance or density data exists in even one model area for every species, stock, or season. The process for developing abundance and density estimates for every species/stock in the 15 potential model areas in all seasons was a multi-step procedure that first utilized data with the highest degree of fidelity. In modeling areas where no abundance estimates were available for a stock, a surrogate abundance was needed. In modeling areas where no abundance estimates were available for a stock, a surrogate abundance was needed. A surrogate abundance estimate derived for a similar oceanographic area for the same species or a conspecific was used. Abundance estimates were derived using the best available information and data (Table 3-8), including

Table 3-8. Marine Mammal Species, Stocks (DPSs), Abundance, and Density Estimates by Season as well as the Associated References for the 15 Proposed SURTASS LFA Modeling Areas in the Central and Western North Pacific Ocean and Indian Ocean (Reference Index Shown at End of Table).

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Model Area #1: East of Japan								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4
Bryde's whale	WNP	20,501	43	0.0006	0.0006	0.0006	0.0006	5
Common minke whale	WNP OE	25,049	6, 38, 56	0.0022	0.0022	0.0022	0.0022	6, 38
Fin whale	WNP	9,250	1, 44			0.0002	0.0002	1
Humpback whale	WNP stock and DPS[26]	1,328	45			0.00036	0.00036	4, 7
North Pacific right whale	WNP	922	46	0.00001[27]	0.00001			
Sei whale	NP	7,000	1, 47	0.00029	0.00029	0.00029	0.00029	13
Baird's beaked whale	WNP	5,688	48, 49			0.0029	0.0029	9
Common dolphin	WNP	3,286,163	2, 3	0.0761	0.0761	0.0761	0.0761	2, 3
Common bottlenose dolphin	WNP Northern Offshore	100,281	10, 49	0.0171	0.0171	0.0171	0.0171	10
Cuvier's beaked whale	WNP	90,725	2, 3	0.0031	0.0031	0.0031	0.0031	2, 3
Dall's porpoise (*truei*)	WNP *truei*	178,157	49, 57	0.0390	0.0520		0.0520	2, 3
False killer whale	WNP	16,668	10	0.0036	0.0036	0.0036	0.0036	10
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3

24 NP=North Pacific; WNP=Western North Pacific; CNP=Central North Pacific; WP=Western Pacific; ECS=East China Sea; SOJ=Sea of Japan; IA=Inshore Archipelago; IND=Indian; NIND=Northern Indian; SIND=Southern Indian; WAU=Western Australia; ANT=Antarctic; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere

25 No density in a season means that the marine mammal is not expected to occur in that model area during that season.

26 DPS=distinct population segment, which is a discrete population or group of populations of the same species that is significant to the entire species. Populations are identified stocks under the MMPA and as DPSs under the ESA. Thus, the humpback whale and other species are listed by stock and DPS (DPS/stock) where relevant.

27 A density value of 0.00001 with no reference citation indicates that no density was available for this species; because a density was necessary to compute takes, the lowest value possible was assigned to the data-sparse species for the purpose of impact estimation.

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Harbor porpoise	WNP	31,046	11, 50	0.0190	0.0190	0.0190	0.0190	11
Hubbs' beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Killer whale	WNP	12,256	2, 3	0.0001	0.0001	0.0001	0.0001	12
Kogia spp.	WNP	350,553	2, 3	0.0031	0.0031	0.0031	0.0031	2, 3
Pacific white-sided dolphin	NP	931,000	20	0.0082	0.0082	0.0082	0.0082	2, 3
Pantropical spotted dolphin	WNP	130,002	51			0.0259	0.0259	10
Pygmy killer whale	WNP	30,214	2, 3	0.0021	0.0021	0.0021	0.0021	2, 3
Risso's dolphin	WNP	143,374	51	0.0097	0.0097	0.0097	0.0097	10
Rough-toothed dolphin	WNP	5,002	51	0.00224	0.00224	0.00224	0.00224	21
Short-finned pilot whale	WNP Northern	20,884	10	0.0128	0.0128	0.0128	0.0128	10
Sperm whale	NP	102,112	52, 53	0.00123	0.00123	0.00123	0.00123	13
Spinner dolphin	WNP	1,015,059	2, 3			0.00083	0.00083	14
Stejneger's beaked whale	WNP	8,000	9	0.0005	0.0005	0.0005	0.0005	2, 3
Striped dolphin	WNP Northern Offshore	497,725	10, 49	0.0111	0.0111	0.0111	0.0111	10
Northern fur seal	WP	503,609	54, 55	0.368	0.158			37
Model Area #2: North Philippine Sea								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4
Bryde's whale	WNP	20,501	43	0.0006	0.0006	0.0006	0.0006	5
Common minke whale	WNP OE	25,049	6, 38, 56	0.0044	0.0044	0.0044	0.0044	6, 38
Fin whale	WNP	9,250	1, 44	0.0002	0.0002			1
Humpback whale	WNP stock and DPS	1,328	45	0.00089	0.00089		0.00089	4, 7
North Pacific right whale	WNP	922	46	0.00001	0.00001			
Omura's whale	WNP	1,800	58	0.00004	0.00004	0.00004	0.00004	15
Blainville's beaked whale	WNP	8,032	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Common dolphin	WNP	3,286,163	2, 3	0.0562	0.0562	0.0562	0.0562	2, 3
Common bottlenose dolphin	Japanese Coastal	3,516	51	0.0146	0.0146	0.0146	0.0146	10
Cuvier's beaked whale	WNP	90,725	2, 3	0.0054	0.0054	0.0054	0.0054	2, 3
False killer whale	WNP	16,668	10	0.0029	0.0029	0.0029	0.0029	10

Marine Mammal Species	Stock Name[24]	Abundance	Abundance References	Density (animals per km^2)[25]				Density References
				Winter	Spring	Summer	Fall	
Fraser's dolphin	WNP	220,789	2, 3	0.0069	0.0069	0.0069	0.0069	16
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Kogia spp.	WNP	350,553	2, 3	0.0031	0.0031	0.0031	0.0031	2, 3
Longman's beaked whale	WNP	7,619	19	0.00025	0.00025	0.00025	0.00025	12
Melon-headed whale	WNP	56,213	51	0.00428	0.00428	0.00428	0.00428	13
Pacific white-sided dolphin	NP	931,000	20	0.0119	0.0119			2, 3
Pantropical spotted dolphin	WNP	130,002	51	0.0137	0.0137	0.0137	0.0137	10
Pygmy killer whale	WNP	30,214	2, 3	0.0021	0.0021	0.0021	0.0021	2, 3
Risso's dolphin	WNP	143,374	51	0.0106	0.0106	0.0106	0.0106	10
Rough-toothed dolphin	WNP	5,002	51	0.00224	0.00224	0.00224	0.00224	21
Short-finned pilot whale	WNP Southern	31,396	51	0.0153	0.0153	0.0153	0.0153	10
Sperm whale	NP	102,112	52, 53	0.00123	0.00123	0.00123	0.00123	13
Spinner dolphin	WNP	1,015,059	2, 3	0.00083	0.00083	0.00083	0.00083	14
Striped dolphin	Japanese Coastal	19,631	10, 49	0.0329	0.0329	0.0329	0.0329	10
Model Area #3: West Philippine Sea								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4
Bryde's whale	WNP	20,501	43	0.0006	0.0006	0.0006	0.0006	5
Common minke whale	WNP OE	25,049	6, 38, 56	0.0033	0.0033	0.0033	0.0033	6, 38
Fin whale	WNP	9,250	1, 44	0.0002	0.0002			1
Humpback whale	WNP stock and DPS	1,328	45	0.00089	0.00089		0.00089	4, 18
Omura's whale	WNP	1,800	58	0.00004	0.00004	0.00004	0.00004	15
Blainville's beaked whale	WNP	8,032	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Common dolphin	WNP	3,286,163	2, 3	0.1158	0.1158	0.1158	0.1158	17
Common bottlenose dolphin	WNP Southern Offshore	40,769	51	0.0146	0.0146	0.0146	0.0146	10
Cuvier's beaked whale	WNP	90,725	2, 3	0.0003	0.0003	0.0003	0.0003	2, 3
Deraniyagala's beaked whale	NP	22,799	2, 3, 59	0.0005	0.0005	0.0005	0.0005	2, 3

Marine Mammal Species	*Stock Name[24]*	*Abundance*	*Abundance References*	*Density (animals per km²)[25]*				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
False killer whale	WNP	16,668	10	0.0029	0.0029	0.0029	0.0029	10
Fraser's dolphin	WNP	220,789	2, 3	0.0069	0.0069	0.0069	0.0069	16
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Kogia spp.	WNP	350,553	2, 3	0.0017	0.0017	0.0017	0.0017	2, 3
Longman's beaked whale	WNP	7,619	19	0.00025	0.00025	0.00025	0.00025	12
Melon-headed whale	WNP	56,213	51	0.00428	0.00428	0.00428	0.00428	13
Pantropical spotted dolphin	WNP	130,002	51	0.0137	0.0137	0.0137	0.0137	10
Pygmy killer whale	WNP	30,214	2, 3	0.0021	0.0021	0.0021	0.0021	2, 3
Risso's dolphin	WNP	143,374	51	0.0106	0.0106	0.0106	0.0106	10
Rough-toothed dolphin	WNP	5,002	51	0.00224	0.00224	0.00224	0.00224	21
Short-finned pilot whale	WNP Southern	31,396	51	0.0076	0.0076	0.0076	0.0076	10
Sperm whale	NP	102,112	52, 53	0.00123	0.00123	0.00123	0.00123	13
Spinner dolphin	WNP	1,015,059	2, 3	0.00083	0.00083	0.00083	0.00083	14
Striped dolphin	WNP Southern Offshore	52,682	10, 49	0.0164	0.0164	0.0164	0.0164	10
Model Area #4: Offshore Guam								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4, 13
Bryde's whale	WNP	20,501	43	0.0004	0.0004	0.0004	0.0004	13
Common minke whale	WNP OE	25,049	6, 38, 56	0.0003	0.0003		0.0003	2, 3
Fin whale	WNP	9,250	1, 44	0.00001	0.00001		0.00001	2, 3
Humpback whale	WNP stock and DPS	1,328	45	0.00089	0.00089		0.00089	4, 18
Omura's whale	WNP	1,800	15, 58	0.00004	0.00004	0.00004	0.00004	15
Sei whale	NP	7,000	1, 47	0.00029	0.00029		0.00029	13
Blainville's beaked whale	WNP	8,032	2, 3	0.00086	0.00086	0.00086	0.00086	19
Common bottlenose dolphin	WNP Southern Offshore	40,769	51	0.00899	0.00899	0.00899	0.00899	19
Cuvier's beaked whale	WNP	90,725	2, 3	0.0003	0.0003	0.0003	0.0003	19

Marine Mammal Species	*Stock Name[24]*	*Abundance*	*Abundance References*	*Density (animals per km²)[25]*				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Deraniyagala's beaked whale	NP	22,799	2, 3	0.00093	0.00093	0.00093	0.00093	2, 3
Dwarf sperm whale	WNP	350,553	2, 3	0.00714	0.00714	0.00714	0.00714	14
False killer whale	WNP	16,668	10	0.00111	0.00111	0.00111	0.00111	13
Fraser's dolphin	CNP	16,992	16	0.02104	0.02104	0.02104	0.02104	19
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.00093	0.00093	0.00093	0.00093	2, 3
Killer whale	WNP	12,256	2, 3	0.00006	0.00006	0.00006	0.00006	19
Longman's beaked whale	WNP	7,619	19	0.00311	0.00311	0.00311	0.00311	19
Melon-headed whale	WNP	56,213	51	0.00428	0.00428	0.00428	0.00428	13
Pantropical spotted dolphin	WNP	130,002	51	0.0226	0.0226	0.0226	0.0226	13
Pygmy killer whale	WNP	30,214	2, 3	0.00014	0.00014	0.00014	0.00014	13
Pygmy sperm whale	WNP	350,553	2, 3	0.00291	0.00291	0.00291	0.00291	14
Risso's dolphin	WNP	143,374	51	0.00474	0.00474	0.00474	0.00474	19
Rough-toothed dolphin	WNP	5,002	51	0.00185	0.00185	0.00185	0.00185	12
Short-finned pilot whale	WNP Southern	31,396	51	0.00797	0.00797	0.00797	0.00797	19
Sperm whale	NP	102,112	52, 53	0.00123	0.00123	0.00123	0.00123	13
Spinner dolphin	WNP	1,015,059	2, 3	0.00083	0.00083	0.00083	0.00083	14
Striped dolphin	WNP Southern Offshore	52,682	10, 49	0.00616	0.00616	0.00616	0.00616	13
Model Area #5: Sea of Japan								
Bryde's whale	WNP	20,501	43	0.0001	0.0001	0.0001	0.0001	2, 3
Common minke whale	WNP JW	2,611	38	0.00016	0.00016	0.00016	0.00016	2, 3
Fin whale	WNP	9,250	1, 44	0.0009	0.0009		0.0009	2, 3
North Pacific right whale	WNP	922	46	0.00001	0.00001			
Omura's whale	WNP	1,800	15, 58	0.00004	0.00004	0.00004	0.00004	15
Western North Pacific gray whale	WNP stock/ Western DPS	140	41, 60	0.00001	0.00001	0.00001	0.00001	
Baird's beaked whale	WNP	5,688	48, 49	0.0003	0.0003		0.0003	9
Common dolphin	WNP	279,182	17	0.1158	0.1158	0.1158	0.1158	17
Common bottlenose dolphin	IA	105,138	10, 48	0.00077	0.00077	0.00077	0.00077	12

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Cuvier's beaked whale	WNP	90,725	2, 3	0.0031	0.0031	0.0031	0.0031	2, 3
Dall's porpoise (*dalli*)	SOJ *dalli*	173,638	61	0.0520	0.0520		0.0520	2, 3
False killer whale	IA	9,777	10, 48	0.0027	0.0027	0.0027	0.0027	2, 3
Harbor porpoise	WNP	31,046	11, 50	0.0190	0.0190		0.0190	11
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Kogia spp.	WNP	350,553	2, 3	0.0017	0.0017	0.0017	0.0017	2, 3
Pacific white-sided dolphin	NP	931,000	10, 20	0.0030	0.0030			3
Risso's dolphin	IA	143,374	51	0.0073	0.0073	0.0073	0.0073	10
Rough-toothed dolphin	WNP	5,002	51	0.00224	0.00224	0.00224	0.00224	21
Sperm whale	NP	102,112	52, 53	0.00123	0.00123	0.00123	0.00123	13
Spinner dolphin	WNP	1,015,059	2, 3			0.00083	0.00083	14
Stejneger's beaked whale	WNP	8,000	9	0.0005	0.0005	0.0005	0.0005	2, 3
Northern fur seal	WP	503,609	54, 55	0.368	0.158			37
Spotted seal	Southern stock and DPS	3,500	62, 63, 64	0.00001	0.00001	0.00001	0.00001	
Model Area #6: East China Sea								
Bryde's whale	ECS	137	65	0.0003	0.0003	0.0003	0.0003	12
Common minke whale	YS	4,492	38, 66	0.0018	0.0018	0.0018	0.0018	6
Fin whale	ECS	500	1, 44, 67	0.0002	0.0002	0.0002	0.0002	1
North Pacific right whale	WNP	922	46	0.00001	0.00001			
Omura's whale	WNP	1,800	15, 58	0.00004	0.00004	0.00004	0.00004	15
Western North Pacific gray whale	WNP stock/ Western DPS	140	41	0.00001	0.00001		0.00001	
Blainville's beaked whale	WNP	8,032	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Common dolphin	WNP	279,182	17	0.1158	0.1158	0.1158	0.1158	17
Common bottlenose dolphin	IA	105,138	10, 48	0.00077	0.00077	0.00077	0.00077	12
Cuvier's beaked whale	WNP	90,725	2, 3	0.0003	0.0003	0.0003	0.0003	2, 3
False killer whale	IA	9,777	10, 48	0.00111	0.00111	0.00111	0.00111	13
Fraser's dolphin	WNP	220,789	2, 3	0.00694	0.00694	0.00694	0.00694	16

Marine Mammal Species	*Stock Name[24]*	*Abundance*	*Abundance References*	*Density (animals per km²)[25]*				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Kogia spp.	WNP	350,553	2, 3	0.0017	0.0017	0.0017	0.0017	2, 3
Longman's beaked whale	WNP	7,619	19	0.00025	0.00025	0.00025	0.00025	12
Melon-headed whale	WNP	56,213	51	0.00428	0.00428	0.00428	0.00428	13
Pacific white-sided dolphin	NP	931,000	10, 20	0.0028	0.0028			2, 3
Pantropical spotted dolphin	WNP	130,002	51	0.01374	0.01374	0.01374	0.01374	10
Pygmy killer whale	WNP	30,214	2, 3	0.00014	0.00014	0.00014	0.00014	13
Risso's dolphin	IA	143,374	51	0.0106	0.0106	0.0106	0.0106	10
Rough-toothed dolphin	WNP	5,002	51	0.00224	0.00224	0.00224	0.00224	21
Sperm whale	NP	102,112	52, 53	0.00123	0.00123	0.00123	0.00123	13
Spinner dolphin	WNP	1,015,059	2, 3	0.00083	0.00083	0.00083	0.00083	14
Spotted seal	Southern stock and DPS	1,000	62	0.00001	0.00001	0.00001	0.00001	
Model Area #7: South China Sea								
Bryde's whale	WNP	20,501	43	0.0006	0.0006	0.0006	0.0006	5
Common minke whale	YS	4,492	38, 66	0.0018	0.0018	0.0018	0.0018	6
Fin whale	WNP	9,250	1, 44	0.0002	0.0002		0.0002	1
Humpback whale	WNP stock and DPS	1,328	45	0.00036	0.00036		0.00036	4, 18
North Pacific right whale	WNP	922	46	0.00001	0.00001			
Omura's whale	WNP	1,800	15, 58	0.00004	0.00004	0.00004	0.00004	15
Western North Pacific gray whale	WNP stock/ Western DPS	140	41	0.00001	0.00001		0.00001	
Blainville's beaked whale	WNP	8,032	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Common dolphin	WNP	279,182	17	0.1158	0.1158	0.1158	0.1158	17
Common bottlenose dolphin	IA	105,138	48	0.00077	0.00077	0.00077	0.00077	12
Cuvier's beaked whale	WNP	90,725	2, 3	0.0003	0.0003	0.0003	0.0003	2, 3
Deraniyagala's beaked whale	NP	22,799	2, 3, 68	0.0005	0.0005	0.0005	0.0005	2, 3

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
False killer whale	IA	9,777	48	0.00111	0.00111	0.00111	0.00111	13
Fraser's dolphin	WNP	220,789	2, 3	0.00694	0.00694	0.00694	0.00694	16
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Kogia spp.	WNP	350,553	2, 3	0.0017	0.0017	0.0017	0.0017	2, 3
Longman's beaked whale	WNP	7,619	19	0.00025	0.00025	0.00025	0.00025	12
Melon-headed whale	WNP	56,213	51	0.00428	0.00428	0.00428	0.00428	13
Pantropical spotted dolphin	WNP	130,002	51	0.01374	0.01374	0.01374	0.01374	10
Pygmy killer whale	WNP	30,214	2, 3	0.00014	0.00014	0.00014	0.00014	13
Risso's dolphin	IA	143,374	51	0.0106	0.0106	0.0106	0.0106	10
Rough-toothed dolphin	WNP	5,002	51	0.00224	0.00224	0.00224	0.00224	21
Short-finned pilot whale	WNP Southern	31,396	51	0.00159	0.00159	0.00159	0.00159	13
Sperm whale	NP	102,112	52, 53	0.0012	0.0012	0.0012	0.0012	13
Spinner dolphin	WNP	1,015,059	2, 3	0.00083	0.00083	0.00083	0.00083	14
Striped dolphin	WNP Southern Offshore	52,682	10, 49	0.00584	0.00584	0.00584	0.00584	12
Model Area #8: Offshore Japan/Pacific (25º to 40ºN)								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4
Bryde's whale	WNP	20,501	43	0.0003	0.0003	0.0003	0.0003	12
Common minke whale	WNP OE	25,049	6, 38, 56	0.0003	0.0003	0.0003	0.0003	6
Fin whale	WNP	9,250	1, 44			0.0001	0.0001	1
Humpback whale	WNP stock and DPS	1,328	45			0.00036	0.00036	4, 7
Sei whale	NP	7,000	1, 47		0.00029	0.00029	0.00029	13
Baird's beaked whale	WNP	5,688	48, 49	0.0001	0.0001	0.0001	0.0001	9
Blainville's beaked whale	WNP	8,032	12, 17	0.0007	0.0007	0.0007	0.0007	12
Common dolphin	WNP	3,286,163	2, 3	0.0863	0.0863	0.0863	0.0863	2, 3
Common bottlenose dolphin	WNP Northern Offshore	100,281	10, 49	0.00077	0.00077	0.00077	0.00077	12

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Cuvier's beaked whale	WNP	90,725	2, 3	0.00374	0.00374	0.00374	0.00374	12
Dall's porpoise	WNP *dalli*	162,000	49, 69	0.0390	0.0520		0.0520	2, 3
Dwarf sperm whale	WNP	350,553	2, 3, 17	0.0043	0.0043	0.0043	0.0043	12
False killer whale	WNP	16,668	10	0.0036	0.0036	0.0036	0.0036	10
Hubbs' beaked whale	NP	22,799	2, 3	0.0005	0.0005	0.0005	0.0005	2, 3
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Longman's beaked whale	WNP	7,619	19	0.00025	0.00025	0.00025	0.00025	12
Melon-headed whale	WNP	56,213	51	0.0027	0.0027	0.0027	0.0027	12
Mesoplodon spp.	WNP	22,799	2, 3, 17	0.0005	0.0005	0.0005	0.0005	2, 3
Northern right whale dolphin	NP	68,000	20	0.00001	0.00001		0.00001	
Pacific white-sided dolphin	NP	931,000	20	0.0048	0.0048	0.0048	0.0048	2, 3
Pantropical spotted dolphin	WNP	130,002	51	0.0113	0.0113	0.0113	0.0113	12
Pygmy killer whale	WNP	30,214	2, 3	0.0001	0.0001	0.0001	0.0001	12
Pygmy sperm whale	WNP	350,553	2, 3, 17	0.0018	0.0018	0.0018	0.0018	12
Risso's dolphin	WNP	143,374	51	0.0005	0.0005	0.0005	0.0005	12
Rough-toothed dolphin	WNP	5,002	51	0.0019	0.0019	0.0019	0.0019	12
Short-finned pilot whale	WNP Northern	20,884	10	0.0021	0.0021	0.0021	0.0021	12
Sperm whale	NP	102,112	52, 53	0.0022	0.0022	0.0022	0.0022	12
Spinner dolphin	WNP	1,015,059	2, 3	0.0019	0.0019	0.0019	0.0019	12
Stejneger's beaked whale	WNP	8,000	9	0.0005	0.0005	0.0005	0.0005	2, 3
Striped dolphin	WNP Northern Offshore	497,725	10, 49	0.0058	0.0058	0.0058	0.0058	12
Hawaiian monk seal	Hawaii	1,427	35	0.00001	0.00001	0.00001	0.00001	
Northern fur seal	Western Pacific	503,609	54, 55	0.0123				20
Model Area #9: Offshore Japan/Pacific (10° to 25°N)								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4
Bryde's whale	WNP	20,501	43	0.0003	0.0003	0.0003	0.0003	12
Fin whale	WNP	9,250	1, 44	0.00001	0.00001			2, 3

Marine Mammal Species	Stock Name[24]	Abundance	Abundance References	Density (animals per km^2)[25]				Density References
				Winter	Spring	Summer	Fall	
Humpback whale	WNP stock and DPS	1,328	45	0.00036	0.00036		0.00036	4, 18
Omura's whale	WNP	1,800	15, 58	0.00004	0.00004	0.00004	0.00004	15
Sei whale	NP	7,000	1, 47	0.00029			0.00029	13
Blainville's beaked whale	WNP	8,032	12, 17	0.0007	0.0007	0.0007	0.0007	12
Common bottlenose dolphin	WNP Southern Offshore	40,769	51	0.00077	0.00077	0.00077	0.00077	12
Cuvier's beaked whale	WNP	90,725	2, 3	0.00374	0.00374	0.00374	0.00374	12
Deraniyagala's beaked whale	NP	22,799	2, 3, 68	0.00093	0.00093	0.00093	0.00093	3
Dwarf sperm whale	WNP	350,553	2, 3	0.0043	0.0043	0.0043	0.0043	12
False killer whale	WNP	16,668	10	0.00057	0.00057	0.00057	0.00057	12
Fraser's dolphin	CNP	16,992	16	0.00251	0.00251	0.00251	0.00251	12
Ginkgo-toothed beaked whale	NP	22,799	2, 3	0.00093	0.00093	0.00093	0.00093	3
Killer whale	WNP	12,256	2, 3	0.00009	0.00009	0.00009	0.00009	12
Longman's beaked whale	WNP	7,619	19	0.00025	0.00025	0.00025	0.00025	12
Melon-headed whale	WNP	56,213	51	0.00267	0.00267	0.00267	0.00267	12
Pantropical spotted dolphin	WNP	130,002	51	0.01132	0.01132	0.01132	0.01132	12
Pygmy killer whale	WNP	30,214	2, 3	0.00006	0.00006	0.00006	0.00006	12
Pygmy sperm whale	WNP	350,553	2, 3	0.00176	0.00176	0.00176	0.00176	12
Risso's dolphin	WNP	143,374	51	0.00046	0.00046	0.00046	0.00046	12
Rough-toothed dolphin	WNP	5,002	51	0.00185	0.00185	0.00185	0.00185	12
Short-finned pilot whale	WNP Southern	31,396	51	0.00211	0.00211	0.00211	0.00211	12
Sperm whale	NP	102,112	52, 53	0.00222	0.00222	0.00222	0.00222	12
Spinner dolphin	WNP	1,015,059	2, 3	0.00187	0.00187	0.00187	0.00187	12
Striped dolphin	WNP Southern Offshore	52,682	10, 49	0.00584	0.00584	0.00584	0.00584	12
Model Area #10: Hawaii North								
Blue whale	CNP	133	19	0.00005	0.00005		0.00005	19
Bryde's whale	Hawaii	1,751	19	0.000085	0.000085	0.000085	0.000085	21

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Common minke whale	Hawaii	25,049	6	0.00423	0.00423		0.00423	22
Fin whale	Hawaii	154	19	0.00006	0.00006		0.00006	19
Humpback whale	CNP stock/ Hawaii DPS	10,103	7, 70	0.00529	0.00529		0.00529	7, 23
Sei whale	Hawaii	391	19	0.00016	0.00016		0.00016	19
Blainville's beaked whale	Hawaii	2,105	19	0.00086	0.00086	0.00086	0.00086	19
Common bottlenose dolphin	Hawaii Pelagic	21,815	19	0.00118	0.00118	0.00118	0.00118	21
	Kauai/Niihau	184	24, 71	0.065	0.065	0.065	0.065	24
	4-Islands	191	24, 71	0.017	0.017	0.017	0.017	24
	Oahu	743	24, 71	0.187	0.187	0.187	0.187	24
	Hawaii Island	128	24, 71	0.028	0.028	0.028	0.028	24
Cuvier's beaked whale	Hawaii	723	19	0.0003	0.0003	0.0003	0.0003	19
Dwarf sperm whale	Hawaii	17,519	14, 71	0.00714	0.00714	0.00714	0.00714	14
False killer whale	Hawaii Pelagic	1,540	25, 60, 72	0.00060	0.00060	0.00060	0.00060	21, 25,
	Main Hawaiian Islands Insular stock and DPS	167	70, 73	0.0008	0.0008	0.0008	0.0008	25, 26,
	Northwestern Hawaiian Islands	617	25, 60, 72	0.00060	0.00060	0.00060	0.00060	21, 25
Fraser's dolphin	Hawaii	51,491	19	0.02104	0.02104	0.02104	0.02104	19
Killer whale	Hawaii	146	19	0.00006	0.00006	0.00006	0.00006	19
Longman's beaked whale	Hawaii	7,619	19	0.00311	0.00311	0.00311	0.00311	19
Melon-headed whale	Hawaiian Islands	8,666	19	0.0020	0.0020	0.0020	0.0020	27
Melon-headed whale	Kohala Resident	447	27, 71	0.1000	0.1000	0.1000	0.1000	27
Pantropical spotted dolphin	Hawaii Pelagic	55,795	19	0.00369	0.00369	0.00369	0.00369	21
	Hawaii Island	220	74	0.061	0.061	0.061	0.061	28
	Oahu	220	74	0.072	0.072	0.072	0.072	28
Pantropical spotted dolphin (Continued)	4-Islands	220	74	0.061	0.061	0.061	0.061	28
Pygmy killer whale	Hawaii	10,640	19	0.00435	0.00435	0.00435	0.00435	19

Marine Mammal Species	*Stock Name[24]*	*Abundance*	*Abundance References*	*Density (animals per km²)[25]*				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Pygmy sperm whale	Hawaii	7,138	14, 71	0.0029	0.0029	0.0029	0.0029	14
Risso's dolphin	Hawaii	11,613	19	0.00474	0.00474	0.00474	0.00474	19
Rough-toothed dolphin	Hawaii	72,528	19	0.00224	0.00224	0.00224	0.00224	21
Short-finned pilot whale	Hawaii	19,503	19	0.00459	0.00459	0.00459	0.00459	21
Sperm whale	Hawaii	4,559	19	0.00158	0.00158	0.00158	0.00158	21
Spinner dolphin	Hawaii Pelagic	3,351	14	0.00159	0.00159	0.00159	0.00159	21
	Kauai/Niihau	601	71	0.097	0.097	0.097	0.097	29
	Hawaii Island	631	71	0.066	0.066	0.066	0.066	30
	Oahu/ 4-Islands	355	71	0.023	0.023	0.023	0.023	29
	Kure/Midway Atoll	260	71	0.0070	0.0070	0.0070	0.0070	14
	Pearl and Hermes Reefs	300	75, 76	0.0070	0.0070	0.0070	0.0070	14
Striped dolphin	Hawaii	61,201	19	0.00385	0.00385	0.00385	0.00385	21
Hawaiian monk seal	Hawaii	1,427	35	0.00004	0.00004	0.00004	0.00004	35, 36
Model Area #11: Hawaii South								
Blue whale	CNP	133	19	0.00005	0.00005		0.00005	19
Bryde's whale	Hawaii	798	16	0.00012	0.00012	0.00012	0.00012	21
Common minke whale	Hawaii	25,049	6	0.00423	0.00423		0.00423	22
Fin whale	Hawaii	154	19, 70	0.00006	0.00006		0.00006	19
Humpback whale	CNP stock/ Hawaii DPS	10,103	7, 70	0.00631	0.00631		0.00631	7, 23
Sei whale	Hawaii	391	19	0.00016	0.00016		0.00016	19
Blainville's beaked whale	Hawaii	2,105	19	0.00086	0.00086	0.00086	0.00086	19
Common bottlenose dolphin	Hawaii Pelagic	21,815	19	0.00126	0.00126	0.00126	0.00126	21
	Oahu	743	24, 71	0.187	0.187	0.187	0.187	24
	4-Islands	191	24, 71	0.017	0.017	0.017	0.017	24
	Hawaii Island	128	24, 71	0.028	0.028	0.028	0.028	24
	Kauai/Niihau	184	24, 71	0.065	0.065	0.065	0.065	24

Marine Mammal Species	***Stock Name[24]***	***Abundance***	***Abundance References***	***Density (animals per km²)[25]***				***Density References***
				Winter	***Spring***	***Summer***	***Fall***	
Cuvier's beaked whale	Hawaii	723	19	0.0003	0.0003	0.0003	0.0003	19
Deraniyagala beaked whale	NP	22,799	2, 3, 68	0.00093	0.00093	0.00093	0.00093	2, 3
Dwarf sperm whale	Hawaii	17,519	14, 71	0.00714	0.00714	0.00714	0.00714	14
False killer whale	Hawaii Pelagic	1,540	25, 60, 72	0.00086	0.00086	0.00086	0.00086	21, 25
	Main Hawaiian Islands Insular stock and DPS	167	70, 73	0.0008	0.0008	0.0008	0.0008	25, 26
Fraser's dolphin	Hawaii	51,491	19	0.02104	0.02104	0.02104	0.02104	19
Killer whale	Hawaii	146	19	0.00006	0.00006	0.00006	0.00006	19
Longman's beaked whale	Hawaii	7,619	19	0.00311	0.00311	0.00311	0.00311	19
Melon-headed whale	Hawaiian Islands	8,666	19	0.0020	0.0020	0.0020	0.0020	27
	Kohala Resident	447	27, 71	0.1000	0.1000	0.1000	0.1000	27
Pantropical spotted dolphin	Hawaii Pelagic	55,795	19	0.00541	0.00541	0.00541	0.00541	21
	Hawaii Island	220	74	0.061	0.061	0.061	0.061	28
	Oahu	220	74	0.072	0.072	0.072	0.072	28
	4-Islands	220	74	0.061	0.061	0.061	0.061	28
Pygmy killer whale	Hawaii	10,640	19	0.00435	0.00435	0.00435	0.00435	19
Pygmy sperm whale	Hawaii	7,138	14, 71	0.0029	0.0029	0.0029	0.0029	14
Risso's dolphin	Hawaii	11,613	19	0.00474	0.00474	0.00474	0.00474	19
Rough-toothed dolphin	Hawaii	72,528	19	0.00257	0.00257	0.00257	0.00257	21
Short-finned pilot whale	Hawaii	19,503	19	0.00549	0.00549	0.00549	0.00549	21
Sperm whale	Hawaii	4,559	19	0.00131	0.00131	0.00131	0.00131	21
Spinner dolphin	Hawaii Pelagic	3,351	14	0.00348	0.00348	0.00348	0.00348	21
	Oahu/4-Islands	601	71	0.023	0.023	0.023	0.023	29
	Hawaii Island	631	71	0.066	0.066	0.066	0.066	30
	Kauai/Niihau	355	71	0.097	0.097	0.097	0.097	29
Striped dolphin	Hawaii	61,201	19	0.00475	0.00475	0.00475	0.00475	21
Hawaiian monk seal	Hawaii	1,427	35	0.00004	0.00004	0.00004	0.00004	35, 36
Model Area #12: Offshore Sri Lanka								

Marine Mammal Species	*Stock Name*[24]	*Abundance*	*Abundance References*	*Density (animals per km²)*[25]				*Density References*
				Winter	*Spring*	*Summer*	*Fall*	
Blue whale	NIND	3,691	77	0.00004	0.00004	0.00004	0.00004	40
Bryde's whale	NIND	9,176	77, 78	0.00041	0.00041	0.00041	0.00041	40
Common minke whale	IND	257,000	77	0.00001	0.00001	0.00625	0.00001	40
Fin whale	IND	1,846	77	0.00001	0.00001	0.00001	0.00001	40
Omura's whale	NIND	9,176	77, 78	0.00041	0.00041	0.00041	0.00041	40
Sei whale	NIND	9,176	77, 78	0.00141	0.00045	0.00045	0.00095	40
Blainville's beaked whale	IND	16,867	78	0.00105	0.00105	0.00105	0.00105	40
Common dolphins	IND	1,819,882	78	0.00513	0.00516	0.00541	0.00538	40
Common bottlenose dolphin	NIND	785,585	78	0.04839	0.04829	0.04725	0.04740	40
Cuvier's beaked whale	NIND	27,272	78	0.00506	0.00508	0.00505	0.00505	40
Deraniyagala beaked whale	IND	16,867	78	0.00513	0.00516	0.00541	0.00538	40
Dwarf sperm whale	IND	10,541	78	0.00005	0.00005	0.00005	0.00005	40
False killer whale	IND	144,188	78	0.00024	0.00024	0.00024	0.00024	40
Fraser's dolphin	IND	151,554	78	0.00207	0.00207	0.00207	0.00207	40
Indo-Pacific bottlenose	IND	7,850	78	0.00048	0.00048	0.00047	0.00047	40
Killer whale	IND	12,593	78	0.00697	0.00155	0.00693	0.00694	40
Longman's beaked whale	IND	16,867	78	0.00513	0.00516	0.00541	0.00538	40
Melon-headed whale	IND	64,600	78	0.00921	0.00920	0.00937	0.00936	40
Pantropical spotted dolphin	IND	736,575	78	0.00904	0.00904	0.00904	0.00904	40
Pygmy killer whale	IND	22,029	78	0.00138	0.00137	0.00152	0.00153	40
Pygmy sperm whale	IND	10,541	78	0.00001	0.00001	0.00001	0.00001	40
Risso's dolphin	IND	452,125	78	0.08641	0.08651	0.08435	0.08466	40
Rough-toothed dolphin	IND	156,690	78	0.00071	0.00071	0.00071	0.00071	40
Short-finned pilot whale	IND	268,751	78	0.03219	0.03228	0.03273	0.03279	40
Sperm whale	NIND	24,446	78, 79	0.00129	0.00118	0.00126	0.00121	40
Spinner dolphin	IND	634,108	78	0.00678	0.00678	0.00678	0.00678	40
Striped dolphin	IND	674,578	78	0.14601	0.14629	0.14780	0.14788	40
Model Area #13: Andaman Sea								
Blue whale	NIND	3,691	77	0.00003	0.00003	0.00003	0.00003	40
Bryde's whale	NIND	9,176	77, 78	0.00038	0.00036	0.00037	0.00037	40

Marine Mammal Species	Stock Name[24]	Abundance	Abundance References	Density (animals per km²)[25]				Density References
				Winter	Spring	Summer	Fall	
Common minke whale	IND	257,500	77		0.00001	0.00968	0.00001	40
Fin whale	IND	1,846	77	0.00001	0.00001		0.00001	40
Omura's whale	NIND	9,176	77	0.00038	0.00036	0.00037	0.00037	40
Blainville's beaked whale	IND	16,867	78	0.00094	0.00089	0.00094	0.00099	40
Common bottlenose dolphin	NIND	785,585	78	0.07578	0.07781	0.07261	0.07212	40
Cuvier's beaked whale	NIND	27,272	78	0.00466	0.00482	0.00480	0.00473	40
Deraniyagala beaked whale	IND	16,867	78	0.00094	0.00092	0.00097	0.00099	40
Dwarf sperm whale	IND	10,541	78	0.00005	0.00006	0.00006	0.00005	40
False killer whale	IND	144,188	78	0.00023	0.00023	0.00024	0.00023	40
Fraser's dolphin	IND	151,554	78	0.00176	0.00179	0.00180	0.00180	40
Ginkgo-toothed beaked whale	IND	16,867	78	0.00094	0.00092	0.00097	0.00099	40
Indo-Pacific bottlenose	IND	7,850	78	0.00076	0.00078	0.00073	0.00072	40
Killer whale	IND	12,593	78	0.00744	0.00178	0.00730	0.00734	40
Longman's beaked whale	IND	16,867	78	0.00444	0.00429	0.00459	0.00440	40
Melon-headed whale	IND	64,600	78	0.00884	0.00848	0.00878	0.00846	40
Pantropical spotted dolphin	IND	736,575	78	0.00868	0.00841	0.00829	0.00873	40
Pygmy killer whale	IND	22,029	78	0.00121	0.00113	0.00125	0.00131	40
Pygmy sperm whale	IND	10,541	78	0.00001	0.00001	0.00001	0.00001	40
Risso's dolphin	IND	452,125	78	0.09197	0.09215	0.09173	0.09366	40
Rough-toothed dolphin	IND	156,690	78	0.00077	0.00078	0.00077	0.00074	40
Short-finned pilot whale	IND	268,751	78	0.03354	0.03364	0.03543	0.03504	40
Sperm whale	NIND	24,446	78, 79	0.00109	0.00099	0.00107	0.00105	40
Spinner dolphin	IND	634,108	78	0.00736	0.00711	0.00701	0.00726	40
Striped dolphin	IND	674,578	78	0.14413	0.14174	0.14123	0.14402	40
Model Area #14: Northwest of Australia[28]								
Antarctic minke whale	ANT	90,000	80		0.00001	0.00001	0.00001	40

28 Seasons are presented following Northern Hemisphere monthly breakdowns for consistency. That is, winter for this mission area would actually be austral summer in the Southern Hemisphere where this mission area is located.

Marine Mammal Species	Stock Name[24]	Abundance	Abundance References	Density (animals per km²)[25]				Density References
				Winter	Spring	Summer	Fall	
Blue whale/Pygmy Blue Whale	SIND	1,657	81, 82		0.00003	0.00003	0.00003	40
Bryde's whale	SIND	13,854	83	0.00032	0.00032	0.00032	0.00032	40
Common minke whale	IND	257,500	77		0.01227	0.01929	0.01947	40
Fin whale	SIND	38,185	84, 85	0.00001	0.00099	0.00128	0.00121	40
Humpback whale	WAU stock and DPS	13,640	86		0.00007	0.00007	0.00007	40
Omura's whale	SIND	13,854	83	0.00032	0.00032	0.00032	0.00032	40
Sei whale	SIND	13,854	83	0.00001	0.00001	0.00001	0.00001	40
Blainville's beaked whale	IND	16,867	78	0.00083	0.00083	0.00082	0.00083	40
Common bottlenose dolphin	WAU	3,000	87	0.03630	0.03652	0.03459	0.03725	40
Cuvier's beaked whale	SH	76,500	88	0.00399	0.00406	0.00402	0.00405	40
Dwarf sperm whale	IND	10,541	78	0.00004	0.00004	0.00004	0.00004	40
False killer whale	IND	144,188	78	0.00020	0.00020	0.00019	0.00020	40
Fraser's dolphin	IND	151,554	78	0.00145	0.00148	0.00149	0.00147	40
Killer whale	IND	12,593	78	0.00585	0.00435	0.00588	0.00580	40
Longman's beaked whale	IND	16,867	78	0.00393	0.00393	0.00403	0.00412	40
Melon-headed whale	IND	64,600	78	0.00717	0.00717	0.00635	0.00637	40
Pantropical spotted dolphin	IND	736,575	78	0.00727	0.00727	0.00715	0.00746	40
Pygmy killer whale	IND	22,029	78	0.00100	0.00104	0.00101	0.00097	40
Risso's dolphin	IND	452,125	78	0.07152	0.07214	0.06944	0.07173	40
Rough-toothed dolphin	IND	156,690	78	0.00059	0.00060	0.00059	0.00059	40
Short-finned pilot whale	IND	268,751	78	0.02698	0.02759	0.02689	0.02716	40
Southern bottlenose whale	IND	599,300	78	0.00083	0.00083	0.00082	0.00083	40
Spade-toothed beaked whale	IND	16,867	78	0.00083	0.00083	0.00082	0.00083	40
Sperm whale	SIND	24,446	78	0.00096	0.00087	0.00097	0.00092	40
Spinner dolphin	IND	634,108	78	0.00561	0.00549	0.00568	0.00563	40

Marine Mammal Species	***Stock Name[24]***	***Abundance***	***Abundance References***	***Density (animals per km²)[25]***				***Density References***
				Winter	***Spring***	***Summer***	***Fall***	
Striped dolphin	IND	674,578	78	0.12018	0.12041	0.11680	0.11727	40
Model Area #15: Northeast of Japan								
Blue whale	WNP	9,250	1, 41, 42	0.00001	0.00001		0.00001	1, 2, 3, 4
Common minke whale	WNP OE	25,049	6, 38, 56	0.0022	0.0022	0.0022	0.0022	6
Fin whale	WNP	9,250	1, 44		0.0002	0.0002	0.0002	1
Humpback whale	WNP stock and DPS	1,328	45		0.000498	0.000498	0.000498	31
North Pacific right whale	WNP	922	89			0.00001	0.00001	
Sei whale	NP	7,000	1, 47		0.00029	0.00029		13, 32
Western North Pacific gray whale	WNP stock/ Western DPS	140	41			0.00001	0.00001	
Baird's beaked whale	WNP	5,688	48, 49		0.0015	0.0029	0.0029	9
Common dolphin	WNP	3,286,163	2, 3	0.0863	0.0863	0.0863	0.0863	2, 3
Cuvier's beaked whale	WNP	90,725	2, 3	0.0054	0.0054	0.0054	0.0054	2, 3
Dall's porpoise	WNP *dalli*	162,000	49, 69	0.0390	0.0520	0.0650	0.0520	2, 3
Killer whale	WNP	12,256	2, 3	0.0036	0.0036	0.0036	0.0036	34
Pacific white-sided dolphin	NP	931,000	20, 90	0.0048	0.0048	0.0048	0.0048	2, 3
Sperm whale	NP	102,112	52, 53	0.0017	0.0022	0.0022	0.0022	12
Stejneger's beaked whale	WNP	8,000	9	0.0005	0.0005	0.0005	0.0005	2, 3
Northern fur seal	Western Pacific	503,609	54, 55	0.00689	0.01378	0.01378	0.01378	20
Ribbon seal	NP	365,000	91	0.0904	0.0904	0.0452	0.0452	34
Spotted seal	Alaska/Bering Sea DPS	461,625	70, 93		0.2770	0.1385		34
Steller sea lion	Western/Asian stocks/Western DPS	71,221	70, 92	0.00001	0.00001	0.00001	0.00001	

TABLE 3-8 CITED LITERATURE REFERENCES

1	Tillman, 1977	32	Murase et al., 2014	63	Nesterenko and Katin, 2008
2	Ferguson and Barlow, 2001	33	Springer et al., 2003	64	Boveng et al., 2009
3	Ferguson and Barlow, 2003	34	Moreland et al., 2012	65	IWC, 1996
4	LGL, 2008	35	NMFS, 2018	66	Hakamada and Hatanaka, 2010
5	Ohsumi, 1977	36	DoN, 2017c	67	Evans, 1987
6	Buckland et al., 1992	37	Horimoto et al., 2016	68	Dalebout et al., 2014
7	Calambokidis et al., 2008	38	Miyashita and Okamura, 2011	69	Miyashita, 1991
8	Masaki, 1977	39	Norris et al., 2017	70	Muto et al., 2018
9	Kasuya, 1986	40	DoN, 2018	71	Carretta et al., 2014
10	Miyashita, 1993	41	Carretta et al., 2015	72	Bradford et al., 2014
11	Hobbs and Waite, 2010	42	Stafford et al., 2001	73	Bradford et al., in review
12	LGL, 2011	43	IWC, 2009	74	Courbis et al., 2014
13	Fulling et al., 2011	44	Mizroch et al., 2009	75	Hoos, 2013
14	Barlow, 2006	45	Bettridge et al., 2015	76	Andrews et al., 2006
15	DoN, 2013	46	Best et al., 2001	77	IWC, 2016
16	Bradford et al., 2013	47	Mizroch et al., 2015	78	Wade and Gerrodette, 1998
17	Carretta et al., 2011	48	Miyashita 1986 and 1990	79	Perry et al., 1999
18	Acebes et al., 2007	49	Kasuya and Perrin, 2017	80	Bannister et al., 1996
19	Bradford et al., 2017	50	Allen and Angliss, 2014	81	Jenner et al., 2008
20	Buckland et al., 1993	51	Kanaji et al., 2018	82	McCauley and Jenner, 2010
21	Forney et al., 2015	52	Kato and Miyashita, 1998	83	IWC, 1981
22	Martin et al., 2015	53	Allen and Angliss, 2015	84	Branch and Butterworth, 2001
23	Mobley et al., 2001	54	Kuzin, 2015	85	Mori and Butterworth, 2006
24	Baird et al., 2009	55	Gelatt et al., 2015	86	Bannister and Hedley, 2001
25	Bradford et al., 2015	56	Wade and Baker, 2011	87	Preen et al., 1997
26	Oleson et al., 2010	57	Miyashita et al., 2007	88	Dalebout et al., 2005
27	Aschettino, 2010	58	Ohsumi, 1980	89	Miyashito and Kato, 1998
28	Oleson et al., 2013	59	Lacsamana et al., 2015	90	Muto et al., 2016
29	Hill et al., 2011	60	Carretta et al., 2016	91	Lowry, 2016
30	Tyne et al., 2014	61	IWC, 2008	92	Burkanov, 2017
31	DoN, 2017d	62	Han et al., 2010	93	Conn et al., 2014

the most up-to-date NMFS draft SARs for U.S. Pacific waters (e.g., Carretta et al., 2018, and Muto et al., 2018).Population-level data for the majority of marine mammal stocks in the Indian Ocean are extremely scarce as few areas of this vast ocean expanse have been surveyed for marine mammals. While the meager Indian Ocean abundance data were used when available, a more comprehensive approach was needed to estimate abundances and densities for the majority of the marine mammal stocks or DPSs occurring in the Indian Ocean mission areas for SURTASS LFA sonar. Therefore, abundances for most stocks were estimated using surrogate data for the same species in a marine area with similar oceanographic and ecological characteristics.

Densities are estimates of the number of individuals in a species or stock that are present per unit area, typically per square nautical mile or kilometer. Statistically, density estimation of marine species, in particular marine mammals and sea turtles, is very difficult because of the large amount of survey effort (at-sea observation) required, often spanning multiple years and covering vast expanses of ocean, to obtain an adequate amount of data upon which to estimate densities. Line-transect sighting surveys (the most common type of "distance sampling" used for density derivation) typically focus on characterizing the probability of visually detecting an animal or group of animals so that the number of individuals missed during the observations can be quantified and estimated. The result of line-transect-based density estimation generally provides a single average density estimate for each species (unless stratification is performed), for the entire area covered by the survey, and usually is constrained to a specific timeframe or season. The estimate does not provide information on the species distribution or concentrations within that area, and does not estimate density for other timeframes/seasons that were not surveyed. However, even given these provisos, line-transect based density estimates typically provide the best available density estimates. When deriving density estimates for the 15 model areas, direct estimates from line-transect (sighting) surveys that occurred in or near the representative model areas were utilized first (e.g., Barlow, 2006).

However, density estimates were not always available for each species/stock in all model areas. Ideally, density data would be available for all species for all areas in all seasons. In areas where survey data are limited or non-existent, known or inferred habitat associations must be used to predict densities. When density estimates derived from line-transect or other surveys were not available in a model area, then density estimates from a region with similar oceanographic/environmental characteristics were extrapolated to that mission area and species/stock. For example, the ETP has been extensively surveyed for marine mammals, with those survey data providing a comprehensive understanding of marine mammals in tropical and warm-temperate oceanic waters (Ferguson and Barlow, 2001, 2003; Wade and Gerrodette, 1993). Data from such well-studied areas are the foundation for population estimates of data-poor species of the western North Pacific and Indian Oceans, where stock and population-level data are scarce. Further, density estimates are sometimes pooled for species of the same genus if sufficient data are not available to compute a density for individual species. This is often the case for species-groups such beaked whales (*Mesoplodon* spp.) or pygmy and dwarf sperm whales (*Kogia* spp.). Density estimates are often available for these species-groups rather than the individual species in some model areas. Last, density estimates are usually not available for very rare marine mammal species or for those that have been newly defined (e.g., the Deraniyagala's beaked whale). For such species, the lowest density estimate of 0.00001 animals per square kilometer (animals/km^2) was used to reflect the very low potential of occurrence in a specific SURTASS LFA sonar model area for data sparse species, such as the North Pacific right whale.

Density estimates for the potentially occurring marine mammal stocks in the modeled areas located in the Indian Ocean were derived from one source (Table 3-8), the Navy's Marine Species Density Database (NMSDD) (DoN, 2017d). The NMSDD provides a systematic method for selecting the most appropriate density value for each species' stock in a given area and season. The NMSDD integrates direct survey sighting data with distance sampling theory to convolve designed-based density estimates, stratified-designed based density estimates, estimates from density spatial models, and habitat-suitability index models to result in spatially and seasonally explicit densities for most marine mammal species. Currently, the NMSDD is not publically available since proprietary geospatial modeling data are included in the database, for which the Navy has established proprietary data sharing agreements. However, products of the Navy's database have been made available to the public, such as the *U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area, NAVFAC Pacific Technical Report* (DoN, 2017c). This report has been used to support Navy environmental compliance documentation for Pacific testing and training areas. The citations for the sighting surveys or other data upon which the densities were derived in the NMSDD have been cited and incorporated herein when appropriate. Densities derived from the NMSDD for the potentially occurring marine mammal stocks were averaged over each modeled area during each season.

Predictions of potential environmental impacts are largely influenced by the accuracy with which the marine mammal abundances and densities are estimated for the selected geographic area and season, which is indicated with measures of uncertainty associated with the population estimates**.** Uncertainty in abundance and density estimates is typically expressed by the coefficient of variation (CV), which is calculated using standard statistical methods and describes the uncertainty as a percentage of the population mean. A CV can range upward from zero, indicating no uncertainty, to higher values approaching one that connotes a higher level of uncertainty about the population estimate. For example, a CV of 0.85 (or 85 percent) would indicate high uncertainty in a given population estimate. When the CV exceeds 1.0, the estimate is very uncertain. Another method for characterizing uncertainty is a confidence interval (CI). This expression typically relates to the 95 percent probability that the "true" population value falls within the given CI range of values. Therefore, a CI with a wider range of values (e.g., 150 to 550) indicates that there is greater uncertainty about the true value than a CI with a smaller range of values (e.g., 300 to 400).

When sufficient information about seasonal movements was available for marine mammal stocks in mission areas or ocean regions, that seasonality is reflected in the density estimates. Density estimates were truncated to no more than five decimal places (Table 3-8). Detailed information on the stock definitions, derivation of the abundance and density estimates, uncertainty (i.e., coefficient of variation [CV] or confidence intervals [CI], as well as the scientific sources from which the information and data were extracted for each species/stock in each model area of the study area for SURTASS LFA sonar may be found in Appendix D.

3.4.3.3.4 Marine Mammal Strandings

Stranding occurs when marine mammals passively (unintentionally) or purposefully go ashore either alive, but debilitated or disoriented, or dead. Although some species of marine mammals, such as pinnipeds, routinely come ashore during all or part of their life history, stranded marine mammals are differentiated by their helplessness ashore and inability to cope with or survive their stranded situation (i.e., they are outside their natural habitat and survival envelope) (Geraci and Lounsbury, 2005). The MMPA defines a stranding as: a) a marine mammal that is dead and is (i) on a beach or shore of the U.S.; or (ii) in waters under the jurisdiction of the U.S. (including any navigable waters); or b) a marine mammal is alive and is (i) on a beach or shore of the U.S. but is unable to return to the water; (ii) on a beach or shore of the U.S. and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the U.S. (including any navigable waters) but is unable to return to its natural habitat under its own power or without assistance (16 U.S. Code Section 1421h).

Strandings of multiple marine mammals are called mass strandings, which occur only rarely. A mass stranding of marine mammals is the stranding of two or more unrelated cetaceans (i.e., not a mother-calf pair) of the same species coming ashore at the same time and place (Geraci and Lounsbury, 2005). Mass strandings typically involve pelagic odontocete marine mammal species that occur infrequently in coastal waters and are usually typified by highly developed social bonds (e.g., pilot whales). Marine mammal strandings and mortality events are natural events that have been recorded historically from as early as 350 B.C. (Aristotle, ca. 350 B.C.), with stranding events occurring throughout the world's oceans.

While anthropogenic factors have been linked directly or indirectly to some marine mammal strandings and mortality, the vast majority of stranding causative factors are natural in origin. Additionally, mass strandings can rarely be attributed to one cause; instead, usually a complex series of conditions, factors, and behaviors have resulted in marine mammals coming ashore and dying. However, the causes of unusual mortality events (UMEs) are often attributable to one specific factor, such as an algal bloom of toxic-producing phytoplankton, or malnutrition. Under the MMPA, an UME is defined as a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands an immediate response (16 U.S.C. 1421h, Section 410(6)). Even for UMEs, however, the likelihood of discerning the cause of a mortality event is not a surety. For instance, of the 65 UMEs that occurred in the U.S. since the UME program began in 1991, causes could only be verified for 32 of the 65 events, with most of the identifiable events being caused by infections, malnutrition, human interactions, and biotoxins (NMFS, 2018f).

Since marine mammal stranding networks have become established, the reporting of marine mammal stranding and mortality events has become better documented and publicized, leading to increased public awareness and concern, especially regarding the potential for anthropogenic causes of stranding and mortality events. Underwater noise, particularly sounds generated by military sonar or geophysical and geologic seismic exploration, has increasingly been implicated as the plausible cause for marine mammal mortality and stranding events. However, despite extensive and lengthy investigations and continuing scientific research, definitive causes or links are rarely determined for the vast majority of marine mammal mass strandings and UMEs. It is generally more feasible to exclude causes of strandings or UMEs than to resolve the specific causative factors leading to these events. For instance, an UME in Alaska in which 46 fin whales died, with 12 of those fin whales having been found dead in a 27-day period, the use of underwater sound (sonar and seismic testing), radiation, ship strikes, infectious diseases, predation, algal toxin exposure, and starvation due to oceanographic changes were all excluded as causes of this long-lasting UME. However, the international team of scientists investigating the UME were unable to determine a definitive cause of the UME, but they noted the unusual oceanographic conditions during the period when the UME occurred (NMFS, 2108f).

Given the difficulty in correlating causative factors to marine mammal stranding and mortality events, it is imperative that assumptions not be made about the cause of these events prior to thorough investigations and analyses being conducted on all the physical evidence and associated factors. As a result of such scientific investigations and research over the last decade, especially on beaked whales, scientific understanding has increased regarding the association between behavioral reactions to natural as well as anthropogenic sources and strandings or deaths of marine mammals. Scientists now understand that for some species, particularly deep-diving marine mammals, behavioral reactions may begin a cascade of physiologic effects, such as gas and fat embolisms, that may result in injury, death, and strandings of marine mammals (Fernández et al., 2005; Cox et al., 2006; Zimmer and Tyack, 2007).

The Navy monitors not only it's SURTASS LFA sonar activities for injured or disabled marine mammals but also monitors the principal marine mammal stranding networks and other media for marine mammal strandings in the study area for SURTASS LFA sonar. The Navy correlates marine mammal stranding events spatially and temporally with SURTASS LFA sonar activities. The Navy compiled marine mammal stranding information from all parts of the study area for SURTASS LFA sonar that occurred over the last two years from e-news alerts, via social media for domestic and international stranding organizations, and by searching available stranding networks for relevant regional information. The majority of the stranding data for the western North Pacific and eastern Indian oceans was reported by the International Dolphin and Whale Stranding Network (https://www.facebook.com/Stranding Network/), which is an informal group of scientists, advocates, and concerned individuals that maintains a thorough compilation of all strandings of marine mammals reported throughout the world. Data for the Philippines were compiled from the Philippines Marine Mammal Stranding Network, although their database is not currently updated through 2017 and 2018 (http://pmmsn.org/), and marine mammal stranding data for Hawaii, Guam, and CNMI were compiled by West (2018).

The Navy has evaluated the spatial and temporal overlap of the compiled strandings with SURTASS LFA sonar activities, and no overlap exists. No mass strandings of marine mammals occurred in the study area for SURTASS LFA sonar during the last year, and no individual strandings of marine mammals occurred in the vicinity of SURTASS LFA sonar activities during or directly following the periods when LFA sonar transmissions occurred. No injured or disabled marine mammals were observed during or after any SURTASS LFA sonar activities. Although causes for the marine mammal strandings were rarely given, when reported, the cause of the stranding or mortality of the stranded cetacean was typically due to ingestion of plastics or entanglement in fishing gear.

3.4.4 Marine Protected Habitats

Many habitats in the marine environment are protected for a variety of reasons, but typically, habitats are designated to conserve and manage natural and cultural resources. Protected marine and aquatic habitats have defined boundaries and are typically enabled under some Federal, State, or international legal authority. Habitats are protected for a variety of reasons including intrinsic ecological value; biological importance to specific marine species or taxa, which are often also protected by federal or international agreements; management of fisheries; and cultural or historic significance. Three types of marine and aquatic habitats protected under U.S. legislation or Presidential EO, critical habitat, essential fish habitat, and marine protected areas, are described in this section.

3.4.4.1 Critical Habitat

The ESA requires NMFS and USFWS to designate critical habitat for any species that it lists under the ESA, except foreign species. Critical habitat is defined under the ESA as the specific areas within the geographic area occupied by a listed threatened or endangered species on which the physical or biological features essential to the conservation of the species are found, and that may require special management consideration or protection; and specific areas outside the geographic area occupied by a listed threatened or endangered species that are essential to the conservation of the species (16 U.S.C. §1532(5)(A), 1978). Critical habitat is not designated in foreign countries or any other areas outside U.S.

jurisdiction. Although not required, critical habitat may be established for those species listed under the ESA prior to the 1978 amendments to the ESA that added critical habitat provisions. Under Section 7 of the ESA, all federal agencies must ensure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or destroy or adversely modify its designated critical habitat.

Critical habitat designations must be based on the best scientific information available and designated in an open public process and within specific timeframes. Before designating critical habitat, careful consideration must be given to the economic impacts, impacts on national security, and other relevant impacts of specifying any particular area as critical habitat. One hundred fifty seven marine and anadromous species have been listed as threatened or endangered under the ESA, including 63 foreign species (NMFS, 2017b). Critical habitat has been designated for 48 of the marine and anadromous species, although some of the critical habitat for anadromous species is located in inland fresh water bodies (NMFS, 2016a). Although NMFS has jurisdiction over many marine and anadromous species listed under ESA and their designated critical habitat, the USFWS also has jurisdiction over marine/anadromous species, such as the manatee, polar bear, walrus, and sea otter; and shares jurisdiction with NMFS for some species, such as the Atlantic salmon, gulf sturgeon, and all sea turtles.

Of the marine species that have been listed as threatened or endangered under the ESA, critical habitat has been designated for two species, the Hawaiian monk seal and the Main Hawaiian Island (MHI) Insular DPS of the false killer whale, within the study area for SURTASS LFA sonar. Critical habitat for the Hawaiian monk seal has been designated in the Northwestern (NWHI) and MHI and includes seafloor and marine neritic and pelagic waters within 33 ft (10 m) of the seafloor from the shoreline seaward to the 628-ft (200-m) depth contour at 10 areas in the NWHI on Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, Nihoa, Kaula Island and Niihau and Lehua Islands, and six areas in the MHI on Kaula, Niihau, Kauai, Oahu, Maui Nui (i.e., Kahoolawe, Lanai, Maui, and Molokai), and Hawaii (excluding National Security Exclusion zones off Kauai, Oahu, and Kahoolawe) (NOAA, 2015a). The MHI critical habitat also includes specific terrestrial areas from the shoreline inland 16 ft (5 m).

The physical or biological features of the Hawaiian monk seal critical habitat that support the species' life history needs include: 1) areas with characteristics preferred by monk seals for pupping and nursing; 2) shallow, sheltered nearshore marine areas preferred by monk seals for pupping and nursing; 3) marine areas up to 1,640 ft (500 m) in depth preferred by juvenile and adult monk seals for foraging; 4) areas with low levels of human disturbance; 5) marine areas with adequate prey quantity and quality; and 6) significant shore areas used by monk seals for hauling out, resting, or molting (NOAA, 2015a).

Nearly all of the critical habitat for the Hawaiian monk seal lies within the coastal standoff distance for SURTASS LFA sonar, wherein the sound field generated by LFA sonar cannot exceed 180 dB re 1 µPa (rms) (SPL) within 22 km (12 nmi) of any land, including islands. A small area of the monk seal's critical habitat at Penguin Bank extends beyond the 22-km coastal standoff distance. Though Penguin Bank extends beyond the protection of the coastal standoff distance, Penguin Bank is an OBIA for SURTASS LFA sonar. Additionally, under the CZMA stipulations with the State of Hawaii for SURTASS LFA sonar, the Navy agreed not to operate LFA sonar in the waters over Penguin Bank or in Hawaii state waters up to the 600-ft (183-m) isobath, which coincides with the OBIA boundary for Penguin Bank. Thus, SURTASS LFA sonar activities would not be conducted in waters of the portion of the monk seal's critical habitat that extends beyond the coastal standoff range.

Critical habitat has been designated for the Main Hawaiian Island Insular DPS of the false killer whale (NOAA, 2018c). The critical habitat for the Main Hawaiian Islands DPS of false killer whales includes waters from the 148- to 10,499-ft (45-to 3,200-m) depth contours around the Main Hawaiian Islands from Niihau east to Hawaii (Figure 3-8). Some Navy and other federal agency areas, such as the Pacific Missile Range Facility offshore ranges, are excluded from the designated critical habitat designation (NOAA, 2018c).

The physical or biological features of the designated critical habitat that are essential for the conservation of the MHI Insular DPS of false killer whales include: 1) island-associated marine habitat (productive, deeper, just offshore waters of varying water depths) for MHI insular false killer whales; 2) prey species (large pelagic fish and squid) of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; 3) waters free of pollutants of a type and amount harmful to MHI insular false killer whales (i.e., good water quality) so that false killer whales can forage and reproduce free from disease and impairment; and 4) habitat free of anthropogenic noise that would significantly impair the value of the habitat for false killer whales' use or occupancy (i.e., no anthropogenic noise of a certain level, intensity, and duration that could alter the ability of false killer whales to detect, interpret, and utilize acoustic cues that support important life history functions, or can result in long-term habitat avoidance or abandonment (NOAA, 2017).

3.4.4.2 Marine Protected Areas

The term "marine protected area" (MPA) is very generalized and is used to describe specific regions of the marine and aquatic environments that have been set aside for protection, usually by individual nations within their territorial waters, although a small number of internationally recognized MPAs exist. Of the estimated 5,000 global MPAs, about 10 percent are international (WDPA, 2009). The variety of names and uses of MPAs has led to confusion over what the term really means and where MPAs are used. Internationally, a MPA is considered "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher, 1999). In the U.S., a MPA is defined by EO 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein."

MPAs have been proven to be effective conservation tools to manage fisheries, preserve habitat and biodiversity, and enhance the aesthetic and recreational value of marine areas (NRC, 2000). Although the objectives for establishing protection of marine areas vary widely, MPAs are typically used to achieve two broad objectives: 1) habitat protection, and 2) fisheries management and protection (Agardy, 2001). Many MPAs are multi-use areas while others only allow restricted uses within the designated MPA boundaries.

3.4.4.2.1 U.S. Marine Protected Areas

In the U.S., MPAs have conservation or management purposes, defined boundaries, a permanent protection status, and some legal authority to protect marine or aquatic resources. In practice, U.S. MPAs are defined marine and aquatic geographic areas where natural and/or cultural resources are given greater protection than is given in the surrounding waters. U.S. MPAs span a range of habitats including the open ocean, coastal areas, inter-tidal zones, estuaries, as well as the Great Lakes and vary widely in purpose, legal authority, agencies, management approaches, level of protection, and restrictions on human uses (NMPAC, 2009). Currently, about 100 federal, state, territorial, and tribal agencies manage more than 1,700 marine areas in the U.S. and its territories, but about 60 percent are managed (NOAA, 2014c). Forty-one percent of U.S. EEZ waters are encompassed in some type of MPA, with 97 percent of existing U.S. MPAs located in Federal waters (NOAA, 2014c). Two U.S. agencies primarily manage Federally-designated MPAs. The Department of Commerce's NOAA manages national marine sanctuaries (NMS), national monuments, fishery management zones, and in partnership with states, national estuarine research reserves, while the Department of Interior manages the national wildlife refuges and the national park system, which includes national parks, national seashores, and national monuments. Over the past century in the U.S., Federal, state, territorial, and local legislation; voter initiatives; and regulations have created the plethora of MPAs. More than 1,700 MPAs now exist, most of which are multi-purpose. The resulting collection of U.S. MPAs, consisting of national marine reserves, refuges, preserves, sanctuaries, parks, monuments, and seashores, as well as areas of special biological significance, fishery management zones, and critical habitat is so fragmented, unrelated, and confusing that potential opportunities for broader regional conservation through coordinated planning and management were often missed.

To address this situation and improve the nation's ability to understand and preserve its marine resources, Presidential EO 13158 of 2000 called for an evaluation and inventory of the existing MPAs and development of a national MPA system and national MPA center. The EO called for a national system that protects both natural and cultural marine resources and is based on a strong scientific foundation. The Department of Commerce established the National MPA Center (NMPAC), which has inventoried U.S. MPAs and has developed the criteria for the National MPA System. Although EO 13158 provided the formal definition of a MPA, the NMPAC has developed a classification system that provides definitions and qualifications for the various terms within the EO (NMPAC, 2011). The National MPA System's classification consists of five key functional criteria that objectively describe MPAs:

- Conservation focus (i.e., sustainable production or natural and/or cultural heritage),
- Level of protection (i.e., no access, no impact, no-take, zoned with no-take area(s), zoned multiple use, or uniform multiple use),
- Permanence of protection,
- Constancy of protection,
- Ecological scale of protection (NMPAC, 2011).

The first two of these criteria, conservation and protection, are the keystones of the classification system. These five criteria influence the effect MPAs have on the local ecosystem and on human users.

By 2014, the most recent year for which data are available, more than 1,700 MPAs had become part of the National MPA System (NOAA, 2014c). Three of the largest MPAs in the U.S. system are located in the western and central North Pacific Ocean. The Papahānaumokuākea Marine National Monument (NM), encompassing the Northwest Hawaiian Islands, was expanded in 2016 to become the largest U.S. MPA and one of the largest in the world, with an area of 439,916 nmi^2 (1,508,870 km^2). The Pacific Remote Islands Marine NM became the second largest MPA in the U.S. system when its area was expanded in 2014 to its current area of 370,710 nmi^2 (1,271,500 km^2), which includes Howland, Baker, and Jarvis Islands; Johnston, Wake, and Palmyra Atolls; and Kingman Reef (Marine Conservation Institute, 2017a). Established in 2009, the Marianas Trench Marine NM includes 71,900 nmi^2 (250,000 km^2) of marine waters and submerged lands, which includes waters and submerged lands in three of the northernmost Mariana Islands and only the submerged land of 21 volcanic sites and the Mariana Trench (USFWS, 2012). The waters of these three largest MPAs in the western and central North Pacific Ocean are located in the study areas of SURTASS LFA sonar.

3.4.4.2.2 International Marine Protected Areas

Although there are several efforts to document international MPAs, including one led by the United Nations, no one organization is responsible for cataloging international MPAs and the ways in which information and statistics about MPAs are compiled differ amongst organizations. International MPAs encompass a very wide variety of habitat types and designation purposes as well as a good degree of variability in the levels of protection and legal mandates associated with each MPA.MPAs have been designated by nearly every coastal country of the world, and by current estimates, more than 15,000 MPAs exist globally, protecting from 3.7 to 7.26 percent of the world's oceans (Figure 3-9) (IUCN, 2017; Marine Conservation Institute, 2017b; Protected Planet, 2018). A number of international MPAs have been established for the sole purpose of protecting cetaceans. Although most international MPAs lie along the coast of the designating country, many international MPAs encompass large extents of ocean area and encompass international as well as territorial waters. Many of the large oceanic MPAs are also listed as World Heritage Sites (UNESCO, 2009). In 2017, Marae Moana or Cook Islands Marine Park was designated by the government of the Cook Islands, making it the largest international MPA, with an area of nearly 583,107 nmi^2 (2 million km^2) (Cook Islands Marine Park, 2017). The Papahānaumokuākea Marine NM of the U.S. is the largest MPA in the study area for SURTASS LFA sonar.

3.4.4.3 National Marine Sanctuaries

The National Marine Sanctuary System includes 13 national marine sanctuaries (NMSs) and the management of two marine national monuments (NMs) (Papahānaumokuākea and Rose Atoll), together encompassing more than 453,072 nmi^2 (1,553,993 km^2) of U.S. marine and Great Lakes waters (see http://sanctuaries.noaa.gov/). National monuments are described in a separate section. Each NMS was established to protect the aquatic habitats, marine and aquatic species, and historical artifacts encompassed within a sanctuary and has an established management plan that guides the activities and programs, sets priorities, and contains relevant regulations. Only one NMS is located in the potential SURTASS LFA sonar study area.

For the purpose of providing a summary of resources in each sanctuary; pressures on those resources; the current condition and trends; and management responses to the pressures that threaten the integrity of the marine environment, Office of National Marine Sanctuaries' (ONMS') Condition Reports divide sanctuary resources into water, habitat, living, and maritime archaeological resources; however, it should be noted that the characterization of sanctuary resources by these categories can be different than or non-inclusive of specific definitions in the NMSA or at 15 C.F.R. pt. 922 for legal and regulatory purposes. For instance, the definition of "sanctuary resource" is established in the NMSA and "cultural resources" and "historical resources" are defined at 15 C.F.R. § 922.3; regulatory definitions are broader than those used in the ONMS condition reports:

- *Sanctuary resource* means any living or non-living resource of a national marine sanctuary that contributes to the conservation, recreational, ecological, historical, educational, cultural, archeological, scientific, or esthetic value of the sanctuary.
- *Cultural resources* means any historical or cultural feature, including archaeological sites, historic structures, shipwrecks, and artifacts.

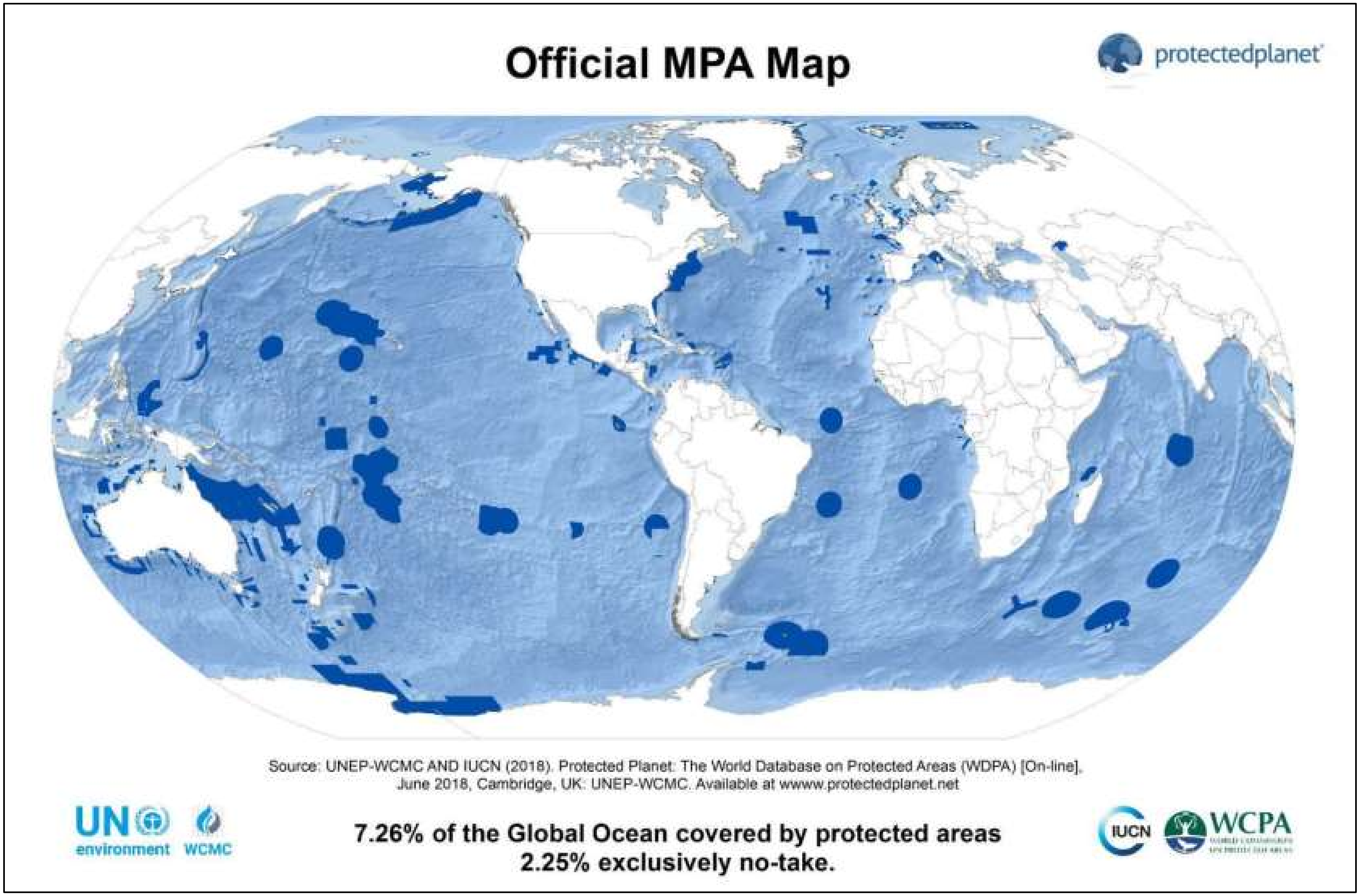

Figure 3-9. Marine Protected Areas of the World's Oceans (Protected Planet, 2018a).

- *Historical resource* means any resource possessing historical, cultural, archaeological or paleontological significance, including sites, contextual information, structures, districts, and objects significantly associated with or representative of earlier people, cultures, maritime heritage, and human activities and events. Historical resources include "submerged cultural resources", and also include "historical properties," as defined in the National Historic Preservation Act, as amended, and its implementing regulations, as amended.

Waters include the water column of the sanctuary; habitat includes pelagic, benthic, and coastal areas of importance within a sanctuary; living resources include the biota, including plants and animals, that occur year-round or seasonally in a sanctuary, and finally, a maritime heritage or archaeological resource is defined any type of historical, cultural, archaeological, or paleontological significance resource that is more than 50 years old.

Sanctuaries have established activities that are prohibited or regulated within the sanctuary boundary. However, Department of Defense (DoD) agencies are exempt from these prohibitions or regulations in many of the NMSs. Details of the military exemptions for each NMS may be found in 15 C.F.R. part 922. The focus of the each sanctuary's habitats descriptions in this section are on those habitats that occur in the waters in which SURTASS LFA sonar is most likely to be operated (i.e., not in intertidal, coastal habitats).

3.4.4.3.1 Hawaiian Islands Humpback Whale NMS

Designated in 1992, the Hawaiian Islands Humpback Whale NMS was created to protect humpback whales and their habitat in Hawaii. Encompassing 1,218 nmi^2 (3,548 km^2) of the submerged lands and waters surrounding the Main Hawaiian Islands from the shoreline to the 600-ft (183-m) isobath, the sanctuary is separated into five discrete protected area around Maui, Lanaʻi, and Molokaʻi, including Penguin Bank, as well as parts of Oʻahu, Kauaʻi and Hawaiʻi. The sanctuary encompasses waters used by an estimated half of the North Pacific population of humpback whales for calving and breeding from late fall through spring (roughly October through May (ONMS, 2010b).

- ***Sanctuary Resources***

  Living (Biota): Hawaii Islands Humpback Whale NMS is comprised of two sanctuary resources: the humpback whale and its habitat. While other marine biota occur in the waters of the sanctuary, including ESA-listed coral, sea turtles, and the Hawaiian monk seal as well as numerous marine fishes, only the humpback whale is detailed. Hawaiian humpback whales are part of the Hawaii DPS, which is not listed under the ESA, as it is not at risk (NOAA, 2015d). Scientists estimate that more than 50 percent of the entire North Pacific humpback whale population migrates to Hawaiian waters each winter to mate, calve, and nurse their young. Humpback whales occur in Hawaiian waters only seasonally, when they arrive to calve from roughly December through April, annually.

- ***Prohibited Activities***

Activities prohibited or regulated in the sanctuary include approaching a humpback whale within 100 yd (91 m) by any means; operating aircraft above the sanctuary within 1,000 ft (304 m) of a humpback whale except as necessary to take off or land the aircraft; taking a humpback whale (unless authorized by the ESA or MMPA); possessing a living or dead humpback whale or its parts; discharging or depositing any materials within or outside the sanctuary that may enter the sanctuary and injure a humpback whale or its habitat; altering the seabed; and interfering in any manner with an enforcement action (CFR 15 §922.184).

- ***DoD Exemptions***

According to CFR 15 §922.183, all classes of military activities that were identified in the FEIS/Management Plan and all classes of military activities that were being or had been conducted before the effective date of the sanctuary regulations (as identified in the FEIS/Management Plan) are allowed activities in the sanctuary and are not subject to further consultation under the NMSA. Military activities proposed after the effective date of the sanctuary regulations are also included as allowed activities if the DoD consults with the ONMS on the activities. If an allowable military action is modified so that it is likely to destroy, injure, or cause the loss of a sanctuary resource significantly greater than was considered in a previous consultation, then the modified activity will be considered a new activity for which consultation is required. If a military activity subject to consultation under section 304 of the NMSA is required to respond to an emergency situation, and the DoD determines in writing that failure to conduct the activity will threaten national defense, the DoD may request that the military activity proceed during the consultation process. If the request is denied, the secretary of the pertinent military branch may decide to proceed with the execution of the military activity; in this case, the secretary of the military branch must provide the ONMS director with a written statement of any effects of the activity on sanctuary resources.

3.4.4.4 Marine National Monuments

Marine NMs are designated by presidential authorization under the Antiquities Act to conserve and protect areas of the marine environment. Five U.S. marine NM have been authorized in the Pacific and Atlantic oceans and are cooperatively managed by federal and some State or territorial agencies. DoD activities within each NM are conducted in accordance with the requirements of the monument's presidential authorization. The Antiquities Act specifies no consultation by Federal agencies in association with NMs. Three large marine NMs lie within the study area for SURTASS LFA sonar: Papahānaumokuākea Marine NM, Pacific Remote Islands Marine NM, and the Marianas Trench Marine NM. The boundaries of these marine NMs have been under review and in 2017, the U.S. Secretary of the Interior recommended to the President that the area of the Pacific Remote Islands Marine NM be reduced and its waters opened to commercial fishing (Zinke, 2017).

3.4.4.4.1 Papahānaumokuākea Marine National Monument

On Friday, August 26, 2016, President Obama signed a proclamation expanding the Papahānaumokuākea Marine NM. Previously the largest contiguous fully-protected conservation area in the U.S., the expanded boundaries made it the largest protected area in the world at 439,916 nmi^2 (1,508,870 km^2), nearly the size of the Gulf of Mexico, and the largest marine NM in the U.S. Papahānaumokuākea NM is globally recognized for its biological and cultural significance; it is also the only mixed United National Educational, Scientific, and Cultural Organization (UNESCO) World Heritage site in the U.S. and only one of 35 mixed World Heritage sites in the world. The expanded monument is managed by four co-trustees: the Federal Departments of Commerce and Interior, Hawaii Department of Land and Natural Resources, and Office of Hawaiian Affairs.

The extensive coral reefs found in Papahānaumokuākea NM include over 7,000 marine species, one quarter of which are found only in the Hawaiian Archipelago. Many of the islands and shallow water environments of the NM are important habitats for rare species such as the threatened green turtle and the endangered Hawaiian monk seal, as well as the 14 million seabirds representing 22 species that breed and nest in the monument. Land areas also provide a home for four species of bird found nowhere else in the world, including the world's most endangered duck, the Laysan duck. For more information about the NM and its resources, please visit the ONMS' website (http://sanctuaries.noaa.gov/papahanaumokuakea-expansion/). Information about the monument's regulations may be found in 50 C.F.R. Part 404.

3.4.4.4.2 Pacific Remote Islands Marine National Monument

The Pacific Remote Islands Marine NM became the second largest marine NM and MPA in the U.S. system when its area was expanded in 2014 to its current area of 370,710 nmi^2 (1,271,500 km^2). Pacific Remote Islands Marine NM includes Howland, Baker, and Jarvis Islands; Johnston, Wake, and Palmyra Atolls; and Kingman Reef (Marine Conservation Institute, 2017c). Pacific Remote Islands Marine NM is co-managed by NOAA and USFWS, except for Wake Island and Johnston Atoll, which are managed by the DoD. The waters of the NM are known for their biodiversity, amongst which are species found no where else on earth.

3.4.4.4.3 Marianas Trench Marine National Monument

Established in 2009, the Marianas Trench Marine NM includes 71,900 nmi^2 (250,000 km^2) of marine waters and submerged lands, which includes waters and submerged lands in three of the northernmost Mariana Islands and only the submerged land of 21 volcanic sites and the Mariana Trench (USFWS, 2012). The Marianas Trench Marine NM is co-managed by the USFWS, NOAA, DoD, and the government of the Commonwealth of the Northern Mariana Islands. The Marianas Trench Marine NM consists of three units, only one of which, the Islands unit, includes marine waters. The other two units consist of submerged land, including the Mariana Trench, which is the deepest place on earth.

3.4.4.5 Essential Fish Habitat

In recognition of the critical importance habitat plays in all lifestages of fish and invertebrate species, the MSFCMA, as amended, protects habitat essential to the production of federally managed marine and anadromous species within the U.S. EEZ. The MSFCMA, reauthorized and amended by the Sustainable Fisheries Act, called for the identification and protection of EFH. Under the MSFCMA, the NMFS has exclusive federal management authority over U.S. domestic fisheries resources and oversees the nine regional fishery management councils (FMCs) and approves all Fishery Management Plans (FMPs). The 1996 EFH mandate and 2002 Final EFH Rule require that regional FMCs, through federal FMPs, describe and identify EFH for each federally managed species, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitats. The NMFS' Highly Migratory Species (HMS) Division functions as a FMC (Secretarial FMC) to oversee EFH designation and FMP preparation for Atlantic highly migratory species, such as sharks and tuna, since the habitat essential to these species may cross FMC and federal jurisdictional boundaries (NMFS, 2009a).

Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" and the term "fish" as "finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds" (16 U.S.C. §1802[10]). The regulations for implementing EFH clarify that "waters" include all aquatic areas and their biological, chemical, and physical properties, while "substrate" includes the sediment, hard bottom, structures underlying the waters, and associated biological communities that make these areas suitable fish habitats (NOAA, 2002). Habitats used at any time during a species' life cycle (i.e., during at least one of its lifestages) must be accounted for when describing and identifying EFH, including inshore bays and estuaries (NOAA, 2002). Habitat areas of particular concern (HAPC) are subsets of EFH areas that are designated to indicate an areas' rarity, susceptibility to anthropogenic-induced degradation, special ecological importance, or location in an environmentally stressed region. HAPC do not confer additional protection or restriction but are intended to prioritize conservation efforts.

The MSFCMA requires federal agencies that fund, permit, or carry out activities that may adversely affect EFH to consult with the NMFS regarding the potential impacts of the federal actions on EFH and respond in writing to the NMFS or FMC recommendations. NMFS' conservation recommendations are non-binding (NMFS, 2002). Adverse effects are defined as "any impact that reduces quality and/or quantity of EFH"; adverse effects include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH (50 CFR §600). Adverse effects to EFH may result from actions occurring within or outside of the areal extent of the designated EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of federal actions. NMFS (2002) describes the process by which federal agencies can integrate MSFCMA EFH consultations with ESA Section 7 consultations.

Nine FMCs, including the HMS Division of NMFS, are responsible for designating EFH and HAPC in all U.S. territorial waters for hundreds of marine and anadromous fish and invertebrate species. Since EFH is only designated in waters of the U.S. EEZ, in the SURTASS LFA sonar study area, EFH is located only in waters of Hawaii, Guam, CNMI, and the Pacific Remote Islands (only some of which are located within the study area). The types of general habitat that have been designated as EFH in U.S. Hawaii state and territorial waters include (NOAA, 2013; WPFMC, 2004):

- **Benthic Habitat:** These seafloor habitats include the seafloor substrate.
- **Structured Habitats:** Areas that provide shelter for a variety of species and include:
  - Coral Reefs: Created by living coral organisms that are inhabited many fishes and invertebrates. EFH may include only parts of the reef, such as the outer reef for some crustacean species. Also includes coral beds of precious corals.
- **Marine Waters:** The water column from the surface of the ocean to water depths from 328 to 2,297 ft (100 to 700 m). Depending upon the species or management group, the designated habitat may refer only to a specific part of the water column, such as surface or bottom waters, to specific water depths in the water column, such as waters from 984 to 2,297 ft (300 to 700 m), or to the entire water column. This habitat is important for a wide variety of species and lifestages.
- **Topographic Features:** These seafloor habitat areas have high vertical (bathymetric) relief and include seamounts, hard rock banks, escarpments, submarine canyons, deep slope terraces, and the continental or insular shelf break.
- **Marine Protected Areas (MPAs):** Specific waters within the U.S. EEZ where fishing is prohibited or only allowed by special permit. Waters landward of the 299-ft (91-m) isobath surrounding Howland, Baker, and Jarvis Islands, Rose Atoll, and Kingman Reef and in a box designated by four corner geographic coordinates around French Frigate Shoals have been designated as no-take (no fishing) MPAs while waters from shore to the 299-ft (91-m) isobath surrounding Palmyra and Johnson Atolls and Wake Island are low-use MPAs, where fishing is only allowed by special permit (WPRFMC, 2006).

EFH in the study area is designated for the following species or management groups (NOAA, 2013; WPFMC, 2004):

- Crustaceans (lobsters, crabs, shrimps)—Water column to depths of 328 ft (100 m) (juvenile and adult lobsters/crabs) or 492 ft (150 m) (eggs and larvae lobsters/crabs) from the shoreline to the U.S. exclusive economic zone (EEZ) boundary. For deepwater shrimp, the outer reef slopes between 984 and 2,297 ft (300 and 700 m) (eggs and larvae) or 1,805 to 2,297 ft (550 to 700 m) (juveniles and adults).
- Bottomfish—Water column to depth of 1,312 ft (400 m) boundary or water column to depth of 1,312 ft (400 m) plus the seafloor from shore to EEZ.
- Seamount groundfish—Water column to depth of 656 ft (200 m) (eggs and larvae) or 1,969 ft (600 m) (juveniles and adults) of all EEZ waters bounded by 29°to 35° N and 171° E to 179° W.
- Pelagics—Water column to depth of 656 ft (200 m) (eggs and larvae) or 3,281 ft (1,000 m) (juveniles and adults) from shore to EEZ boundary.
- Precious Corals—Known (nine named locations) precious coral beds in Hawaiian Islands.
- Coral Reef Ecosystem—All seafloor and water column to depth of 328 ft (100 m) from shore to EEZ boundary.

3.5 Economic Resources

Since SURTASS LFA sonar operates in open ocean areas, it has the potential to interact with other activities taking place in these areas, including: commercial fishing, aboriginal subsistence whaling, and recreational activities including diving and whale watching. The following section will outline activities that may take place concurrently with SURTASS LFA sonar activities. Many aquatic activities take place in nearshore or inland water areas where SURTASS LFA sonar is not proposed to operate.

3.5.1 Commercial Fisheries

Global commercial fisheries were discussed in detail in subchapter 3.3.1 of the 2012 EIS/SEIS (DoN, 2012); that information remains pertinent and valid to the discussion of commercial fisheries going forward and is therefore provided herein by reference. The following discussion relates to information on global commercial fisheries that occur in the study area for SURTASS LFA sonar.

3.5.1.1 Global Fisheries Production

Global fishery statistics are compiled per year by the United Nation’s Food and Agriculture Organization of the United Nations (FAO). The general composition of the global fisheries catches in 2012 was marine fishes, crustaceans, and mollusks with a total of 87.9 million tons (79.7 million metric tons) of overall landings. Regardless of the variations highlighted between 2012 and 2013, global fishery harvest/production totals have been stable for the last fifteen years, varying between 97.3 and 103.4 million tons (107.3 and 114 metric tons), despite variations in production by country, fishing area, and species every year (FAO, 2015).

The inland and marine fisheries (minus anchoveta) increased slightly between 2012 and 2013, but the anchoveta (*Engraulis ringens*) fishery harvest increased significantly between the two years, with the landings increasing by about 1.1 million tons (1.2 million metric tons). The total global capture production reached a new maximum in 2013 at 33.2 million tons (30.1 million metric tons). The Peruvian anchovy (anchoveta) was the top marine species landed globally during 2013, with 6,254,554 tons landed (FAO, 2015).

In 2013, the top worldwide fisheries producing countries were China, Peru, Indonesia, and the U.S. (Table 3-9). China's fishery harvest/production was more than twice that of any other nation in 2012 and 2013. The northwest Pacific Ocean region of the world had significantly more mass landed for both 2012 and 2013 than any other fishing regions.

Table 3-9. Top 10 Worldwide Fishing Nations in 2013 by Mass Fishery Landings (FAO, 2015).

Country	*Total 2013 Landings (tons)*
China	15,396,824
Peru	6,423,093
Indonesia	6,270,539
United States of America	5,736,971
Russian Federation	4,501,639
Japan	3,996,531
India	3,768,605
Viet Nam	2,875,269
Myanmar	2,737,998
Philippines	2,348,747

3.5.1.2 Trends of the Top Fish Producing Countries

As of 2012, Vietnam and Myanmar were among the top 10 worldwide fishery producing nations (Table 3-9). Since the descriptive information for the remaining top fishery producing nations has changed little from that presented in the 2012 SEIS/SOEIS for SURTASS LFA sonar (DoN, 2012), the national fishery information presented in subchapter 3.3.1.1 of the Navy's 2012 SEIS/SOEIS remains pertinent and valid, and is incorporated herein by reference. Particularly since both Myanmar and Vietnam lie within the study area for SURTASS LFA sonar and presumably some of their fishery harvest occurs in those waters, information on these fisheries follows.

3.5.1.2.1 Myanmar

In Myanmar, which is the largest country in Southeast Asia, fishery products are a staple diet and a major source of animal protein for Myanmar's people. With a shoreline over 1,864 miles (3,000 km) in length, large river systems, and an extensive area of inland lakes and reservoirs, which results in fisheries playing an important role as a source of food, income, and employment (FAO, 2010). In 2011, Myanmar's population was 18 million people and the fishery sector provided direct employment for about 2.9 million people. In 2007, the per capita consumption of fish of 93.7 pounds (lb)/year (42.5 kilograms [kg]/yr) was one of the highest in the world (FAO, 2012a).

The total fish production was estimated at 4.2 million tons (3.8 million metric tons) in 2011, with capture fisheries contributing 3.3 million tons (3.1 million metric tons) (FAO, 2012a). By 2013, fishery landings were estimated at 2.7 million tons (2.5 million metric tons) (FAO, 2015). Some 31,600 fishing vessels were reported for Myanmar, but more than half of which were not equipped with an engine. The fish-food supply during 2011 was 3,193 thousand tons (2,897 thousand metric tons) in live weight equivalent (FAO, 2012a).

In 2011, Myanmar exported the equivalent of $555.4 million U.S. dollars (USD) in fish and fishery products compared to import of $14.5 million USD (FAO, 2012a). Myanmar fishery harvest production decreased from 2013/2014 to 2014/2015, with 137,918 metric tons of fishery products exported in 2013/2014 at a value of 291.6 million USD (Win, 2015). China is the largest importer of Myanmar's fisheries products, particularly marine fishery products. Myanmar exported between 5 and 10 percent of its production to the European Union in 2010 (FAO, 2012a).

3.5.1.2.2 Vietnam

The fisheries industry in Vietnam consists of marine fisheries, inland fisheries, and aquaculture, with the marine fisheries sector being the largest contributor to the countries' fisheries production. The main fishing areas in the country are in the Gulf of Tonkin, central Vietnam, southeastern Vietnam, and southwestern Vietnam. Marine catches are the highest in central and southeast Vietnam (FAO, 2005). The fisheries sector, which has been growing considerably, plays an important role in the national economy. In 2003, the per capita consumption of 42.8 lb (19.4 kg) provided about half of the annual supply of animal protein in the national human diet. Nearly 10 percent of the population derives its main income from fisheries, with over 10 percent of the total export earnings also derived from fisheries. Vietnam exports mainly seafood products, and imported sea products, mainly salmon, crab meat, and caviar from Norway, France, the U.S., and other countries in 2001 (FAO, 2005). In 2012, the latest year for which FAO statistics are available, fishery exports were valued at $653,850 USD (FAO, 2012b).

The marine fishery resources potential has been estimated at 4.6 million tons (4.2 million metric tons), of which the annual allowable catch is 1.9 million tons (1.7 million metric tons). This included 936,964 tons (850,000 metric tons) of demersal fish, 771,617 tons (700,000 metric tons) of small pelagic fish, and 132,277 tons (120,000 metric tons) of oceanic pelagic fish. The most important commercial fishery species' groups are shrimp, tuna, squid, sea bream, snappers, groupers, and small pelagics. In 2013, the fishery landings were estimated at 2.9 million tons (FAO, 2015). In recent years, the number of fishing boats in Vietnam has increased, but only a small number have the capacity for deep-sea fishing. In 2012, 129,376 powered fishing boats were reported for Vietnam. Foreign boats often penetrate into Vietnamese waters to fish illegally. The quantity of marine catches taken by these foreign boats is estimated at about 110,231 tons (100,000 metric tons) per year (FAO, 2005).

3.5.2 Subsistence Harvest of Marine Mammals

SURTASS LFA sonar would not be operated in Arctic waters nor in the Gulf of Alaska or off the Aleutian Archipelago where subsistence uses of marine mammals occurs in the U.S. Therefore, no subsistence hunting regulated under the MMPA would occur in the study area for SURTASS LFA sonar.

3.5.3 Recreational Marine Activities

Marine recreational activities include swimming, snorkeling, recreational diving, and whale watching. Swimming and snorkeling may occur anywhere in relatively shallow waters near any shoreline.

Recreational dive sites are less numerous, as they typically occur in nearshore waters where some underwater feature or habitat, such as coral reefs or shipwrecks, create destinations for recreational divers. Likewise, whale watching only occurs in marine waters in which marine mammals can be observed, at least seasonally.

3.5.3.1 Recreational Diving

Recreational dive sites are typically located in coastal waters between shore and the 130 ft (40 m) depth contour, which is about the depth limit to which most recreational scuba divers dive. With more advanced training, divers could descend to water depths deeper than 130 ft (40 m), but this type of diving would usually no longer be considered recreational diving (PADI, 2016). The Professional Association of Diving Instructors (PADI), which is the largest dive training organization in the world, has issued over 25 million diver certifications globally since 1967 (PADI, 2017). Some of the world's premier and most popular diving sites are located in the study area for SURTASS LFA sonar (Table 3-10).

3.5.3.2 Whale Watching

Sustainable whale watching conducted in harmony with cetacean populations in a healthy environment is the goal of the IWC. The IWC works with scientists, governments, and the whale watching industry to assess threats and identify best practices to provide safe observing conditions for both humans and cetaceans. This ongoing research has resulted in the development of principles and guidelines for whale watching which have helped guide the development of whale watching regulations around the world. The IWC's Whale-watching Working Group has produced a five-year whale watching strategy that has been adopted by the IWC and is developing a Handbook for Whale Watching. This handbook will be a web-based tool that will provide guidelines and support to whale watching operators, national, and regional regulators to ensure that whale watching is sustainable into the future (IWC, 2016a).

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Table 3-10. Examples of Major Recreational Diving Locations In or Near the Study Area for SURTASS LFA Sonar (Dive Zone, 2013; Kuoni, 2017; PADI, 2013; SCUBA Diving Magazine, 2015;SCUBA Diving Phuket, 2018; SCUBA Travel, 2018 and 2018a).

Geographic Location	***Dive Site Name***
Central North Pacific Ocean	
Hawaii	Molokini Crater Wall
	Kailua-Kona/Blue Pyramid Pinnacle
	Lanai
Western North Pacific Ocean	
Guam	Apra Harbor
	20 dive sites off western coast
Commonwealth of the Northern Mariana Islands	Eagle Ray City
	Fleming
	Twin Coral
	Senhanom Cave (Rota Hole)
Palau	Blue Corner Wall
	Ulong Channel
	Peleliu Island
Micronesia	Chuuk/Truk Lagoon
	Yap
Philippines	Verde Island/Drop Off
	Apo Reef
	Puerto Galera
	Tubbataha (Palawan)
Republic of the Marshall Islands	Bikini Atoll
Thailand	Similan Islands (Ko Similan/East of Eden)
	Hin Mouang
	Richelieu Rock
	Koh Tao
Eastern Indian Ocean	
Bali, Indonesia	U.S. *Liberty* wreck
Malaysia-Borneo	Barracuda Point, Sipadan Island
	South Point/ Sipadan Drop Off
	Sabah/Tunku Abdul Rahman Park; Edgell Patches and Mayne Rock
The Keeling/Cocos Islands	Cabbage Patch, Garden of Eden
	Two Caves
	Direction Island
India	Andaman and Nicobar Islands
	Lakshadweep Archipelago
Sri Lanka	HMS *Hermes* wreck; Uga Bay, Passikudah
Republic of Maldives	Ari Atoll
	Baa Atoll
	Dhaalu Atoll
	Faafu Atoll

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4 ENVIRONMENTAL CONSEQUENCES

4.1 Introduction

This chapter presents an analysis of the potential direct and indirect impacts of each alternative on the affected environment. The following discussion elaborates on the nature of the characteristics that might relate to resources. "Significantly," as used in NEPA, requires considerations of both context and intensity. Context means that the significance of an action must be analyzed in several contexts such as society as a whole (e.g., human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of a proposed action. For instance, in the case of a site-specific action, significance would usually depend on the impacts in the locale rather than in the world as a whole. Both short- and long-term impacts are relevant (40 CFR part 1508.27). Intensity refers to the severity or extent of the potential environmental impact, which can be thought of in terms of the amount of the likely change. In general, the more sensitive the context, the less intense a potential impact needs to be in order to be considered significant. Likewise, the less sensitive the context, the more intense a potential impact would need to be in order to be considered significant.

4.2 Environmental Stressors

In determining impacts to the environment, both the indirect and direct impacts of an action are identified and assessed. The aspects of an action that may affect the environment are the "stressors" for which risk of exposure is estimated and protective measures proposed to reduce the likelihood of possible exposure. The principal stressors related to the use of LFA sonar are the:

- Presence and movements of the T-AGOS vessels;
- Animal strike or entanglement in the passive sonar array (SURTASS);
- Sound energy from the HF/M3 active component of the monitoring/mitigation system; and
- Sound energy from the LFA sonar.

Although these potential stressors related to the use of LFA sonar have been described in detail in the 2001 FOEIS/EIS (Department of the Navy (DoN), 2001), the 2007 FSEIS (DoN, 2007), the 2012 SEIS/SOEIS (DoN, 2012), and the 2017 SEIS/SOEIS (DoN, 2017b), and are incorporated herein by reference, a brief summary is provided, including how potential impacts are reduced or eliminated by the operational characteristics of the SURTASS LFA sonar system and vessels in addition to the suite of mitigation and monitoring measures implemented aboard SURTASS LFA sonar vessels.

4.2.1 Presence and Movement of T-AGOS Vessels

Potential adverse impacts associated with the presence and movements in the marine environment of SURTASS LFA vessels for SURTASS LFA sonar training and testing activities are ship strikes, ship discharges, and noise generated by the vessel engines or propellers. The potential for SURTASS LFA sonar vessels to strike a marine mammal, sea turtle, or marine fish is so low that it is discountable (NMFS, 2017). In the 16 years of SURTASS LFA sonar use, there has never been a ship strike associated with the operation of the vessels. The miniscule potential for ship strikes is due in part to the low speed at which the SURTASS LFA vessels travel, which is 3 to 4 kt (5.6 to 7.4 kph) during sonar transmissions and up to 10 or 12 kt (18.5 to 22.2 kph) during transit. Additionally, since the lookouts that keep watch during vessel transit and maneuvering are also trained visual observers for marine mammals and sea turtles, they are likely to detect any marine mammals or sea turtles in the vessel's path. Movements of

SURTASS LFA vessels are not unusual or extraordinary and are in line with routine operations of seagoing vessels. In addition to the slow speed of travel, the design of the T-AGOS vessels, with the catamaran-type split-hull shape and enclosed propeller system, make the potential for striking and harming a marine mammal or sea turtle very unlikely. The lower ship speed also results in so little engine or propeller cavitation noise being generated into the surrounding marine environment that its extent and impact would be negligible.

Although some incidental discharges from the SURTASS LFA sonar vessels are normal for ship operations, the vessels are operated in compliance with all requirements of the CWA and the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), as implemented by the APPS (33 United States Code [U.S.C.] 1901 to 1915). Therefore, no unregulated pollutants would be discharged nor will unregulated environmental impacts from the operation of the SURTASS LFA sonar vessels occur. Air emissions associated with the operation of SURTASS LFA sonar vessels are discussed in the air quality section (Section 4.3).

4.2.2 Passive Sonar (SURTASS)

The SURTASS component is a passive system that only receives and does not transmit any sound energy into the marine environment. Additionally, when the SURTASS HLA is being towed by a T-AGOS vessel, the vessel speed is so slow (~3 kt [5.6 kph]) that the potential for any animal being struck by the array is discountable (NMFS, 2017), as the slow tow speed would provide sufficient time for a marine animal to move and avoid the array if it were in close proximity. The likelihood of a marine mammal, sea turtle, or fish to become entangled in the towed SURTASS HLA is also discountable because of the slow tow speed (NMFS, 2017). For these reasons, operation of the SURTASS HLA is not reasonably likely to result in impacts to the environment.

4.2.3 Transmission of the High-Frequency Active Sonar (HF/M3) Component of the Monitoring/Mitigation System

The HF/M3 sonar is a Navy-developed, enhanced HF commercial sonar used as a mitigation and monitoring asset to detect, locate, and track marine mammals and, to an extent, sea turtles, that may pass close enough to the SURTASS LFA sonar's transmit array to enter the LFA mitigation zone plus the 0.54-nmi (1-km) buffer zone. The HF/M3 sonar operates with a similar power level, signal type, and frequency as HF "fish finder" type sonars. The HF/M3 sonar and its operating protocols were designed to minimize possible impacts on marine animals.

The SL of 220 dB re 1 µPa @ 1 m [rms] is required for the HF/M3 sonar to effectively detect marine mammals (and possibly sea turtles) to the extent of the 180-dB LFA sonar mitigation and buffer zones under the most adverse oceanographic conditions (low echo return and high ambient noise). The maximum HF/M3 sonar pulse is 40 msec, with source frequencies from 30 to 40 kHz, and a variable duty cycle that is nominally about 3 to 4 percent. The HF/M3 sonar system is located at the top of the LFA sonar VLA, about 328 ft (100 m) below the sea surface. Due to the water depth at which the deployed LFA VLA is positioned, the HF/M3 sonar system was not designed to detect marine mammals or sea turtles at or near the surface in proximity to the SURTASS LFA vessel.

The operating profile of the HF/M3 sonar and the high transmission loss of its HF signals (i.e., over 40 dB of transmission loss in the first 100 m [328 ft] of the HF/M3 source) together reduce the possibility for the sonar to affect marine mammals, sea turtles, or fishes. Additionally, the HF/M3 sonar's frequency is not in the range of best hearing frequencies for mysticetes, pinnipeds, sea turtles, or fishes but is within the best hearing range for odontocetes. However, the required ramp-up period from a SL of 180 dB re 1 µPa rms @ 1 m in 10-dB increments to full power is designed to provide sufficient time for a marine mammal, such as an odontocete that can hear the HF/M3 signal, to move away from the vessel and the transmitting HF/M3 sonar. In total, these factors result in a predicted negligible impact on marine mammals, sea turtles, or fishes from exposure to HF/M3 sonar.

4.2.4 Transmission of LFA Sonar

The transmission of low-frequency signals by the SURTASS LFA sonar system may affect the marine environment. The characteristics of the signals transmitted by LFA sonar and its operating profile are described in Chapter 2 and must be considered in determining the potential for impacts on the environment (Section 4.4).

4.3 Air Quality

Under both action alternatives, SURTASS LFA sonar vessels would conduct training and testing activities at sea, both potentially in the territorials seas (waters between 3 and 12 nmi [5.6 to 22 km] from shore) of the U.S. in Hawaii, Guam, and CNMI as well as in the global commons (i.e., beyond the territorial seas of any nation). During the execution of their training and testing missions, SURTASS LFA sonar vessels would emit HAPs as the result of the combustion of marine diesel fuel necessary to operate the vessels.

Air Quality Potential Impacts:

- No Action: No change to baseline air quality
- Alternative 1/2: Minor, localized, and intermittent air emissions, principally in the atmosphere of the global commons with an negligible concentration in the atmosphere over U.S. territorial seas

4.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline air quality. Therefore, no significant impacts to air quality or air resources would occur with implementation of the No Action Alternative. Details of the air quality analysis methodology may be found in Appendix E.

4.3.2 Alternative 1/Alternative 2

Under Alternative 1, the Navy would transmit 360 hours of LFA sonar transmissions per year pooled across all vessels, while under Alternative 2, the Navy's Preferred Alternative, the Navy would transmit 496 hours of LFA sonar transmissions per year across all vessels in the first four years, and would increase LFA sonar transmissions to 592 hours in year five and continuing into the foreseeable future, regardless of the number of vessels. Under both action alternatives, transmissions would be consistent with the operating profile described in Chapter 2.

4.3.2.1 Potential Impacts to Air Quality

Impacts on air quality are based on estimated direct and indirect emissions associated with the action alternatives. Estimated emissions from a proposed federal action are typically compared with the relevant national and state standards to assess the potential for increases in pollutant concentrations. The region of influence (ROI) for assessing air quality impacts is the air basin in which the project is located. The study area for SURTASS LFA sonar includes the western and central North Pacific and eastern Indian oceans.

The provisions of the CAA, however, only pertain to state and territorial waters of the U.S. Thus, the ROI for this assessment of air quality impacts is the western and central North Pacific Ocean portion of the study area for SURTASS LFA sonar in which the State of Hawaii and the territories of Guam and CNMI are located. However, due to Title 10 exemptions for the Navy's SURTASS LFA sonar vessels, the Navy's ocean surveillance vessels would not go into port in Hawaii, Guam, nor CNMI. Additionally, SURTASS LFA sonar vessels cannot conduct training and testing activities in the territorial seas of any foreign nation and transit in and out of ports or foreign port activities are not part of training and testing activities. Accordingly, the analysis of air quality for the Proposed Action does not include transit to and from ports nor port visits (or pier side activities) in any U.S. territories or foreign territories. Training and testing activities using SURTASS LFA sonar, however, may be conducted in the waters of the territorial sea (3 to 12 nmi [5.6 to 22 km]) of Hawaii, Guam, and CNMI, albeit at a reduced power level (coastal standoff range mitigation). Thus, a very small amount, approximately 5 percent, of training and testing activities in U.S. territorial seas are included in the analysis of air quality, while the vast majority (95 percent) of training and testing air emissions are assumed to be occurring beyond the limits of both U.S. and foreign territorial seas.

For inert pollutants, the ROI is generally limited to a few miles downwind from the pollutant source. For a photochemical pollutant, such as ozone, the ROI may extend much farther downwind. The concentration of many small emission sources, under the right circumstances, could incrementally contribute to regional air quality degradation. The good quality of the atmosphere over the western and central Pacific Ocean portion of the study area for SURTASS LFA sonar results from the relatively low number of air pollutant sources, as well as the size, topography, and prevailing meteorological conditions.

4.3.2.1.1 Air Emission Analysis and Estimates

The air quality analysis conducted on the Proposed Action as part of this SEIS/SOEIS evaluates the impacts of air pollutants emitted by SURTASS LFA sonar training and testing activities in two areas 1) the waters of the U.S. territorial seas in Hawaii, Guam, and CNMI that are outside the limits of state or territory waters pursuant to NEPA; and 2) beyond U.S. and foreign territorial seas (i.e., global commons) of the western and central North Pacific Ocean pursuant to EO 12114. The air emission analysis determined the concentrations of the six primary air pollutants generated by the SURTASS LFA sonar vessels: CO, nitrogen oxides (NO_x), particulate matter under 10 microns and under 2.5 microns (PM_{10} and $PM_{2.5}$, respectively), sulfur oxides (SOx), and volatile organic compounds (VOC) in the two areas where testing and training activities may occur.

The Alternative 1 analysis of SURTASS LFA sonar vessel emissions released during training and testing activities was based on 5 percent of the 360 sonar transmit hours (18 transmit hours) being transmitted in waters of the territorial seas of Hawaii, Guam, and CNMI and 95 percent of the 360 sonar transmit hours (342 hours) being generated in waters outside U.S. or foreign territorial seas (Table 4-1). For Alternative 1, the highest concentration of any of the six primary air pollutants in both the territorial seas and global commons is NOx, with the total estimated concentration of 14.87 metric tons (mt).

Per Navy guidance, the air emission analysis for Alternative 2 was based on the year in which the maximum direct and indirect emissions would be greatest, which would be year 5 and beyond when the total transmit time was increased to 592 transmit hours, pooled over all vessels. Thus, the Alternative 2 air emission analysis was based on evaluation of the emissions generated during SURTASS LFA sonar

Table 4-1. Concentrations of Criteria Air Pollutant Emissions Resulting from Execution of Alternatives 1 and 2 by SURTASS LFA Sonar Vessels.

Percent of Transmit Hours in and outside Territorial Seas	*Concentrations of Criteria Air Pollutants (tons per year)*					
	CO	*NOx*	*PM_{10}*	*$PM_{2.5}$*	*SO_x*	*VOC*
Alternative 1 (360 total transmit hours)						
Vessels in territorial seas of HI, GU, and CNMI (5 percent)	0.04	0.74	0.01	0.01	0.11	0.02
Vessels in global commons (outside any territorial seas) (95 percent)	0.70	14.13	0.23	0.23	2.15	0.45
Total Alternative 1	0.74	14.87	0.24	0.24	2.26	0.47
Alternative 2 (592 maximum, total transmit hours)						
Vessels in territorial seas of HI, GU, and CNMI (5 percent)	0.06	1.22	0.02	0.02	0.19	0.04
Vessels in global commons (outside any territorial seas) (95 percent)	1.17	23.22	0.37	0.37	3.54	0.76
Total Alternative 2	2.23	24.44	0.39	0.39	3.73	0.80

Note: CO= carbon monoxide; NOx=nitrogen oxides; PM_{10}=particulate matter under 10 microns; $PM_{2.5}$=particulate matter under 2.5 microns; SO_x=sulfur oxides; VOC=volatile organic compounds

training and testing activities in the territorial seas of Hawaii, Guam, and CNMI in which 5 percent of 592 total transmit hours (29.6 hours) were conducted, in addition to emissions generated during 95 percent of 592 transmit hours (562.4 hours) conducted in waters outside U.S. and foreign territorial seas (Table 4-1). Under Alternative 2, the Preferred Alternative, in year 5 and beyond when the total LFA sonar transmit hours would total 592, the highest estimated concentration of primary air pollutants generated during the operation of the SURTASS LFA sonar vessels is similar to Alternative 1, with the concentration of NO_x being the highest in both the territorial seas of Hawaii, Guam, and CNMI as well as in the global commons. The total concentration of NO_x during year 5 and beyond is estimated as 24.44 mt.

4.3.3 Greenhouse Gas Emissions and Climate Change

To estimate the global warming potential of an activity, the U.S. quantifies greenhouse gas emissions using the 100-year timeframe values established by the Intergovernmental Panel on Climate Change (IPCC) in 2007 (IPCC, 2007), in accordance with the reporting procedures of the United Nations Framework Convention on Climate Change. All global warming potentials are expressed relative to the reference gas, carbon dioxide (CO_2), which is assigned a global warming potential equal to 1. Greenhouse gas emissions are multiplied by their global warming potential, and the results are summed to calculate the total equivalent emissions of CO_2 or CO_2 equivalency.

The Navy has derived the CO_2 equivalency associated with the operation of up to four SURTASS LFA sonar vessels per the Proposed Action and alternatives. Estimated greenhouse gas emissions are 532 .93 and 876.34 mt per year CO_2 equivalency, respectively for Alternative 1 and 2 (Table 4-2). The levels of greenhouse gas emissions are comparable for Alternatives 1 and 2. To put these emission values into a more understandable perspective, the total U.S. greenhouse gas emissions in 2015 was 6,587,000 mt of

CO_2 equivalency, the most current year for which data are available (EPA, 2017). Additionally, the International Maritime Organization (IMO) in their 2014 study of greenhouse gas emissions reported the annual average CO_2 equivalency emissions from international shipping for the period 2007 to 2012 was 846,000,000 mt (IMO, 2014).

Table 4-2. Estimated Annual Greenhouse Gas Emissions (CO_2) Associated with Employment of Up to Four SURTASS LFA Sonar Vessels Conducting Training and Testing Activities.

T-AGOS Vessel Activity/Number Days Conducting Activity	*Annual CO_2 Equivalent Emissions (metric tons per year)*
No Action Alternative	0.0
Alternative 1	532.93
Alternative 2	876.34

CO_2=carbon dioxide

4.3.3.1 Federal Policies Related to Climate Change

Federal legislation related to climate change includes the Energy Policy Act of 2005, which addressed energy efficiency, renewable energy, energy tax incentives, and ethanol in motor fuels (EPA, 2016f), and the Energy Independence and Security Act of 2007, which reinforces energy reduction goals for federal agencies. Under the CAA, the EPA has developed and implemented greenhouse gas emission standards for stationary sources through the Greenhouse Gas Tailoring Rule and the Greenhouse Gas Reporting Program (EPA, 2016g).

Several EOs have been issued in recent years that direct federal agencies to address climate change and greenhouse gas emissions with emission reductions and preparedness planning and implementation. EO 13653, *Preparing the U.S. for the Impacts of Climate Change* (EO 13653, 2013), establishes task forces, research funding, and state, local, private-sector, and nonprofit-sector support to address climate preparedness, resilience, and adaptation. However, this EO was revoked by EO 13783 on March 28, 2017. EO 13693, *Planning for Federal Sustainability in the Next Decade* (2015), requires federal agencies to meet emission-reduction goals associated with energy use, water use, building design and utilization, Fleet vehicles, and procurement and acquisition decisions. EO 13693, however, was revoked and replaced by EO 13834, *Efficient Federal Operations*, on May 17, 2018. The DoD and Navy are currently evaluating the extent of changes resulting from this EO, with additional information to be included herein as the evaluation is completed.

In accordance with NEPA, federal agencies are required to consider greenhouse gas emissions and climate change when conducting environmental assessments . Navy guidance states that the Navy must address the effects of climate change, identifying and quantifying greenhouse gas emissions (where possible) that may be generated during the executing of a Proposed Action and must also describe the beneficial activities being implemented Navy-wide to reduce greenhouse gas emissions.

4.3.3.2 Department of Defense Policies Related to Climate Change

The DoD and the DoN have established various directives, including Navy environmental guidance and DoD Directive 4715.21 (January 2016), which integrates climate change considerations into all aspects of the department (DoD, 2016a). DoD agencies are charged with assessing, managing risks, and mitigating the effects of climate change on natural and cultural resource management, force structure, basing, and training and testing activities in the field environment.

Additionally, the DoD 2016 *Operational Energy Strategy* (DoD, 2016b) sets forth plans to reduce the demand for energy and secure energy supplies. This policy also directs DoD components to reduce GHG emissions from operational forces. Other recent policies, updates, and/or directives include the FY 15

DoD Sustainability Performance Plan (DoD, 2015) and the 2014 Climate Change Adaptation Roadmap (DoD, 2014), which focuses on various actions DoD is taking to increase its resilience to the impacts of climate change. The Secretary of the Navy set goals to improve energy security, increase energy independence, and reduce the reliance on petroleum by increasing the use of alternative energy (Navy, 2010b).

4.3.4 Summary of Potential Impacts between Alternatives

The potential sources of air emissions during the execution of the Proposed Action are the SURTASS LFA sonar vessels. Due to the increased sonar transmit hours associated with Alternative 2 compared to Alternative 1, SURTASS LFA sonar vessels would likely be at sea a greater amount of time to conduct a greater number of training and testing activities under Alternative 2 than as part of Alternative 1. This increased operational vessel time resulted in greater air emissions, including greenhouse gases, for Alternative 2 compared to Alternative 1. However, the concentrations of air pollutants and greenhouse gases resulting under either action alternative represent small gas emissions annually.

Regardlesss of the action alternative, the resulting air emissions, including greenhouse gases, would largely disperse rather than concentrate in an area due to meteorological and air chemistry processes over the open ocean. Thus, based on the small quantities of expected air emissions resulting from Alternatives 1 or 2, the meteorology of the study area, and the frequency and isolation of the proposed training and testing activities, the incremental contribution of air emissions resulting from the execution of the Proposed Action would not result in significant additional impacts on air quality in the study area or beyond. Thus, the execution of the Proposed Action would not result in significant impacts to Air Quality.

4.4 Marine Water Resources

As described in Chapter 3, the marine water resource that may experience direct or indirect impacts from implementation of the alternatives is the intermittent increase in the ambient noise level in the frequency band (100-500 Hz) in which LFA sonar operates. The stressor that is analyzed is the same for all alternatives, which is the transmission of low-frequency sound energy.

Water Resource Potential Impacts:

- Intermittent increase in ambient noise level during SURTASS LFA sonar transmissions

4.4.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline marine water resources. Therefore, no significant impacts to marine water resources would occur with implementation of the No Action Alternative.

4.4.2 Alternative 1/Alternative 2

Under Alternative 1, the Navy would transmit 360 hours of LFA sonar transmissions per year pooled across all vessels, while under Alternative 2, the Navy's Preferred Alternative, the Navy would transmit 496 hours of LFA sonar transmissions per year across all vessels in the first four years, and would increase usage to 592 hours of LFA sonar transmissions in year five and continuing into the foreseeable future, regardless of the number of vessels. Under both action alternatives, transmissions will be consistent with the operating profile described in Chapter 2.

4.4.2.1 Potential Impacts to Marine Water Resources

When deployed and transmitting, transmissions from SURTASS LFA sonar will temporarily add to the ambient noise level in the frequency band (100 to 500 Hz) in which LFA operates, but the impact on the overall noise levels in the ocean will be minimal. In most of the ocean, the 10 to 500 Hz portion of the ambient noise spectrum is dominated by anthropogenic noise sources, particularly shipping and seismic airguns. Commercial vessels are the most common source of low-frequency noise and their impact on ambient noise is basin-wide (Hildebrand, 2009).

SURTASS LFA sonar produces a coherent low-frequency signal with a duty cycle of less than 20 percent and an average pulse length of 60 sec (i.e., a 60-sec signal could be transmitted a maximum of every 5 minutes). The transmission time for this system under Alternative 1 is 360 hours per year across all vessels. The total acoustic energy output of individual sources was considered in calculating an annual noise energy budget in energy units of Joules (Hildebrand, 2005). Commercial supertankers were estimated to contribute 3.7 x 10^{12} Joules of acoustic energy into the marine environment each year (Joules/yr); seismic airguns were estimated to contribute 3.9 x 10^{13} Joules/yr; and mid-frequency military sonar was estimated to contribute 2.6 x 10^{13} Joules/yr (Hildebrand, 2005). Scaling the calculations in Hildebrand (2005) to account for the proposed transmission hours, under Alternative 1, the total contribution from 360 hours of LFA transmissions would be 1.4 x 10^{11} Joules/yr. Under Alternative 2 in years 1 to 4, the contribution from 496 hours of LFA transmissions would be 2.0 x 10^{11} Joules/yr and in years 5 and beyond, the contribution from 592 hours of LFA transmissions would be 2.3 x 10^{11} Joules/yr. The percentage of the total anthropogenic acoustic energy budget added by LFA source transmissions is estimated to be 0.21 percent under Alternative 1 and 0.29 and 0.34 percent, respectively for years 1 to 4 and year 5 and beyond, under Alternative 2 (Hildebrand, 2005). Therefore, within the existing ocean environment, the potential for accumulation of noise due to the intermittent operation of SURTASS LFA sonar is considered negligible.

4.4.3 Summary of Potential Impacts between Alternatives

Implementation of Alternative 2/Preferred Alternative would not result in significant impacts to water resources since LFA transmission hours would add less than 0.34 percent to the total anthropogenic acoustic energy budget. Alternative 1 would have an even smaller and less significant impact on ocean ambient noise levels than Alternative 2 due to the fact that the total transmission time is less.

4.5 Biological Resources

This analysis focuses on marine species, including marine and anadromous fishes, sea turtles, and marine mammals, and marine habitats. The information below builds on the analyses previously conducted in the Navy's 2001 EIS/OEIS and 2007, 2012, 2015, and 2017 SEIS/SOEISs for SURTASS LFA Sonar (DoN, 2001, 2007, 2012, 2017b), which are incorporated by reference. Potential impacts to marine species are presented, including the quantitative impact analysis to marine mammals, followed by the potential impacts to marine habitats.

Potential impacts on marine species from transmission of LFA sonar include:

- **Non-auditory impacts:** Non-auditory impacts include direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas. These types of impacts have the potential to cause (1) resonance of the lungs/organs, (2) tissue damage, and (3) mortality.

- **Auditory impacts:** Auditory impacts include permanent threshold shift (PTS), which is a condition that occurs when sound intensity is very high and/or of such long duration that the result is a permanent loss of hearing sensitivity over the frequency band of the exposure; i.e., a physical injury. PTS constitutes Level A incidental "harassment" for marine mammals under the MMPA as it is considered auditory tissue injury that causes irreparable damage (Southall et al., 2007). Temporary threshold shift (TTS) is a lesser impact to hearing caused by underwater sounds of sufficient loudness to cause a transient condition in which an animal's hearing sensitivity over the frequency band of exposure is impaired for a period of time (minutes to days). With TTS, hearing is not permanently or irrevocably damaged and no physical tissue damage occurs, so TTS is not considered an injury (Richardson et al., 1995; Southall et al., 2007) and constitutes Level B incidental harassment under the MMPA.
- **Behavioral change:** Behavioral responses to sounds in a marine animal's environment vary from subtle changes in surfacing and breathing patterns to cessation of vocalization or even active avoidance or escape from regions of high sound levels (Wartzok et al., 2003/04). For military readiness activities such as the use of SURTASS LFA sonar, Level B incidental "harassment" under the MMPA is defined as any act that disturbs or is likely to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or significantly altered.
- **Masking:** The presence of intense sounds in the environment can potentially interfere with an animal's ability to hear relevant sounds. This impact, known as "auditory masking", could interfere with the animal's ability to detect biologically-relevant sounds, such as those produced by predators, prey, or reproductively active mates. During auditory masking, an animal may, thus, not be able to escape predacious attack, locate food, or find a reproductive partner.
- **Physiological stress:** Exposure to underwater sound may evoke a response in a physiological mediator (e.g., glucocorticoids, cytokines, or thyroid hormones) (Atkinson et al., 2015). The type, duration, and magnitude of the stress response may have a metabolic cost, which is termed the allostatic load. How stress responses might be linked to individual- and population-level consequences is an area much in need of research (National Research Council, 2005).

Biological Resource Potential Impacts:

- Marine Fishes: low to moderate probability of non-auditory, auditory, behavioral, masking, or physiological stress effects when fish are in close proximity (<0.54 nmi (<1 km)) of the LFA sonar
- Sea turtles: low to moderate probability of non-auditory, auditory, behavioral, masking, or physiological stress effects when sea turtles are in close proximity (<0.54 nmi [<1 km]) of the LFA sonar
- Marine mammals: potential for auditory or behavioral effects evaluated quantitatively with the best available science; low to moderate probability of non-auditory, masking, or physiological stress assessed with best available information
- Marine habitats: LFA sonar transmissions are a small contribution to the overall noise budget and would not affect the quality of marine habitats

The potential for impacts is assessed from the perspective of an individual animal as well as the populations that comprise those individuals. Under the ESA, the potential for an effect to the fitness level of an individual, defined as changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success, is considered (National Marine Fisheries Service (NMFS), 2012). Similarly under the MMPA, "any act that injures or has the significant potential to injure" or "disturbs or is likely to disturb…causing disruption of natural behavioral patterns…to a point where they are abandoned or significantly altered" is considered.

The potential for impacts to marine habitats, including critical habitat, essential fish habitat, marine protected areas, and national marine sanctuaries, was considered within the context of the addition of sound energy to the marine environment while SURTASS LFA sonar is transmitting. SURTASS LFA sonar represents a vanishingly small percentage of the overall annual underwater acoustic energy budget and would not adversely affect the ambient noise environment of marine habitats. The reader is referred to Section 4.3.2.1 for an analysis of the contribution of SURTASS LFA sonar to the ocean's sound energy budget.

4.5.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur, which means that Navy would not use SURTASS LFA sonar for training and testing activities and NMFS would not grant authorize the incidental take of marine mammals associated with the use of SURTASS LFA sonar. Since SURTASS LFA sonar would not transmit acoustic energy, there would be no change to biological resources. Therefore, no significant impacts to biological resources would occur with implementation of the No Action Alternative.

4.5.2 Alternative 1/Alternative 2

The action alternatives include the transmission of acoustic energy by SURTASS LFA sonar in training and testing activities and the issuance of permits by NMFS for incidental takes of marine mammals associated with these activities. The study area for the analysis of impacts to biological resources associated with Alternative 1 and Alternative 2/Preferred Alternative includes the western and central North Pacific and eastern Indian oceans. SURTASS LFA sonar training and testing activities will not occur in polar waters, the western Indian Ocean, or the Sea of Okhotsk, or within the territorial seas (12 nautical miles [nmi] [22 kilometers (km)]) of foreign nations. Additional geographical restrictions include maintaining received levels for SURTASS LFA sonar below established levels within 12 nmi (22 km) of any land, within 0.54 nmi (1 km) of designated OBIA boundaries during their effective periods of biological activity, and within known recreational and commercial dive sites, as described in Chapter 5. Under Alternative 1, the Navy would transmit 360 hours of LFA sonar transmissions per year pooled across all vessels, while under Alternative 2, the Navy would transmit 496 hours of LFA sonar transmissions per year pooled across all vessels in the first four years, and would increase usage to 592 hours of LFA sonar transmissions in year five and continuing into the foreseeable future, regardless of the number of vessels. Under both action alternatives, transmissions will be consistent with the operating profile described in Chapter 2.

4.5.2.1 Potential Impacts to Biological Resources: Marine Wildlife

4.5.2.1.1 <u>Marine and Anadromous Fishes</u>

The 2007, 2012, and 2017 SEIS/SOEISs included extensive discussions of research studies on fishes and their potential responses to LFA sonar; those documents are incorporated herein by reference (DoN, 2007, 2012, 2017b). For the convenience of the reader, a summary of the research that examined the response of fishes to LFA sonar signals is included below; the remainder of this section will focus on research that has been published since the 2017 SEIS/SOEIS.

A Working Group organized under the American National Standards Institute-Accredited Standards Committee S3, Subcommittee 1, Animal Bioacoustics, developed sound exposure guidelines for fish and sea turtles (Popper et al., 2014), hereafter referred to as the ANSI Sound Exposure Guideline technical report. This technical report developed sound exposure guidelines for fishes in which they identified three types of fishes depending on how they might be affected by underwater sound. The categories include fishes with no swim bladder or other gas chamber (e.g., dab and other flatfish); fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume (e.g., salmonids); and fishes with a swim bladder that is involved in hearing (e.g., channel catfish). DoN (2017c) extended these categories to include one more type of fishes: those with a swim bladder involved in hearing and having high-frequency hearing sensitivity (up to 110 kHz). Data suggest that most species of marine fish either lack a swim bladder (e.g., sharks and flatfishes) or have a swim bladder not involved in hearing and can only detect sounds below 1 kHz. Some marine fishes (clupeiforms) with a swim bladder involved in hearing are able to detect sounds to about 4 kHz (Colleye et al., 2016; Mann et al., 1997; Mann et al., 2001). One subfamily of clupeids (i.e., Alosinae) can detect high- and very high-frequency sounds (i.e., frequencies from 10 to 100 kHz, and frequencies above 100 kHz, respectively), although auditory thresholds at these higher frequencies are elevated and the range of best hearing is still in the low-frequency range (below 1 kHz) similar to other fishes.

All fishes with a swim bladder involved in hearing are most sensitive to sound since they are able to detect particle motion and pressure. These guidelines are based on sound pressure levels, which are the best available data. However, it is recognized that particle motion stimulates the otolith organs and is the fundamental element in hearing for fishes (Popper and Hawkins, 2018).

- ***Non-auditory Impacts***

A few species of fishes were tested in captive or laboratory settings for non-auditory injuries (e.g., barotrauma, hemorrhaging or rupturing of organs or tissues) when exposed to SURTASS LFA sonar signals and seismic airguns (Kane et al., 2010; Popper et al., 2007; Popper et al., 2005; Song et al., 2008). In all fishes, the swim bladder was intact after exposure and there was no damage to tissues either at the gross or cellular levels as determined by an expert fish pathologist (Kane et al., 2010; Popper et al., 2007). No new studies of non-auditory impacts to fishes have been published since the 2017 SEIS/SOEIS that are relevant to LFA sonar. Since previous studies had exposed fish up to 193 dB rms without injury, Popper et al. (2014) based their threshold of greater than 193 dB re 1 µPa rms for mortality and potential mortal injury and recoverable injury for fishes with a swim bladder both involved and not involved in hearing on these studies. For fishes with no swim bladder, Popper et al. (2014) estimated the potential for mortality and potential mortal injury and recoverable injury as being low at all distances from LF sources. Non-impulsive sound sources (e.g., sonar, acoustic modems, and sonobuoys) have not been known to cause direct injury or mortality to fish under conditions that would be found in the wild (Halvorsen et al., 2012; Kane et al., 2010; Popper et al., 2007). Potential direct injuries (e.g., barotrauma, hemorrhage, or rupture of organs or tissue) from non-impulsive sound sources, such as sonar, are unlikely because of slow rise times, lack of a strong shock wave such as that associated with an explosive, and relatively low peak pressures.

Since the potential for non-auditory injury to an individual fish is discountable in that it is extremely unlikely to occur, the potential for more than a minimal portion of any fish stock to experience such exposures is negligible; thus, the potential for non-auditory injury to fish stocks is a discountable impact.

➢ ***Auditory Impacts***

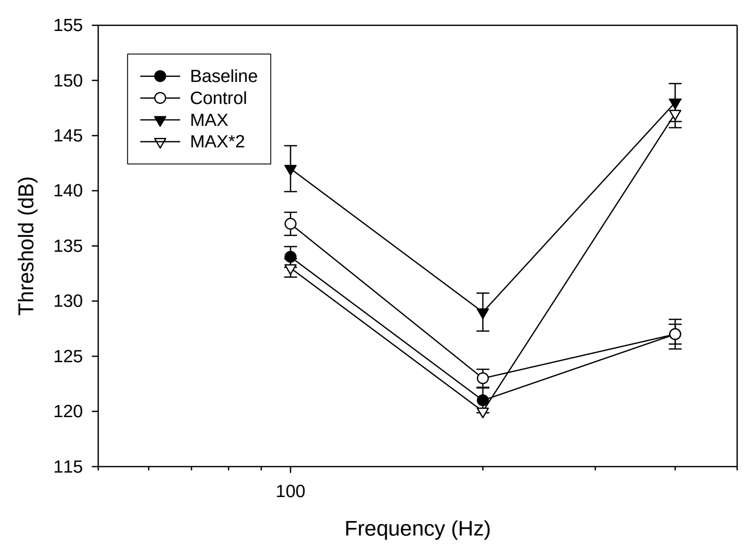
A number of studies have examined the impacts of high-intensity sound on the sensory hair cells of the ear. Cox et al. (2018) conducted a meta-analysis of the effect of aquatic noise on fish behavior and physiology. They found that all categories of aquatic noise except music had the potential to result in negative impacts to auditory thresholds of fishes. One of these categories was anthropogenic sound;Tthe most relevant studies for evaluating the potential effects of LFA sonar signals are those conducted with LFA sonar signals. A study on the impacts of SURTASS LFA sonar sounds on three species of fishes (rainbow trout, a fish with a swim bladder not involved in hearing and a reference species for ESA-listed salmonids; channel catfish, a fish with a swim bladder involved in hearing; and hybrid sunfish, a fish without a swim bladder) examined long-term impacts on sensory hair cells of the ear. In all species, even up to 96 hours post-exposure, there were no indications of any damage to sensory cells (Halvorsen et al., 2013; Popper et al., 2007).

The overall findings of the Popper et al. (2007) study show the following with respect to impacts on fish hearing:

1. Catfish and some (but not all) specimens of rainbow trout showed 10 to 20 dB SPL of hearing loss immediately after exposure to the LFA sound when compared to baseline and control animals (Figure 4-1), but hearing appeared to return to, or close to, normal within about 24 hours for catfish. Recovery data on rainbow trout that had a hearing loss was insufficient to reach firm conclusions on the time for recovery, but preliminary data suggest that recovery is likely to occur in less than 96 hours. Moreover, there is evidence that hearing loss in the trout, when it occurs at all, is primarily at 400 Hz, whereas it is over the complete range of frequencies (200 to 1,000 Hz) tested for catfish.

2. There is an interesting and potentially very important variation in the impacts of exposure on trout. Some groups of trout showed hearing loss, whereas others did not. All animals received identical treatment, and the only variable between experimental times was likely to be how the fish were raised prior to being obtained for the study. The significance here is not only were there differences in the impacts of sound on different species, but there may also be differences within a species, depending on environmental and other variables. However, and most importantly, under no circumstances did exposure to LFA sound result in unrecoverable hearing loss in rainbow trout, and there was no impact on any other organ systems. While there is no direct evidence to support the differences in impact on different groups of rainbow trout, another study has shown that fish from the identical genetic stock (i.e., probably same parents) will have different hearing thresholds, possibly depending on how the eggs were stored prior to being allowed to develop (Wysocki et al., 2007). This provides an additional variable in trying to understand the impacts of sound on fishes, but also indicates that the hearing of salmonids is not consistently affected by exposure to intense sounds.

No new studies of auditory impacts to fishes have been published since the 2017 SEIS/SOEIS that are relevant to LFA sonar. Given the results of the above studies, Popper et al. (2014) defined a threshold of greater than 193 dB rms for TTS for fishes with no swim bladder and fishes with a swim bladder not involved in hearing, and a threshold of 193 dB rms for TTS for fishes with a swim bladder involved in



These data are for rainbow trout and compare hearing for baseline and control animals, and animals that received MAX and MAX*2 signals. Data represent means and standard errors of the means. Note that maximum hearing loss occurred at 400 Hz where there was over a 20 dB SPL TTS. It is not clear why there was more hearing loss after MAX stimulation than MAX*2 but this could be related to signals being closer together in the former. (Note: the "thresholds" shown are not calibrated and so do not reflect the lowest sounds that fishes necessarily hear at these frequencies.)

Figure 4-1. Examples of Hearing Data Obtained in the SURTASS LFA Sonar Studies.

hearing. Considering the signal durations of these exposures, 324 and 648 seconds, results in cumulativesound exposure levels of 218 and 220 dB re 1 µPa^2-sec, respectively (Kane et al., 2010; Popper et al., 2007). In addition, exposure of fishes with a swim bladder involved in hearing to low-frequency sonar at a sound pressure level of 195 dB re 1 µPa for 324 seconds (cumulative sound exposure level of 215 dB re 1 µPa^2-sec) resulted in TTS (Halvorsen et al., 2013). As a conservative measure, the threshold for TTS from exposure to low-frequency sonar for all fish hearing groups with a swim bladder was rounded down to a cumulative sound exposure level of 210 dB re 1 µPa^2-sec (DoN, 2017c).

To receive an exposure that would exceed the thresholds of 210 dB SEL_{cum}, an individual fish would need to be within 3.3 ft (1 m) of an LFA projector (SL of 215 dB re 1 µPa at 1 m) for more than 2 sec or within the general proximity of the array (<0.54 nmi [<1 km] where the RL is 180 dB rms) for a longer period of time while it was transmitting. The probability of this occurring is extremely unlikely. Therefore, the potential for auditory injury to an individual fish is a discountable impact.

In fish, permanent hearing loss or PTS has not been documented (NMFS, 2015). Permanent hearing loss may be caused by the death of sensory hair cells in the ear, damage to auditory nerves, or damage to other tissues, such as the swim bladder, that may be part of the auditory pathway (Popper et al., 2014). Unless sensory hair cells die, the sensory hair cells of fishes can regenerate, unlike in marine mammals where hair cell loss is permanent (Smith et al., 2006).

Since the potential for TTS or auditory injury to an individual fish is discountable in that it is extremely unlikely to occur, the potential for more than a minimal portion of any fish stock to experience such exposures is negligible. Therefore, the potential for auditory injury to fish stocks is a discountable impact.

➢ ***Behavioral Change***

A number of studies have examined the impacts of high intensity sound on behavioral change, but the most relevant to this discussion are those conducted with LFA sonar signals, which were outlined above.

The overall findings of the Popper et al. (2007) study show the following with respect to behavioral responses of fishes:

- Fish behavior[29] after sound exposure was no different from behavior prior to or after tests. At the onset of the sound presentation, the trout would tend to move to the bottom of the experimental tank, but this did not last for the duration of the sound. Immediately after the sound was turned off, the fish would mill around the tank in the same pattern as they did prior to sound presentation.
- Catfish showed an immediate quick "startle"[30] response and slight motion of the body, but then the fish tended to line up facing the signal source and generally stayed in that position for the duration of the sound. Once the sound was turned off, the catfish would return to normal "milling" around the tank in a pattern that was statistically no different from pre-sound patterns.

In addition to the studies incorporated by reference, fishes exposed to low-frequency vessel noise had varying responses. Juvenile Ambon damselfish and European eels showed slower reaction times and lacked startle responses to predatory attacks during both simulated and actual predation experiments during exposures to vessel noise (Simpson et al., 2015; Simpson et al., 2016). In contrast, larval Atlantic cod showed a stronger anti-predator response and were more difficult to capture during simulated predator attacks (Nedelec et al., 2015).

One caveat to developing an understanding of impacts of sounds on behavior is that such studies are only useful when fish are unconstrained. That is, if fish are in any kind of cage or tank, no matter what the size, it is possible that the physical barriers will result in behaviors that would not normally be encountered in the wild in response to exposure to the same type of signal. Studies that examined impacts on behavior involving confined animals must be considered with the caveat that the observed response may not be indicative of how fish would respond in the wild. Cox et al. (2018) conducted a meta-analysis of the effect of aquatic noise on fish behavior and physiology in which they summarized the results of 42 studies, 36 of which were conducted in a laboratory setting. They found that some categories of aquatic noise had the potential to result in negative impacts to the behavior of fishes, which is consistent with the results of the other research studies summarized here.

All of the impacts described here are measurable responses. However, none of these responses rise to the level considered by Popper et al. (2014) for defining response thresholds, which was defined as "substantial change in behavior…may include long-term changes in behavior and distribution, such as moving from preferred sites for feeding and reproduction, or alteration of migration patterns. This behavioral criterion does not include impacts on single animals, or where animals become habituated to the stimulus, or small changes in behavior such as a startle response or small movements."

Therefore, the thresholds defined by Popper et al. (2014) are the best available for considering the potential for behavioral response. For fishes with no swim bladder and fishes with a swim bladder not involved in hearing, there is a low probability of behavioral response occurring at any distance from low

29 Note that behavior in the tank has no relevance to how fish would behave if they were not confined to the tank. Behavior monitoring was done only to provide insight into the health of the fish during the experiments and to compare in-cage responses before, during, and after sound exposure.

30 The word "startle" is used with caution. The behavior of the fish was, indeed, one that indicated detection of something unknown—a rapid movement over a short distance. However, the word "startle" has taken on a very specific meaning for some fish biologists and includes a twist of the body (c-start) at the onset of a stimulus and then rapid movement away from the stimulus. In these experiments, the video recording was not fast enough to determine if an actual c-start occurred.

frequency sources. For fishes with a swim bladder involved in hearing, a threshold of >197 dB SPL rms was defined.

To be exposed to a RL of >197 dB SPLrms, an individual fish would need to be within close proximity (<0.54 nmi (<1 km)) of the LFA sonar while it was transmitting. There is the potential for minor, temporary changes in behavior, including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which are significant. Therefore, the potential for biologically significant behavioral responses of an individual fish to LFA sonar is insignificant.

Since the potential for behavioral responses by an individual fish is discountable, and fishes must be in close proximity to the LFA sonar while it was transmitting for such a response to occur, it is unlikely that more than a minimal to negligible portion of any fish stock would experience behavioral responses. Therefore, the potential for behavioral responses by fish stocks is an insignificant impact.

➢ ***Masking***

There are no data on masking of fishes by sonar. Radford et al. (2014) suggested ways in which fishes might be able to alter their acoustic signaling if masking were to occur and research studies that could be conducted to further the science in this field. If masking were to occur coincident to the use of SURTASS LFA sonar, it would only be during LFA sonar transmissions (nominal 60-sec duration wavetrain every 10 min) and within the narrow bandwidth of the signal (duration of each continuous-frequency sound transmission within the wavetrain is no longer than 10 sec in the frequency range of 100 to 500 Hz). Given the hearing abilities of fishes and the operational profile of LFA sonar, there is a very limited potential for LFA sonar to mask fish signals. This conclusion is supported by Popper et al. (2014) in which they subjectively assess the relative risk of masking occurring as a low probability at any distance for fishes with no swim bladder and fishes with a swim bladder not involved in hearing. For fishes with swim bladder involved in hearing, Popper et al. (2014) subjectively assess the relative risk of masking occurring as a low probability at intermediate and far distances (hundreds to thousands of meters) and a moderate probability at near distances (tens of meters).

There is the potential for temporary masking to occur within the frequency range of 100 to 500 Hz during LFA transmissions (nominal duration of 60 sec), but with a maximum duty cycle of 20 percent, any masking would be minimal. Therefore, the potential for masking to an individual fish by LFA sonar is insignificant.

Since the potential for masking to an individual fish is insignificant, and fishes would only be masked in the frequency range of transmissions while the LFA sonar was transmitting, it is unlikely that more than a minimal to negligible portion of any fish stock would experience masking. Therefore, the potential for masking to fish stocks is an insignificant impact.

➢ ***Physiological Stress***

Very few studies have examined the potential for physiological stress in fishes. Smith et al. (2004) found that increased ambient noise (160 to 170 dB rms) caused a transient stress response in goldfish that was not sustained over long-term exposures. Wysocki et al. (2006) also found that three species of fishes (the common carp and the gudgeon, hearing specialists, and the European perch, a hearing generalist) increased cortisol secretion when exposed to ship noise. Nichols et al. (2015) examined the impact of outboard motor noise on stress levels in juvenile giant kelpfish, a coastal marine species. Continuous or intermittent outboard motor noise, separated by recordings of natural ambient noise, was played back in small (18 gal [67 L]) tanks. Intermittent noise created statistically significantly higher levels of cortisol than continuous noise or ambient noise only recordings. Random intermittent noise signals produce more stress than regular intermittent signals. Furthermore, the cortisol level scaled linearly with increases in sound levels in the tanks, the first time a magnitude response has been studied.

Similar to other potential impacts on fishes, the probability of a stress response is low and would require fishes to be within general proximity (<0.54 nmi [<1 km]) of the LFA sonar, which is unlikely since the sonar array and vessel are moving through the ocean. Therefore, the potential for a stress response by an individual fish by LFA sonar is insignificant.

Since the potential for a stress response by an individual fish is discountable, and fishes could only exhibit a stress response while the LFA sonar was transmitting, it is unlikely that more than a minimal to negligible portion of any fish stock would exhibit a stress response. Therefore, the potential for stress responses by fish stocks is an insignificant impact.

- ***Summary***

Given the studies of sound exposure to fishes, the potential for impacts is restricted to within close proximity of LFA sonar while it is transmitting. A summary of the thresholds defined by Popper et al. (2014), and modified by DoN (2017c) to account for the signal duration of exposure and add fishes with high-frequency hearing sensitivity, shows that the probability of an impact is low to moderate and would require fishes to be within close proximity (<0.54 nmi [<1 km]) of the LFA sonar (Table 4-3). There is a minimal to negligible potential for an individual fish to experience non-auditory impacts, auditory impacts, or a stress response. There is a low potential for minor, temporary behavioral responses or masking of an individual fish to occur when LFA sonar is transmitting and there is no potential for fitness level consequences. Since a minimal to negligible portion of any fish stock would be in sufficient proximity during LFA sonar transmissions to experience such impacts, there is minimal potential for LFA sonar to affect fish stocks.

- ***Comparison of Potential Impacts between Alternatives***

Under Alternative 1, the Navy would transmit 360 hours of LFA sonar transmissions per year, while under Alternative 2, the Navy would transmit 496 hours of LFA sonar transmissions per year in the first four years and 592 hours of LFA sonar transmissions in year five and continuing into the foreseeable future. Alternative 2 represents a 38% and 64% increase in transmission hours in years 1 to 4 and years 5 and beyond, respectively, over Alternative 1 conditions. Therefore, there is a slight increase in the potential for impacts under Alternative 2 compared to Alternative 1. However, both alternatives represent a decrease from the currently authorized transmission hours of 1,020 per year and it is still unlikely that individual fishes would be impacted and minimal potential for effects to fish stocks.

4.5.2.1.2 Sea Turtles

The information below builds on the analyses previously conducted in the Navy's 2007, 2012 and 2017 SEIS/SOEISs for SURTASS LFA Sonar (DoN, 2007, 2012, 2017b), which are incorporated by reference. Although it is known that sea turtles can hear LF sound (Lavender et al., 2014; Martin et al., 2012), there is limited information on their behavioral and physiological responses to LF sound underwater. Very few studies exist on the potential impacts of underwater sound on sea turtles and most of the available research examined the impacts of sounds of much longer duration or of different types (e.g., seismic airgun) than LFA sonar signals (McCauley et al., 2000). Additionally, very little is known about sea turtle hearing and what, if anything, may cause a sea turtle to incur permanent or even temporary loss of hearing (Popper et al., 2014).

Table 4-3. Summary of Fish Exposure Thresholds for Low Frequency Sonar (DoN, 2017c; Popper et al., 2014).

Type of Fish	Recoverable Injury	TTS	Masking	Behavior
Fish: No swim bladder	>218 dB SEL_{cum}	NC	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low
Fish: Swim bladder not involved in hearing	>218 dB SEL_{cum}	>210 dB SEL_{cum}	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low
Fish: Swim bladder involved in hearing	>218 dB SEL_{cum}	210 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	>197 dB SPL_{rms}
Fish: Swim bladder involved in hearing and high-frequency hearing sensitivity	NC	210 dB SEL_{cum}	NC	NC

(N) = near (i.e. 10s of meters from the source); (I) = intermediate (i.e. 100s of meters from the source); (F) = far (1000s of meters from the source); NC=no criteria

This lack of information on hearing sensitivity is confounded by a lack of population data on sea turtles in the open ocean. The best available data on sea turtle populations (abundance estimates) are underestimates in that they only consist of counts of nesting females. The distribution of sea turtles in the open ocean is very different than their distribution in nearshore and coastal waters, with nearshore foraging hotspots having been identified for the loggerhead turtles (Seminoff, 2014) and nearshore breeding aggregations numbering in the thousands for some species (i.e., olive ridley). Nearly all species of sea turtles occur in low numbers over most of their ranges, resulting in greatly and widely dispersed distributions in the open ocean. Coupled with low numbers dispersed over enormous geographic areas is the additional complexity of some sea turtle's lifestages, such as the leatherback and olive ridley turtles, which spend their entire lives dispersed widely in pelagic waters, while the early lifestages of other sea turtle species spend only the "lost years" drifting around the central ocean gyres. In addition, most sea turtle species spend a high percentage of their lives in the upper 328 ft (100 m) of the water column, particularly if they are transiting between foraging and nesting grounds in the open ocean. The potential for sea turtles to be exposed to LFA sonar must be considered within this context.

➢ **Non-auditory Impacts**

No data are available on the potential for LF sonar to cause non-auditory injury in sea turtles. Direct injury to sea turtles from exposure to SURTASS LFA sonar is unlikely because of relatively lower peak pressures and slower rise times than impulsive sound sources such as seismic airguns. Popper et al. (2014) estimated the probability for mortality and potential mortal injury to be low at all distances from LF sonar.

➢ **Auditory Impacts**

No studies have been conducted on hearing loss in any turtles (Popper et al., 2014). Furthermore, there have been no studies to determine if the hair cells of the basilar papilla are lost, damaged, or fatigued during exposure to intense sounds. However, given that sea turtles hear best underwater at 100 to 400 Hz (Lavender et al., 2014; Martin et al., 2012), there is the potential for diving sea turtles to experience auditory impacts from exposure to LFA sonar. Popper et al. (2014) estimated the probability for TTS to be moderate at near and intermediate distances (tens to hundreds of meters) and low at far distances (thousands of meters) from LFA sonar.

In *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*, an auditory weighting function and an exposure function in sound exposure level (SEL) were developed to estimate onset TTS and PTS (DoN, 2017a). Both functions estimate the most sensitive hearing of sea turtles at a frequency of approximately 170 Hz, with sensitivity decreasing rapidly at frequencies above and below. For SURTASS LFA sonar operating at frequencies between 100 and 500 Hz, the most protective calculations would utilize auditory weighting and thresholds at 170 Hz. Therefore, the threshold for onset TTS is 200 dB re 1 μPa^2-sec and onset PTS is 220 dB re 1 μPa^2-sec and would be be weighted by 0 dB (DoN, 2017a). To calculate the distance at which onset TTS and onset PTS might occur from exposure to SURTASS LFA sonar, the length of a nominal LFA transmission (60 sec) must be considered. If the assumption is made that all RLs are at the same sound pressure level (SPL) RL (i.e., the animal and vessel remain at the same distance and depth from each other for an entire minute), the thresholds are lowered by approximately 18 dB ($10x\log_{10}$[60 sec]=17.8). This results in SPL thresholds for onset TTS and onset PTS of 182 dB re 1 µPa and 202 dB re 1 µPa, respectively. Based on simple spherical spreading (i.e., TL based on $20x\log_{10}$[range{m}]), sea turtles would need to be within 143 ft (44 m) or 14 ft (4 m), respectively, for the duration of an entire 60-sec LFA transmission to experience onset TTS or onset PTS.

For sea turtles to experience auditory impacts, they would need to swim at approximatley 3 kts for the 60-sec signal of the SURTASS LFA sonar, to match its speed. This speed is faster than average swim speeds of sea turtles (Chapter 3), but within the range of their fastest swim speeds. However, the HF/M3 active sonar mitigation measure is able to detect sea turtles within the 180 dB re 1 µPa mitigation zone (a range of approximately 0.54 nmi [1 km]). Thus, it is unlikely that a sea turtle would remain within 143 ft (44 m) of the LFA sonar for an entire 60-sec signal without being detected to experience TTS. It is even more unlikely that a turtle would be within 14 ft (4 m) of the LFA sonar to experience PTS.

➢ **Behavioral Change**

Behavioral responses of sea turtles to anthropogenic activity have not been extensively investigated. The majority of available research is on the response of sea turtles to underwater seismic noise. Studies of captive turtles exposed to sound from individual seismic airguns suggest that they may show startle or avoidance responses to airguns (Bartol and Musick, 2003; McCauley et al., 2000; O'Hara and Wilcox, 1990). The work by O'Hara and Wilcox (1990), McCauley et al. (2000), and DeRuiter and Doukara (2012) reported behavioral changes of sea turtles in response to exposure to seismic airgun transmissions. O'Hara and Wilcox (1990) reported avoidance behaviors by loggerheads in response to airguns with sound levels (RL) of 175 to 176 dB re 1 µPa (peak-to-peak). McCauley et al. (2000) reported noticeable increases in swimming behavior for both green and loggerhead turtles at RLs of 166 dB re 1 µPa (peak-to-peak). At 175 dB re 1 µPa (peak-to-peak) RL, both green and loggerhead sea turtles displayed increasingly erratic behavior (McCauley et al., 2000). DeRuiter and Doukara (2012) reported that basking loggerhead turtles interrupted basking behavior and dove in response to the sound from seismic airguns; 49 of 86 observed turtles (or 57 percent) dove at or before their closest range to the airguns and at least six loggerheads dove immediately following an airgun shot, often showing a startle response. However, seismic airguns transmit impulsive signals characterized by a large frequency bandwidth, high energy, and short duration signals. Therefore, airgun signals cannot be directly compared with SURTASS LFA sonar, since the signal characteristics are very different, and the likelihood of impacts on living tissue are dissimilar as well.

Watwood et al. (2016) tagged green sea turtles in Port Canaveral, Florida to monitor their movements during a mid-frequency, pierside submarine sonar test. No significant long-term displacement was exhibited, though the authors note that Port Canaveral is an urban habitat and turtles may be less likely to respond than naiive populations. Popper et al. (2014) estimated the probability for behavioral impacts to be low at all distances from LF sonar. Given the best available data from airgun exposures, a behavioral response threshold of 175 dB re 1 µPa SPL rms based on seismic data was developed by the Navy and NMFS (DoN, 2017a). This RL could occur at a distance of approximately 1 nmi (2 km) from the SURTASS LFA sonar. It is possible for sea turtles to be exposed to received levels from SURTASS LFA sonar transmissions that could result in some minor or temporary behavioral responses. However, the scale of these changes is unlikely to constitute harassment under the ESA, which requires "that actions significantly disrupt normal behavioral patterns..." Therefore, the potential for biologically significant behavioral responses of an individual sea turtle to LFA sonar is insignificant.

- **Masking**

Little is known about how sea turtles use sound underwater. It is likely they can sense underwater objects through auditory and visual cues, but they are not known to produce sounds underwater for communication. Masking impacts may occur for sea turtle species since their frequencies of greatest hearing sensitivity overlap the frequencies at which LFA sonar transmits, but masking would only occur during sonar transmissions, which is unlikely to result in ecological consequences for sea turtles. Popper et al. (2014) estimated the probability for masking to be low at all distances from LF sonar.

- **Physiological Stress**

Physiological stress responses have been observed in sea turtles during capture and handling (Gregory et al., 1996; Gregory and Schmid, 2001), but no acoustic exposure studies have been conducted to determine the potential for a stress response from underwater sound. Without sufficient information, it is impossible to determine the potential for physiological stress from exposure to LFA sonar. However, as stated earlier, given the hearing sensitivities of sea turtles and the operational profile of LFA sonar, sea turtles are very unlikely to be in proximity to LFA sonar while it is transmitting, resulting in a very limited potential for a stress response to occur.

- **Summary**

The paucity of data on underwater hearing sensitivities of sea turtles, whether sea turtles use underwater sound, or the responses of sea turtles to sound exposures make a quantitative analysis of the potential impacts from LFA sonar transmissions difficult (NMFS, 2012), but available information suggests that there is a low to moderate potential for impacts to occur (Table 4-4). DoN (2017a) developed an auditory weighting function and an exposure function to estimate onset TTS and PTS as 200 dB re 1 μPa^2-sec and 220 dB re 1 μPa^2-sec, respectively. As discussed above, sea turtles would need to be within 143 ft (44 m) or 14 ft (4 m), respectively, for the duration of an entire 60-sec LFA transmission to experience onset TTS or onset PTS. This would require them to swim at approximatley 3 kts for the 60-sec signal, which is faster than their average swim speeds, without being detected by the HF/M3 active sonar mitigation measure. The best estimate of a threshold for behavioral response (175 dB re 1 µPa SPL rms) is based on airgun exposure data (DoN, 2017a). This RL could occur at a distance of approximately 1 nmi (2 km) from the SURTASS LFA sonar.

Table 4-4. Sea Turtle Exposure Thresholds for Low Frequency Sonar (DoN, 2017a; Popper et al., 2014).

Type of Animal	*PTS*	*TTS*	*Masking*	*Behavior*
Sea turtles	220 dB re 1 μPa^2-sec (weighted)	200 dB re 1 μPa^2-sec (weighted)	(N) Low (I) Low (F) Low	175 dB re 1 μPa SPL rms

(N) = near (i.e. tens of meters from the source); (I) = intermediate (i.e. 100s of meters from the source); (F) = far (thousands of meters form the source)

Given these thresholds, the probability of TTS is low and PTS is extremely low. There is no evidence that sea turtles use sound to communicate or capture prey, so if any hearing loss were to occur, the potential for impact on important biological functions is likely limited. It is possible for sea turtles to be exposed to received levels from SURTASS LFA sonar transmissions that could result in some minor or temporary behavioral responses. However, the scale of these changes is unlikely to constitute harassment under the ESA, which requires "that actions significantly disrupt normal behavioral patterns..." Therefore, the potential for biologically significant behavioral responses of an individual sea turtle to LFA sonar is insignificant.

In addition, given the lack of data on the distribution and abundance of sea turtles in the open ocean, it is not feasible to estimate the percentage of a stock that could be exposed to SURTASS LFA transmissions in a modeling site. Given that the majority of sea turtles encountered in the oceanic areas in which LFA sonar is proposed to be used would in high likelihood be transiting and not lingering, the possibility of significant behavior changes, especially from displacement, are unlikely and there is no potential for fitness level consequences. The geographical restrictions imposed on LFA sonar use would greatly limit the potential for exposure to occur in areas such as nesting sites where sea turtles would be aggregated, especially in large numbers. While it is possible that a turtle could hear the transmissions if it were in close proximity to LFA sonar, when this is combined with the low probability of sea turtles being near the LFA sound source while it is transmitting and traveling at a speed of three to four knots, the potential for impacts from exposure to LFA sonar is considered negligible.

- **Comparison of Potential Impacts between Alternatives**

Under Alternative 1, the Navy would transmit 360 hours of LFA sonar transmissions per year, while under Alternative 2, the Navy would transmit 496 hours of LFA sonar transmissions per year in the first four years and 592 hours of LFA sonar transmissions in year five and continuing into the foreseeable future. This represents a 38% and 64% increase over Alternative 1 conditions, respectively. Therefore, there is a slight increase in the potential for impacts under Alternative 2 compared to Alternative 1, though both alternatives represent a decrease from the currently authorized transmission hours of 1,020 per year. However, the potential for impacts from exposure to LFA sonar is considered negligible under both action alternatives.

4.5.2.1.3 Marine Mammals

Marine mammals exposed to natural or man-made sound may experience non-auditory and auditory impacts, ranging the spectrum of severity (Southall et al., 2007). When exposed to LFA sonar, marine mammals may experience auditory impacts (i.e., PTS and TTS), behavioral change, acoustic masking, or physiological stress (Atkinson et al., 2015; Clark et al., 2009; Nowacek et al., 2007; Southall et al., 2007).

Underwater sound has also been implicated in strandings of marine mammals, considered a non-auditory impact. Details and information on these types of impacts and the associated conclusions provided in previous documentation for SURTASS LFA sonar (DoN, 2007, 2012, 2017b) are incorporated by reference herein except as addressed below in summaries of recent research and information that may pertain to impacts associated with LF sources or may be pertinent to the assessment of impacts associated with SURTASS LFA sonar. A quantitative analysis of the potential impacts on marine mammals from LFA sonar follows after the summaries.

- **Non-auditory Impacts**

Nowacek et al. (2007) and Southall et al. (2007) reviewed potential types of non-auditory injury to marine mammals from active sonar transmissions. These types of injuries include direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas. The detailed descriptions and information on these types of non-auditory impacts were provided in previous documentation for SURTASS LFA sonar (DoN, 2007, 2012, 2017b) and related conclusions are incorporated by reference herein.

No new data have emerged to contradict any of the assumptions or conclusions in previous LFA documentation, especially the conclusion that SURTASS LFA sonar transmissions are not expected to cause gas bubble formation or strandings, particularly those of beaked whales. No strandings have occurred coincident to SURTASS LFA sonar in over sixteen years of its use and no studies indicate that strong avoidance reactions to LFA sonar would occur that would increase the risk of gas bubble formation.

- **Auditory Impacts**

One potential impact from exposure to high-intensity sound is auditory impacts, specifically TTS; no studies have provided direct data on PTS. Several studies by a number of investigators have been conducted, focusing on the relationships among the amount of threshold shift and the level, duration, and frequency of the stimulus (DoN, 2017a; NMFS, 2018). These studies are typically conducted such that threshold shifts of 6 dB represent the upper limit of noise exposure. None of these studies have resulted in direct data on the potential for PTS, empirical measurements of hearing, or the impacts of noise on hearing for mysticetes, which are believed to be most sensitive to LFA sonar.

In addition to impacts on hair cells measured as threshold shifts, studies have shown that very large temporary threshold shifts can result in neural degeneration, resulting in auditory injury. Kujawa and Liberman (2009) found that noise exposures that produced a TTS of 40 dB, measured 24-hr post-exposure, resulted in loss of afferent nerve synapses and cochlear neurons in mice. Similar impacts were demonstrated in guinea pigs, where a TTS of approximately 50 dB, measured 24 hr post-exposure, resulted in neural degeneration (Lin et al., 2011). This observed neural degeneration is an auditory injury that will cause loss of hearing sensitivity, though it occurs under exposure conditions that result in high levels of TTS (40 to 50 dB measured 24 hr after exposure).

The best available data are used for the analysis of potential auditory impacts and, when necessary, protective assumptions are implemented that aim to provide the greatest protection to marine animals. The detailed descriptions and information on auditory impacts provided in previous documentation for SURTASS LFA sonar (DoN, 2007, 2012, 2017b) are incorporated by reference herein. Houser (2017) reviewed the development of auditory weighting functions for marine mammals, the primary use of which has been to predict and prevent noise-induced hearing loss.

NMFS (2018) provided guidance for assessing the impacts of anthropogenic sound on marine mammals under their regulatory jurisdiction, which includes whales, dolphins, seals, and sea lions. The guidance specifically defines hearing groups, develops auditory weighting functions, and identifies the received levels, or acoustic threshold levels, above which individual marine mammals are predicted to experience changes in their hearing sensitivity (PTS or TTS) for acute, incidental exposure to underwater sound.

Recognizing that marine mammal species do not have equal hearing capabilities, five hearing groups of marine mammals were defined:

- Low-frequency (LF) Cetaceans—this group consists of the mysticetes with a collective generalized hearing range of 7 Hz to 35 kHz.
- Mid-frequency (MF) Cetaceans—includes most of the dolphins, all toothed whales except for *Kogia* spp., and all the beaked and bottlenose whales with a generalized hearing range of approximately 150 Hz to 160 kHz.
- High-frequency (HF) Cetaceans—incorporates all the true porpoises, the river dolphins, plus *Kogia* spp., *Cephalorhynchid* spp. (genus in the dolphin family Delphinidae), and two species of *Lagenorhynchus* (Peale's and hourglass dolphins) with a generalized hearing range estimated from 275 Hz to 160 kHz.
- Phocids Underwater (PW)—consists of true seals with a generalized underwater hearing range from 50 Hz to 86 kHz.
- Otariids Underwater (OW)—includes sea lions and fur seals with a generalized underwater hearing range from 60 Hz to 39 kHz.

Within their generalized hearing ranges, the ability to hear sounds varies with frequency, as demonstrated by examining audiograms of hearing sensitivity (DoN, 2017a; NMFS, 2018). To reflect higher noise sensitivities at particular frequencies, auditory weighting functions were developed for each functional hearing group that reflected the best available data on hearing ability (composite audiograms), susceptibility to noise-induced hearing loss, impacts of noise on hearing, and data on equal latency (Figure 4-2). These weighting functions are applied to individual sound received levels to reflect the susceptibility of each hearing group to noise-induced threshold shifts, which is not the same as the range of best hearing.

NMFS (2018) defined acoustic threshold levels at which PTS is predicted to occur for each hearing group for impulsive and non-impulsive signals. LFA sonar is a non-impulsive source in that its signals do not have the high peak pressure with rapid rise time and decay that impulsive sounds do; instead the pressure (i.e., intensity) of the LFA sonar transmission is consistent throughout the signal. The acoustic threshold levels for non-impulsive sounds are defined as the cumulative sound exposure level (SEL) over a 24-hr period with the appropriate frequency weighting for each hearing group (Figure 4-2; Table 4-5), which is reflected in the subscript of each threshold (e.g., the LF cetacean threshold is identified as $L_{E,LF,24h}$). The cumulative SEL metric takes into account both received level and duration of exposure over the duration of the activity within a 24-hr period. The TTS threshold is defined as 20 dB less than the PTS threshold. A summary of the cumulative sound exposure acoustic thresholds for PTS and TTS are provided (Table 4-4).

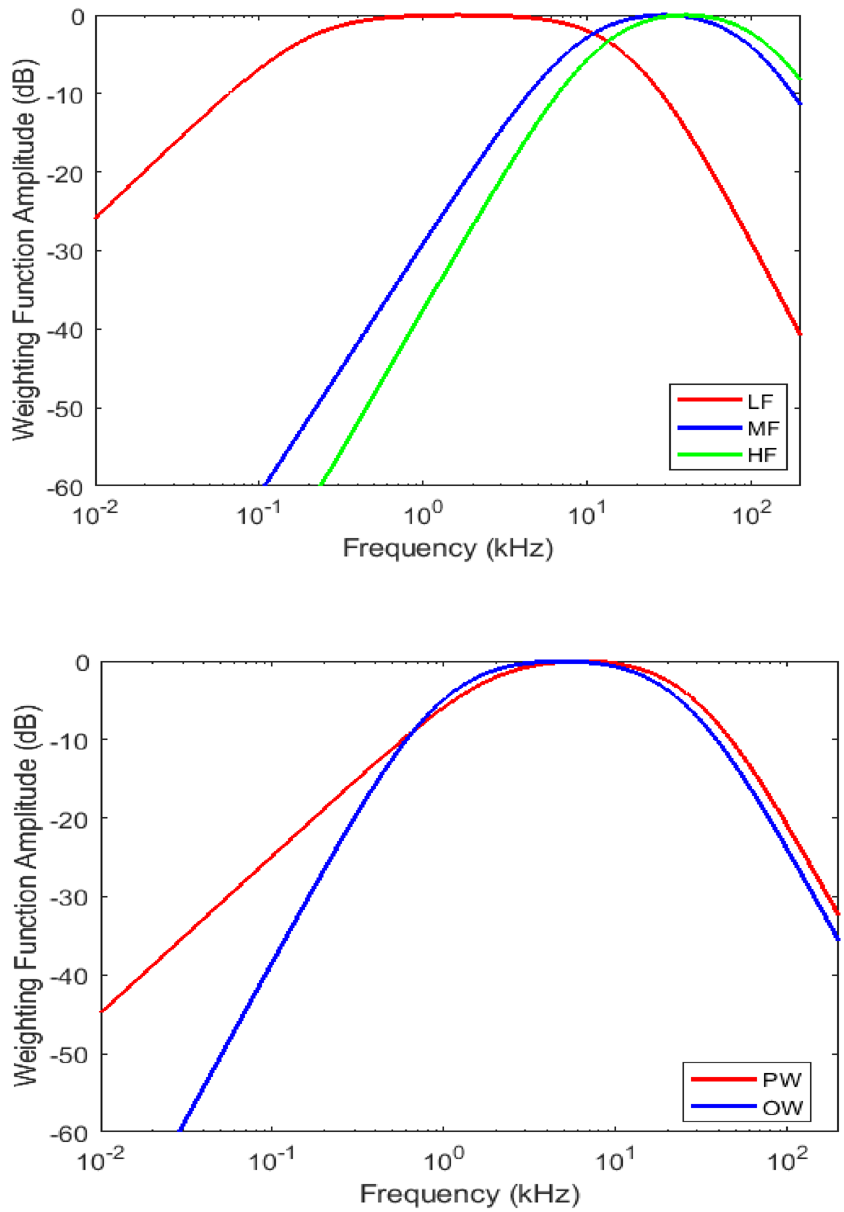


Figure 4-2. Auditory Weighting Functions for Cetaceans (Top Panel: LF, MF, and HF Species) and Pinnipeds (Bottom Panel: PW, OW) (NMFS, 2018).

➢ **Behavioral Change**

The primary potential impact on marine mammals from exposure to LFA sonar is behavioral responses, which do not necessarily constitute significant changes in biologically important behaviors. The National Research Council (2005) noted that an action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce, wherein an impact on individuals can lead to population-level consequences and affect the viability of the species. The complexities associated with such an evaluation are becoming clear as researchers compile and evaluate

Table 4-5. PTS and TTS Acoustic Threshold Levels for Marine Mammals Exposed to Non-impulsive Sounds (National Oceanic and Atmospheric Administration (NOAA, 2018).

Hearing Group	PTS Onset	TTS Onset
Low-frequency (LF) cetaceans ($L_{E,LF,24h}$)	199 dB SEL	179 dB SEL
Mid-frequency (MF) cetaceans ($L_{E,MF,24h}$)	198 dB SEL	178 dB SEL
High-frequency (HF) cetaceans ($L_{E,HF,24h}$)	173 dB SEL	153 dB SEL
Phocid pinnipeds underwater ($L_{E,PW,24h}$)	201 dB SEL	181 dB SEL
Otariid pinnipeds underwater ($L_{E,OW,24h}$)	219 dB SEL	199 dB SEL

data on extensively studied species as exemplar models of how short-term changes in behavior may accumulate to indirectly impact fitness through individual survival and reproduction (Maresh et al., 2014; New et al., 2014; Robinson et al., 2012).

An example of the amount of data needed to link a disturbance with an animal's health and how that may affect vital rates that would result in population-level consequences can be seen in a study of southern elephant seals (New et al., 2014). Southern elephant seals return to the same haul-out location twice a year after foraging trips, allowing animals to be sedated for health assessments and instruments to be attached to the animals and recovered after a foraging trip for at-sea measurements. Having such long-term access to the same animals is highly unusual in marine mammal research, but it is such individualized measurements that help inform linkages among behavioral responses and population-level consequences. In this study, an animal's lipid mass (i.e., fat content) could be measured at the beginning and end of a foraging trip, while the archival instruments measured dive data that could be correlated with their foraging success while at sea. It is unlikely that such an analysis will be possible for the majority of marine species because of the difficulties associated with collecting the necessary information (Tougaard et al., 2015).

Several review papers have been published in recent years that summarize the research that has occurred on potential effects of noise on wildlife. Shannon et al. (2016) conducted a systematic and standardized review of the scientific literature published from 1990 to 2013 on the effects of anthropogenic noise on both terrestrial and aquatic wildlife. Their review found that 37 percent of studies focused on birds and 28 percent focused on aquatic mammals, including marine mammals. A vast majority (81 percent) of the research has been conducted in North America or Europe, with a rapid increase in the volume of published, peer-reviewed articles since 2010. In evaluating 242 papers, 88 percent reported a statistically measured biological response to noise exposure (i.e., statistics determined that the response was outside what would be considered normal variation and was in fact a differential response), but only a small number investigated impacts to population persistence (survival, reproductive fitness), community interactions (predator-prey), and ecosystem services (pollination).

Another systematic literature review (370 papers) and analysis (79 studies, 195 data cases) found that behavioral response in cetaceans was best explained by the interaction between sound source type (continuous, sonar, or seismic/explosion) and hearing group (Gomez et al., 2016). Sound levels received by the animal were not part of the model best explained by the data, demonstrating that more severe behavioral responses were not consistently associated with higher RL, but that the type of source transmitting the acoustic energy was a key factor, highlighting the importance of context of exposure in impact analysis. Finally, Southall et al. (2016) summarized the suite of recent field experiments studying cetacean responses to simulated or actual active military sonars in the 1 to 8 kHz frequency range. Several of these studies are discussed later, but a common theme is the context-dependent nature of behavioral responses (e.g., Friedlaender et al., 2016; Goldbogen et al., 2013b; Miller et al., 2014).

The Low Frequency Sound Scientific Research Program (LFS SRP) in 1997 to 1998 provided important results on, and insights into, the types of responses of baleen whales to LFA sonar signals and how those responses scaled relative to RL and context. These experiments still represent the most relevant predictions of the potential for behavioral changes from exposure to LFA sonar. The results of the LFS SRP confirmed that some portion of the total number of whales exposed to LFA sonar responded behaviorally by changing their vocal activity, moving away from the source vessel, or both; but the responses were short-lived and animals returned to their normal activities within tens of minutes after initial exposure (Clark and Fristrup, 2001). Perhaps the most important result came from the LFS SRP Phase II study, where the LFA stimulus was presented to migrating gray whales. When the source was in the migratory path, the whales diverted around the source transmitting at source levels of 170 to 178 dB re 1µPa. However, when the source was moved offshore to the edge of the migratory corridor, with an increased SL to maintain the same received levels at the whales, the migrating gray whales exhibited no response to the LFA stimulus (Clark et al., 1999). The context of an exposure scenario is clearly important for determining the probability, magnitude, and duration of a response (Ellison et al., 2012).

The results of the LFS SRP were used to derive the LFA risk continuum function, from which the potential for biologically significant behavioral response is calculated as described in the impact analysis section below. This function has been described in detail in the Navy's 2001, 2007, 2012 and 2017 SEISs for SURTASS LFA sonar (DoN, 2001, 2007, 2012, 2017b), which are incorporated by reference. The risk continuum is based on the premise that a smooth, continuous function that maps RL to risk is most appropriate for defining the potential or risk for a biologically significant behavioral response (Figure 4-3). A summary of the risk continuum function follows; the reader is referred to Appendix B for additional details.

The LFS SRP experiments, which exposed baleen whales to RLs ranging from 120 to about 155 dB re 1 µPa (rms) (SPL), detected only minor, short-term behavioral responses. Short-term behavioral responses do not necessarily constitute significant changes in biologically important behaviors. The fact that none of the LFS SRP observations revealed a significant change in a biologically important behavior helped determine an upper bound for risk. However, the LFS SRP results cannot be used to prove that there is zero risk at these levels. Accordingly, the risk continuum assumes that risk is small, but not zero, at the RLs achieved during the LFS SRP. The basement value below which risk is negligible is 120 dB SPE. Fifty percent risk of a behavioral response is defined at 165 dB SPE (Figure 4-3). The steepness of the curve, termed the risk transition sharpness parameter, is defined as 10 for LFA sonar.

The risk continuum modeled a smooth increase in risk that culminates in a 95 percent level of risk of significant change in a biologically important behavior at 180 dB SPE. In this region, the risk continuum is unsupported by observations. Since the risk continuum function was derived from the behavioral response data of baleen whales collected with an actual SURTASS LFA sonar source, these data are realistic contextually and remain the best available for the response of LF-sensitive marine mammals to the SURTASS LFA sonar source.

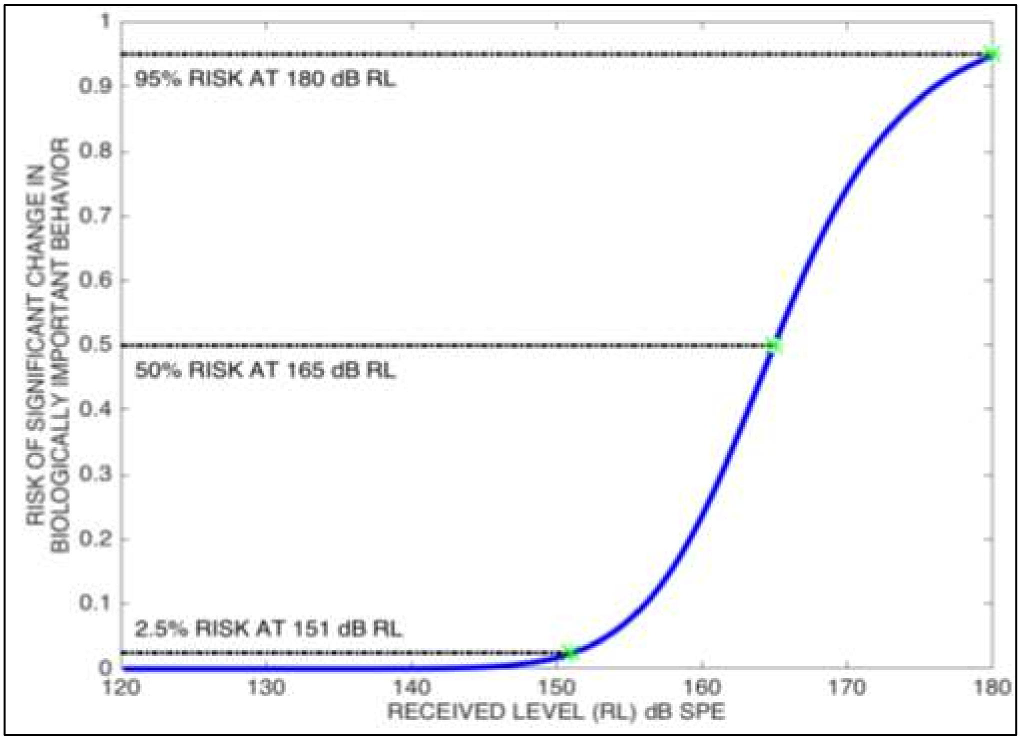


Figure 4-3. Risk Continuum Function for SURTASS LFA Sonar Analysis that Relates the Risk of Significant Change in Biologically Important Behavior to Received Levels in Decibels Single Ping Equivalent (SPE).

Additional studies of behavioral responses of marine mammals to naval sonar have occurred. None have used a low-frequency (<1 kHz) source or been deployed from a slow moving vessel. Therefore their applicability to determining potential responses to LFA sonar is not clear. Nevertheless, these data represent additional information and are presented herein for awareness. Southall et al. (2016) provided an overview of the Southern California Behavioral Response Study (SOCAL-BRS). This program uses advanced tagging efforts and visual and acoustic observations to investigate behavioral responses to mid-frequency sonar signals. Blue whales exposed to simulated mid-frequency sonar showed complex, though brief, avoidance responses (Goldbogen et al., 2013a). Surface feeding animals typically showed no response to the sonar signal, while non-feeding and deep-feeding animals both aborted deep feeding dives and made prolonged mid-water dives. Body orientation and horizontal displacement away from the source were additional responses. The addition of information on the water column and prey fields as explanatory variables explained approximately five times more of the variability in blue whale behavior (Friedlaender et al., 2016). When changes in prey fields were considered, blue whales had greater responses to pseudo-random noise, a unique stimulus in their environment, than they did to MF sonar, to which they may be habituated.

Beaked whales appear to be remarkably sensitive to noise exposure. Moretti et al. (2014) examined historical records of mid-frequency sonar operations and the vocal behavior of Blainville's beaked whales. They were able to describe the probability of the beginning of a Group Vocal Period as a function of the received level of operational mid-frequency sonars. These data were used to create a behavioral dose-response function for Blainville's beaked whales that has a structure similar to the LFA risk continuum, but with a 50 percent probability of response at 150 dB re 1µPa and a shallower slope (steepness parameter). Cuvier's beaked whale responses to mid-frequency sonar have also been described (DeRuiter et al., 2013). One whale exposed to low-level simulated sonar at close ranges (RL 89 to 127 dB) responded strongly, ceasing echolocation and fluking, extended its dive duration and swam away rapidly. However, another whale incidentally exposed to distant operational mid-frequency sonars at low levels (78 to 106 dB) did not show a response. This variation in responses again illustrates the importance of context in interpreting these results.

Miller et al. (2015) presented a single northern bottlenose whale with a 1 to 2 kHz sonar signal. The initial received level at the animal was 98 dB re 1 µPa, and at this level the whale approached the sound source. When the level reached 130 dB re 1µPa, the whale turned 180° away and began the longest and deepest dive ever recorded for this species (94 min and 7,674 ft [2,339 m]). This one data point suggests that this species may also show marked responses to anthropogenic noise, as do many of the beaked whales.

This same bottlenose whale response, as well as those of minke and humpback whales, were examined by an expert panel to assess the severity of these responses (Sivle et al., 2015). The minke whale began avoiding the sonar signal at a received level of 146 dB re 1µPa. Eleven humpbacks were tested, and their response levels ranged from 94 to 179 dB re 1µPa. Responses were judged using a severity score table based on that of Southall et al. (2007) and modified by Miller et al. (2012) that included four subgroups: a) No response (score=0), b) Responses unlikely to affect vital rates (score=1 to 3), c) Responses with the potential to affect vital rates (score=4 to 6), and d) Responses likely to affect vital rates if repeated or of long duration (score=7 to 9). The avoidance by the minke whale and the long duration avoidance by the bottlenose whale both earned a severity score of 8. The scores of the humpback whale responses ranged from 1 to 7.

Antunes et al. (2014) presented 1 to 2 and 6 to 7 kHz simulated sonar signals to pilot whales as part of the 3S Experiment. One or more individuals within groups of long-finned pilot whales were instrumented with suction-cup-attached archival tags (DTAGs; Johnson and Tyack, 2003) along the coast of northern Norway (Miller et al., 2012). After a baseline, pre-exposure period, the whales were exposed to sonar signals. Source levels were increased as the vessel approached the tagged whales. The two-dimensional tracks of the animals were examined to determine the changepoint in their behavior. A dose-response curve was created, which had a 50 percent probability of behavioral change at 170 dB re 1 µPa or 173 dB SEL. While the value of the 50 percent probability of response is similar to that of the LFA risk function, the slope of their function is much shallower than the LFA function.

Killer whales were also presented with these 1 to 2 and 6 to 7 kHz FM sweeps (Miller et al., 2014). They appeared to respond with changes in swim speed and direction. The response thresholds range from 94 to 164 dB re 1µPa. The authors created a dose-response function with a 50 percent probability of avoidance value at 142 dB re 1µPa. They attributed the remarkable variation in response thresholds to intra-individual variability and other unidentified contextual values, such as proximity of the source.

Sperm whales were exposed to 1 to 2 kHz simulated naval sonar as well as playback of killer whales calls (Isojunno et al., 2016). The whales stopped foraging in response to the 1-2 kHz sonar signal at received levels of 131 to 165 dB re 1µPa as well as to the playback of the killer whales signals. No change in foraging was observed in response to the 6-7 kHz signals at received levels from 73 to 158 dB re 1µPa.

Curé et al. (2016) also found stronger responses by sperm whales to killer whale vocalizations and 1 to 2 kHz sonar upsweeps than the 6 to 7 kHz sonar signals. However only playbacks of killer whale vocalizations produced grouping behavior, an indication of predator detection. Thus the actual signal structure was shown to be an important predictor of response, more so than received sound level. This study also demonstrated the value of referencing response strength to the response to a known biologically important signal (i.e., killer whales).

Two minke whales were exposed to simulated naval sonar in the 1 to 4 kHz frequency range (Kvadsheim et al., 2017). The first animal was exposed to 1.3 to 2.0 kHz upsweeps at a maximum source level of 214 dB re 1µPa at 1m. This whale began to respond at a received level of 83 dB re 1 µPa with a brief change in diving behavior and later responded at a received level of 156 dB re 1 µPa by increasing its speed from approximately 2.2 to 11.2 miles per hour (mph) (1 m/s to 5 m/s) and moving in a more linear direction, directly away from the sonar source, which was classified as an '8' on the Southall et al. (2007) severity scale (Sivle et al., 2015). The second whale was presented with a complex series of sweeps and tone between 3.5 and 4.05 kHz with a maximum source level of 210 dB re 1µPa at 1m (Kvadsheim et al., 2017). This whale began avoiding the source and swimming away in a more linear fashion at a received level of 149 dB re 1µPa, but it did not increase its speed.

Vocalizing minke whales were tracked with the hydrophone array at the U.S. Navy Barking Sands training range off Kauai, HI (Martin et al., 2015). The mean number of animals within the 3,780 km^2 training range was estimated as 3.64 before training, 2.81 whales during training but without MF sonar transmissions, 0.69 whales during MF sonar transmissions, and 4.44 whales following training activities. It is not known if the decrease was due to whales leaving the area or simply an alternation of their acousic behavior.

Additional peer-reviewed papers have been published considering the impact of LF sound on marine mammals. Risch et al. (2012) documented reduction in humpback whale vocalization concurrent with transmissions of the low-frequency Ocean Acoustic Waveguide Remote Sensing (OAWRS) system, at distances of 108 nmi (200 km) from the source. The LF pulses recorded in Stellwagen Bank NMS had a bandwidth of approximately 50 Hz, duration of 1 sec, and mean center frequencies of 415, 734, and 949 Hz (Risch et al., 2012). The OAWRS source appears to have affected more whales, by producing a greater response with a lower sound source level, than reported from the Phase III of the Low Frequency Sound Scientific Research Program LFS SRP, even though OAWRS had a lower RL (88 to 110 dB re 1 µPa) than the LFA signal. Gong et al. (2014) assessed the effects of the OAWRS transmissions on calling rates on Georges Bank and determined constant vocalization rates of humpback whales, with a reduction occurring before the OAWRS system began transmitting. Risch et al. (2014) pointed out that the results of Risch et al. (2012) and Gong et al. (2014) are not contradictory, but rather highlight the principal point of their original paper that behavioral responses depend on many factors, including range to source, RL above background noise level, novelty of signal, and differences in behavioral state.

Humpback whale foraging behavior appears to be negatively affected by low-frequency vessel noise (Blair et al., 2016). Ten foraging whales with non-invasive archival tags were studied in Stellwagen Bank NMS in the western North Atlantic Ocean. Ship noise collected on the archival tags was assessed with seven parameters of feeding behavior. As the received level of vessel noise increased, three parameters of foraging behavior decreased: number of side roll feeding events, ascent rate, and descent rate (Blair et al., 2016). Reducing in foraging behavior of individual whales could lead to population-levels impacts of shipping noise on foraging success.

A series of playback experiments using vessel noise and seismic airgun signals was conducted with humpback whales migrating along the east coast of Australia. One analysis considered the effects of both vessel presence and received level of airgun transmissions (Dunlop et al., 2017). While neither stimulus produced abnormal behaviors, the presence of the vessel, with and without operating airguns, did alter behavior, reducing dive time. The airgun signals caused a prolonged increase in respiration rate, a decrease in dive time, and movement of travel path away from the sound source (as indicated by the reduction in southward movement). This avoidance was more likely at received SELs greater than 135 dB re 1μPa^2-s and at ranges less than 2.2 nmi (4 km). A similar experiment with a single 20 cubic inch or 140 cubic inch airgun found that avoidance was more likely within 1.6 nmi (3 km) of the vessel and at SELs greater than 140 dB re 1μPa^2-s, with no response during control periods, indicating avoidance was due to the air guns and not the source vessel itself (Dunlop et al., 2017).

In summary, the results of these studies show that behavioral responses can occur at a range of received levels and may or may not rise to the level of biologically significant impacts. The current scientific literature on the possible effects of LF sound transmissions on marine species provide no contradictory information showing different potential behavioral impacts than those documented by the LFS SRP. The results of the SRP remain the best available data to estimate the potential for biologically important behavioral responses to the use of SURTASS LFA sonar since the studies used the SURTASS LFA sonar and exposed LF specialists while engaged in critical behaviors. The risk continuum function, which is based on LFS SRP data, continues to be used to define behavioral effects from exposure to LFA sonar. Additionally no other studies have been conducted with low frequency sonars or other non-impulsive sources that utilize frequency bands similar to SURTASS LFA sonar that could be used to supplement the SRP results. The Navy acknowledges the age of the LFS SRP data, but as noted previously, the mere age of these data does not invalidate them, their contributions to science, nor the conclusions based upon those data.

- **Masking**

Erbe et al. (2016) reviewed the current state of understanding of masking in marine mammals, including anti-masking strategies for both receivers and senders. When a signal and noise are received from different directions, a receiver with directional hearing can reduce the masking impact. This is known as spatial release from masking, and this ability has been found in dolphins, killer whales and harbor seals. Given the hearing abilities of marine mammals, it is likely that most, if not all, species have this ability to some extent.

The detectability of a signal amidst noise may also be affected by the temporal and spectral properties of the signal. Cunningham et al. (2014) conducted masking experiments where the signals were complex, including frequency and amplitude modulation as well as the presence of harmonics, parameters that are typical for natural animal signals. The ability of the receivers to detect complex signals was far better than predicted using simple energetic masking predictions, likely because of the complex structure of the signal.

Animals may be able to counteract masking by involuntarily increasing the source level of their vocalizations in the presence of noise, known as the Lombard vocal response. The SLs of vocalizations of killer whales and beluga whales have been shown to increase as the level of ship noise in the environment increased (Holt et al., 2011; Scheifele et al., 2005). Another mechanism may be to increase their calling rate or change the call structure, as demonstrated by gray whales when exposed to vessel noise (Dahlheim and Castellote, 2016). Changes in call structure included increased source level, more frequency-modulated calls, and an increased number of pulses per call. Migrating humpback whales off Australia increased the amplitude of their social calls by 0.9 dB for every 1.0 dB increase in wind-created ambient noise (Dunlop et al., 2014). While increasing their amplitude may be effective at improving communication, it may come with an increased metabolic cost, as was shown with bottlenose dolphins (Holt et al., 2015).

The potential for masking from LFA sonar signals is limited for a number of reasons. First, the typical LFA sonar signal is not a constant tone but consists of a sequence of sound transmissions (waveforms) that vary in frequency and duration. Continuous-frequency waveforms have durations of no longer than 10 seconds. Waveforms with varying frequencies (frequency-modulated or FM waveforms) have limited bandwidths (30 Hz). Therefore, within the frequency range in which masking is possible, the impact would be limited because animals that use this frequency range typically use signals with greater durations and bandwidths. Thus, only a portion of the frequency band for the animal's signal is likely to be masked by the LFA sonar transmissions. Furthermore, when LFA sonar is in use, the source is active only 7.5 to 10 percent of the time, with a maximum 20 percent duty cycle, which means that for 90 to 92.5 percent of the time, there is no potential for masking. Therefore, within the area in which energetic masking is possible, any impact of LFA sonar transmissions would be minimal because of the limited bandwidth and intermittent nature of the signal, and the fact that animals that use this frequency region typically produce signals with greater bandwidth that are repeated for many hours.

- **Physiological Stress**

Atkinson et al. (2015) reviewed the physiology of the stress response in marine mammals. As a result of the interest of the National Research Council in the population consequences of underwater noise (NRC, 2005), there has been broadened research into marine mammal responses to environmental stressors and linking these reponses to costs at the individual level that may have reprecussions at the population level (Maresh et al., 2014; New et al., 2014; Robinson et al., 2012). The data do not exist for such an assessment with noise exposure, but the processes being developed highlight the research gaps that need to be prioritized for those advances to be made. A study with southern elephant seals (New et al., 2014) highlights the linkages between animal foraging success, environmental change, and population growth rates, and the level of data needed for such an assessment.

A limited amount of research has been conducted on stress responses resulting from sound exposure. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al., 1990), but showed an 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 an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin and Geraci, 1989).

Increases in heart rate were observed in bottlenose dolphins to which calls from other bottlenose dolphins were played, although no increase in heart rate was observed when ambient noise from aquarium tanks was played back (Miksis et al., 2001). A beluga's heart rate was observed to increase during exposure to noise, with increase dependent on frequency band of noise and duration of exposure, with a sharp decrease to normal or below-normal levels upon cessation of the exposure (Lyamin et al., 2011). A recently-captured beluga whale showed a two-phase heart rate response to noise exposures (frequencies of 19 to 38 kHz, levels of 150 to 160 dB). The heart rate response was indicative of changes in response to stress or emotionally negative external stimuli in terrestrial mammals and humans (Bakhchina et al., 2017). After one year of captivity, the beluga whale showed no response to the same or more intense noise exposures, indicating habituation within the dolphinarium.

It is unknown how chronic exposure to acoustic stressors may affect marine mammals. Opportunistic comparison of levels of stress-related hormone metabolites in North Atlantic right whale feces collected before and after the events of 11 September 2001 showed a decrease in metabolite levels corresponding to lower levels of ambient noise due to reduced ship traffic (Rolland et al., 2012). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Atkinson et al. (2015) highlighted the need for long-term monitoring of individuals to better understand natural life-history influences on variations in stress responses and develop baselines that can be used for comparison. Since marine mammals are air-breathers that live in an underwater, oceanic environment, they have separated their need for oxygen from many biological functions for which it is directly linked in terrestrial mammals. Thus, there appear to be significant modifcations to expected physiological mediators, resulting in unexpected observations. For example, where a terrestrial animal may start breathing heavily as part of a stress response, a marine mammal may have decoupled that response to conserve oxygen for underwater survival. Much more research is needed to begin to understand the potential for physiological stress in marine mammals during noise exposure scenarios.

➢ **Quantitative Impact Analysis for Marine Mammals**

The Navy conducted a risk assessment to analyze and assess potential impacts associated with using SURTASS LFA sonar for training and testing activities in the western and central North Pacific and eastern Indian oceans. The acoustic impact analysis presented herein represents an evolution that builds upon the analysis, methodology, and impact criteria documented in previous SURTASS LFA sonar NEPA efforts (DoN, 2001, 2007, 2012, 2017b), but incorporates the most current acoustic impact criteria and methodology to assess the potential for auditory impacts (PTS and TTS) and behavioral responses of marine mammal species. A summary of the analysis, as well as the exposure estimates, follow; a more thorough description of the impact analysis is provided in Appendix B.

Fifteen representative model areas in the western and central North Pacific and eastern Indian oceans were analyzed to represent the acoustic regimes and marine mammal species that may be encountered during SURTASS LFA sonar training and testing activities (Table 4-6). Modeling was conducted in each season for each model area. Seasons were defined according to the following monthly breakdown:

- Winter: December, January, and February
- Spring: March, April, and May
- Summer: June, July, and August
- Fall: September, October, and November.

For consistency, the seasonality for marine mammals in all model areas is presented according to this monthly arrangement, even for the one model area located in the southern hemisphere (Model Area #14 Northwest of Australia). Therefore, “winter” (encompassing the months of December, January, and February) for Model Area #14 is actually austral summer, when for instance, most baleen whales would be expected to be foraging in Antarctic waters.

To estimate the potential impacts to marine mammals in each of the model areas, a list of marine mammal stocks likely to be encountered in each region, by season, was developed and abundance and density estimates were derived from the most current published literature and documentation available (Chapter 3).

Table 4-6. Locations of the 15 Representative Model Areas for SURTASS LFA Sonar.

Model Area	*Model Area Name*	*Location of Model Area Center*	*Notes*
1	East of Japan	38°N, 148°E	
2	North Philippine Sea	29°N, 136°E	
3	West Philippine Sea	22°N/124°E	
4	Offshore Guam	11°N, 145°E	Navy Mariana Islands Testing and Training Area
5	Sea of Japan	39°N, 132°E	
6	East China Sea	26°N, 125°E	
7	South China Sea	14°N, 114°E	
8	Offshore Japan 25° to 40°N	30°N, 165°E	
9	Offshore Japan 10° to 25°N	15°N, 165°E	
10	Hawaii North	25°N, 158°W	Navy Hawaii-Southern California Testing and Training Area; Hawaii Operating Area
11	Hawaii South	19.5°N, 158.5°W	Navy Hawaii-Southern California Testing and Training Area; Hawaii Operating Area
12	Offshore Sri Lanka	5°N, 85°E	
13	Andaman Sea	7.5°N, 96°E	
14	Northwest of Australia	18°S, 110°E	
15	Northeast of Japan	52°N, 163°E	

Modeling was conducted for one 24-hr period in each of the four seasons in each model area. To predict acoustic exposure, the LFA sonar ship was simulated traveling in a triangular pattern at a speed of 4 kt (7.4 kph), with the time on each bearing (each “leg” of the triangle) being 8 hr (480 min). The duration of LFA sonar transmissions was modeled as 24 hr, with a signal duration of 60 sec and a duty cycle of 10 percent (i.e., the source transmitted for 60 sec every 10 min for 24 hr, which equates to a total of 2.4 transmission hours). The acoustic field around the LFA sonar source was predicted with the Navy standard parabolic equation propagation model using the defined LFA sonar operating parameters. Each marine mammal species potentially occurring in a model area in each season was simulated by creating animats (model simulated animals) programmed with behavioral values describing their dive and movement patterns, including dive depth, dive duration, surfacing time, swimming speed, and direction change.

The Acoustic Integration Model© (AIM) integrated the acoustic field created from the underwater transmissions of LFA sonar with the three-dimensional (3D) movement of marine mammals to estimate their potential sonar exposure at each 30-sec timestep within the 24-hr modeling period. Thus, the output of AIM is the time history of exposure for each animat.

Since AIM records the exposure history for each individual animat, the potential impact is determined on an individual animal basis. The sound energy received by each individual animat over the 24-hr modeled period was calculated as SEL and the potential for that animal to experience PTS and then TTS was considered using the NMFS (2018) acoustic guidance thresholds. If an animal was not predicted to experience PTS or TTS, then the sound energy received over the 24-hr modeled period was calculated as dB SPE and used as input to the LFA risk continuum function to assess the potential risk of a behavioral reaction. A step-wise process is undertaken to ensure that each individual is considered for only one potential impact (i.e., there is no double counting). The potential for PTS is considered first, as it represents the highest threshold. If an individual does not exceed the PTS threshold, then the potential for TTS is considered. If an animal does not exceed the TTS threshold, then the potential for a behavioral response is considered. Thus, individuals are only considered for one acoustic impact during a 24-hr exposure scenario.

To estimate the potential impacts for each marine mammal stock on an annual basis, several calculation steps are required. The first step is to calculate the potential impact for one LFA sonar transmission hour. The 24-hr modeling results for each season are for 2.4 transmission hours (i.e., the SURTASS LFA sonar was simulated to transmit at a 10 percent duty cycle, so 24 hours of LFA sonar use equate to 2.4 sonar transmission hours; Appendix B). Therefore, the impact estimates from 24 hours of LFA sonar use (2.4 transmission hours) were divided by 2.4 to transform the results into potential impacts on a per transmission hour basis. Then, because the use of SURTASS LFA sonar is not driven by any seasonal factors, and LFA sonar activities are most likely to occur with equal frequency in any of the four seasons, the per transmission hour impact estimates for each season were averaged to provide a single annual per transmission hour impact estimate. At this point, the average impact of an hour of SURTASS LFA transmission during any time of the year has been calculated for every species or stock.

The second step for calculating the potential impacts from all SURTASS LFA transmsisions within a year is to determine the number of LFA sonar transmission hours that might occur in each model area, for each activity. To develop the total annual LFA sonar transmission hours, the Navy determined the training and testing activities that occur each year, the number of transmission hours conducted during each activity for each action alternative, and the model areas in which each activity is expected to occur (Tables 4-7 and 4-8), as not all proposed activities would occur in all modeled areas. To calculate the potential impact in each model area for each activity, the number of annual LFA sonar transmissions hours for each activity was evenly distributed across the model areas in which that activity might occur. The hours for each activity were evenly distributed across the model areas in which that activity might occur because there is an equal chance of activities happening in each model area identified for an activity; the Navy is not aware of any planning factors that would influence the distribution of activity hours among model areas. For example, the execution of vessel and equipment maintenance is estimated to require a total of 64 transmission hours, which are planned to occur only in either Model Area #2 or Model Area #3. Therefore, the 64 transmission hours were equally distributed to Model Areas #2 and #3, or 32 hours in each model area, for vessel and equirpment maintenance activities.

The third step was to determine the number of model areas in which each stock may occur for each activity. The fourth step was to select the maximum per hour impact for each stock that may occur in the model areas for that activity. For instance, for maintenance activities that occur in model areas #2 and #3, if a stock occurs in both model areas, whichever per hour impact estimate for that stock was higher between the two modeling areas was selected for all subsequent calculations for estimating the impacts from mainteance activities.

The final step was to multiply the results of steps two, three, and four to calculate the potential annual impacts per activity, which are then summed across the stocks for a total potential impact for all activities. The maximum estimate of the per hour impact (result of step three) was multiplied by the

Table 4-7. Activities and Transmission Hours Per Year Expected to Occur in each of the 15 Representative Model Areas Under Alternative 1.

Model Area Number/Name	*Activity (Transmission Hours Per Year)*				
	Contractor Crew Training (80)	*MILCREW Training (64)*	*Naval Exercises (72)*	*Maintenance (48)*	*Acoustic Research Testing (96)*
1 /East of Japan		X			X
2 /North Philippine Sea	X	X	X	X	X
3 /West Philippine Sea	X	X	X	X	X
4 /Guam		X	X		X
5 /Sea of Japan		X			X
6 /East China Sea		X			X
7 /South China Sea		X	X		X
8 /Offshore Japan (25 to 40N)		X			X
9 / Offshore Japan (10 to 25N)		X			X
10 /Hawaii-North		X	X		X
11 /Hawaii-South		X	X		X
12 /Offshore Sri Lanka		X			X
13 /Andaman Sea		X			X
14 /Northwest Australia		X			X
15 /Northwest Japan		X			X

Table 4-8. Activities and Transmission Hours Per Year Expected to Occur in each of the 15 Representative Model Areas Under Alternative 2/Preferred Alternative.

Model Area Number/Name	*Activity (Transmission Hours Per Year)*					
	Contractor Crew Training (80)	*MILCREW Training (96)*	*Naval Exercises (96)*	*Maintenance (64)*	*Acoustic Research Testing (160)*	*Years 5+: New LFA System Testing (96)*
1 /East of Japan		X			X	X
2 /North Philippine Sea	X	X	X	X	X	X
3 /West Philippine Sea	X	X	X	X	X	X
4 /Guam		X	X		X	X
5 /Sea of Japan		X			X	X
6 /East China Sea		X			X	X
7 /South China Sea		X	X		X	X
8 /Offshore Japan (25 to 40N)		X			X	X
9 /Offshore Japan (10 to 25N)		X			X	X
10 /Hawaii-North		X	X		X	X
11 /Hawaii-South		X	X		X	X
12 /Offshore Sri Lanka		X			X	X
13 /Andaman Sea		X			X	X
14 /Northwest Australia		X			X	X
15 /Northwest Japan		X			X	X

planned transmission hours for each activity per model area (result of step two) and by the number of model areas in which the stock might occur for that activity (result of step four). The end result is the maximum potential impact per stock for each activity, allowing flexibility for the activity to occur in any season and any of the planned model areas for that activity.

To help explain the modeling process, the potential impacts to the Blainville's beaked whale are described as an illustrative example. Three stocks of Blainville's beaked whale are found in the study area, with the WNP stock occurring in Model Areas #2, 3, 4, 6, and 7; the Hawaii stock found in Model Areas #10 and 11; and the Indian Ocean stock occurring in Model Areas #12, 13, and 14. Contractor training (total of 80 transmission hr) and maintenance (total of 64 transmission hr) may occur in Model Areas #2 or 3, for a total of 144 transmission hr across both model areas or 72 transmission hr per model area (result of step two). Only the WNP stock of Blainville's beaked whale occurs in these two model areas. The potential impact in Model Area #2 is 0.68 behavioral takes per transmission hour, while in Model Area #3, 0.53 behavioral takes per transmission hour were computed. Since 0.68 behavioral takes per transmission hour is the greater or maximum take of the two model areas in which these two activities may occur, 0.68 behavioral takes per transmission hour is selected as the maximum (result of step four). The potential impact of 0.68 behavioral takes per transmission hour is multiplied by72 transmission hours per model area and by 2 model areas (since Blainville's beaked whale may occur in both model areas; result of step three) for a total potential impact of 97.92 behavioral takes for both contractor training and maintenance activities for the WNP stock of Blainville's beaked whales. The algebraic equation for these steps is presented below:

$$0.68\,\frac{takes}{transmission\ hr}\ x\ 72\,\frac{transmssion\ hr}{mission\ area}\ x\ 2\ mission\ areas = 97.92\ takes$$

The LFA sonar use as part of the naval exercises support activity may occur in Model Areas #2, 3, 4, 7, 10, and 11 for a total of 96 transmission hours. This results in 16 transmission hours per model area, when the 96 transmission hours are divided equally among the 6 model areas (result of step two). Two stocks of Blainville's beaked whale might be exposed to transmissions from the naval exercise support activity: the WNP stock occurs in Model Areas #2, 3, 4, and 7 (result of step three is four model areas for the WNP stock) and the Hawaii stock occurs in Model Areas #10 and 11 (result of step three is two model areas for the Hawaii stock). The maximum potential impact in any of the modeling areas in which the WNP stock occurs is 0.94 behavioral takes (result of step four); the maximum potential impact in any of the modeling areas in which the Hawaii stock occurs is 0.95 behavioral takes (result of step four). Thus for the WNP stock, the potential impact of 0.94 behavioral takes per transmission hour is multiplied by 16 transmission hours per model area and by 4 model areas for a total potential impact of 60.16 behavioral takes from SURTASS LFA use during naval exercise support activities. For the Hawaii stock, the potential impact of 0.95 behavioral takes per transmission hour is multiplied by 16 transmission hours per model area and by 2 model areas for a total potential impact of 30.40 behavioral takes from SURTASS LFA use during naval exercises support activities.

The same process occurs for the remaining activities (MILCREW training and acoustic research in years 1 to 4, plus the addition of new LFA sonar system testing in years 5 and beyond), which may occur in all fifteen model areas.

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[31]*	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Antarctic minke whale	ANT	0.07	0.00%	0	0.00%	0	0.00%
Blue whale	CNP	2.14	1.64%	0	0.00%	2	1.64%
	NIND	0.27	0.00%	0	0.00%	0	0.00%
	WNP	4.48	0.00%	52	0.52%	56	0.52%
	SIND	0.37	0.03%	0	0.00%	0	0.03%
Bryde's whale	ECS	2.13	1.56%	7	4.87%	9	6.42%
	Hawaii	3.73	0.43%	0	0.00%	4	0.43%
	WNP	139.65	0.82%	145	0.63%	285	1.45%
	NIND	2.53	0.02%	2	0.02%	5	0.04%
	SIND	3.13	0.02%	1	0.01%	4	0.03%
Common minke whale	Hawaii	190.46	0.76%	201	0.82%	392	1.57%
	IND	510.04	0.18%	284	0.09%	794	0.27%
	WNP JW	2.07	0.08%	0	0.00%	2	0.08%
	WNP OE	816.05	3.33%	831	3.33%	1,647	6.65%
	YS	35.83	0.80%	85	1.89%	121	2.69%
Fin whale	ECS	1.18	0.23%	4	0.89%	6	1.12%
	Hawaii	2.39	1.57%	0	0.00%	2	1.57%
	IND	0.09	0.00%	0	0.00%	0	0.00%
	SIND	8.23	0.02%	6	0.01%	14	0.03%
	WNP	167.36	1.84%	1,469	15.76%	1,636	17.60%
Humpback whale	CNP stock and Hawaii DPS	116.98	1.16%	207	2.07%	324	3.22%
	WAU stock and DPS	0.53	0.00%	0	0.00%	1	0.00%

31 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; JW=Sea of Japan; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[31]	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Humpback whale (Continued)	WNP stock and DPS	230.16	17.40%	1,862	140.28%	2,092	157.68%
North Pacific right whale	WNP	2.42	0.21%	53	5.78%	56	5.99%
Omura's whale	NIND	2.53	0.02%	2	0.02%	5	0.04%
	SIND	3.13	0.02%	0	0.00%	3	0.02%
	WNP	10.23	0.60%	0	0.00%	10	0.60%
Sei whale	Hawaii	6.49	1.64%	6	1.64%	13	3.27%
	SIND	0.10	0.00%	0	0.00%	0	0.00%
	NP	71.64	1.03%	1,911	27.33%	1,983	28.36%
	NIND	2.46	0.02%	0	0.00%	2	0.02%
Western North Pacific gray whale	WNP stock and Western DPS	0.29	0.21%	0	0.00%	0	0.21%
Baird's beaked whale	WNP	1,716.62	30.16%	0	0.00%	1,717	30.16%
Blainville's beaked whale	Hawaii	43.07	2.03%	0	0.00%	43	2.03%
	WNP	201.53	2.47%	0	0.00%	202	2.47%
	IND	29.63	0.17%	0	0.00%	30	0.17%
Common bottlenose dolphin	4-Islands	3.21	1.70%	0	0.00%	3	1.70%
	Hawaii Island	0.28	0.24%	0	0.00%	0	0.24%
	Hawaii Pelagic	65.21	0.28%	0	0.00%	65	0.28%
	IA	66.12	0.07%	0	0.00%	66	0.07%
	IND	1,190.43	39.67%	0	0.00%	1,190	39.67%
	Japanese Coastal	1,391.09	39.54%	0	0.00%	1,391	39.54%
	Kauai/Niihau	9.07	4.91%	0	0.00%	9	4.91%
	Oahu	26.16	3.54%	0	0.00%	26	3.54%
	WNP Northern Offshore	363.00	0.36%	0	0.00%	363	0.36%
	WNP Southern Offshore	2,107.38	5.13%	0	0.00%	2,107	5.13%

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[31]	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Common bottlenose dolphin (Continued)	WAU	396.81	13.22%	0	0.00%	397	13.22%
Common dolphin	IND	32.70	0.00%	0	0.00%	33	0.00%
	WNP	130,453.81	7.94%	0	0.00%	130,454	7.94%
Cuvier's beaked whale	Hawaii	178.28	5.84%	0	0.00%	178	5.84%
	IND	144.30	0.53%	0	0.00%	144	0.53%
	SH	48.10	0.07%	0	0.00%	48	0.07%
	WNP	4,677.12	5.24%	0	0.00%	4,677	5.24%
Dall's porpoise	SOJ *dalli* type	383.97	0.22%	0	0.00%	384	0.22%
	WNP dalli ecotype	13,785.02	8.51%	0	0.00%	13,785	8.51%
	WNP *truei* ecotype	304.55	0.18%	0	0.00%	305	0.18%
Deraniyagala's beaked whale	IND	98.60	0.58%	0	0.00%	99	0.58%
	NP	136.74	0.56%	0	0.00%	137	0.56%
Dwarf sperm whale	Hawaii	449.18	2.55%	0	0.00%	449	2.55%
	IND	1.90	0.03%	0	0.00%	2	0.03%
	WNP	314.98	0.09%	0	0.00%	315	0.09%
False killer whale	Hawaii Pelagic	39.57	2.55%	0	0.00%	40	2.55%
	IA	159.13	1.63%	0	0.00%	159	1.63%
	IND	7.33	0.00%	0	0.00%	7	0.00%
	Main Hawaiian Islands Insular stock and DPS	0.47	0.28%	0	0.00%	0	0.28%
	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%
	WNP	540.22	3.25%	0	0.00%	540	3.25%
Fraser's dolphin	CNP	363.33	2.15%	0	0.00%	363	2.15%
	Hawaii	1,332.71	2.60%	0	0.00%	1,333	2.60%
	IND	58.10	0.03%	0	0.00%	58	0.03%

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[31]	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Fraser's dolphin (Continued)	WNP	1,787.92	0.91%	0	0.00%	1,788	0.91%
Ginkgo-toothed beaked whale	IND	7.21	0.04%	0	0.00%	7	0.04%
	NP	210.99	0.91%	0	0.00%	211	0.91%
Harbor porpoise	WNP	228.71	0.73%	0	0.00%	229	0.73%
Hubbs' beaked whale	NP	16.38	0.07%	0	0.00%	16	0.07%
Indo-Pacific bottlenose dolphin	IND	7.07	0.09%	0	0.00%	7	0.09%
Killer whale	Hawaii	4.39	3.02%	0	0.00%	4	3.02%
	IND	248.03	1.97%	0	0.00%	248	1.97%
	WNP	6,549.20	53.41%	0	0.00%	6,549	53.41%
Kogia spp.	WNP	1,016.10	0.24%	0	0.00%	1,016	0.24%
Longman's beaked whale	Hawaii	506.79	6.66%	0	0.00%	507	6.66%
	IND	203.27	1.20%	0	0.00%	203	1.20%
	WNP	324.88	4.24%	0	0.00%	325	4.24%
Melon-headed whale	Hawaiian Islands	124.01	1.42%	0	0.00%	124	1.42%
	IND	251.03	0.40%	0	0.00%	251	0.40%
	Kohala Resident	6.33	0.28%	0	0.00%	6	0.28%
	WNP	1,237.96	2.20%	0	0.00%	1,238	2.20%
Mesoplodon spp.	WNP	6.49	0.03%	0	0.00%	6	0.03%
Northern right whale dolphin	NP	0.16	0.00%	0	0.00%	0	0.00%
Pacific white-sided dolphin	NP	6,092.68	0.68%	0	0.00%	6,093	0.68%
Pantropical spotted dolphin	4-Islands	21.72	9.87%	0	0.00%	22	9.87%
	Hawaii Island	15.49	7.04%	0	0.00%	15	7.04%
	Hawaiian Pelagic	203.91	0.38%	0	0.00%	204	0.38%
	IND	194.53	0.03%	0	0.00%	195	0.03%
	Oahu	15.87	7.23%	0	0.00%	16	7.23%

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[31]	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Pantropical spotted dolphin (Continued)	WNP	3,860.43	2.99%	0	0.00%	3,860	2.99%
Pygmy killer whale	Hawaii	269.64	2.55%	0	0.00%	270	2.55%
	IND	37.20	0.17%	0	0.00%	37	0.17%
	WNP	683.55	2.18%	0	0.00%	684	2.18%
Pygmy sperm whale	Hawaii	182.42	2.55%	0	0.00%	182	2.55%
	IND	0.18	0.00%	0	0.00%	0	0.00%
	WNP	131.13	0.05%	0	0.00%	131	0.05%
Risso's dolphin	Hawaii	283.95	2.46%	0	0.00%	284	2.46%
	IA	674.37	0.45%	0	0.00%	674	0.45%
	WNP	5,309.63	2.34%	0	0.00%	5,310	2.34%
	IND	2,888.07	0.63%	0	0.00%	2,888	0.63%
Rough-toothed dolphin	Hawaii	146.06	0.19%	0	0.00%	146	0.19%
	IND	25.90	0.00%	0	0.00%	26	0.00%
	WNP	1,045.55	20.88%	0	0.00%	1,046	20.88%
Short-finned pilot whale	Hawaii	271.39	1.37%	0	0.00%	271	1.37%
	IND	953.47	0.37%	0	0.00%	953	0.37%
	WNP Northern Ecotype	327.84	1.58%	0	0.00%	328	1.58%
	WNP Southern Ecotype	4,442.86	14.09%	0	0.00%	4,443	14.09%
Southern bottlenose whale	IND	14.02	0.00%	0	0.00%	14	0.00%
Spade-toothed beaked whale	IND	9.88	0.06%	0	0.00%	10	0.06%
Sperm whale	Hawaii	72.58	1.61%	0	0.00%	73	1.61%
	NIND	20.82	0.09%	0	0.00%	21	0.09%
	NP	957.91	0.85%	0	0.00%	958	0.85%

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[31]	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Sperm whale (Continued)	SIND	9.81	0.04%	0	0.00%	10	0.04%
Spinner dolphin	Hawaii Island	0.85	0.14%	0	0.00%	1	0.14%
	Hawaii Pelagic	131.28	3.92%	0	0.00%	131	3.92%
	IND	149.80	0.03%	0	0.00%	150	0.03%
	Kauai/Niihau	56.95	9.49%	0	0.00%	57	9.49%
	Kure/Midway Atoll	0.00	0.00%	0	0.00%	0	0.00%
	Oahu/4-Islands	13.51	3.83%	0	0.00%	14	3.83%
	Pearl and Hermes Reef	0.00	0.00%	0	0.00%	0	0.00%
	WNP	399.30	0.00%	0	0.00%	399	0.00%
Stejneger's beaked whale	WNP	125.60	1.56%	0	0.00%	126	1.56%
Striped dolphin	Hawaii	184.40	0.28%	0	0.00%	184	0.28%
	IND	3,162.17	0.47%	0	0.00%	3,162	0.47%
	Japanese Coastal	2,776.49	14.17%	0	0.00%	2,776	14.17%
	WNP Northern Offshore	166.84	0.04%	0	0.00%	167	0.04%
	WNP Southern Offshore	2,487.30	4.76%	0	0.00%	2,487	4.76%
Hawaiian monk seal	Hawaii	6.27	0.44%	0	0.00%	6	0.44%
Northern fur seal	Western Pacific	5,296.89	1.07%	0	0.00%	5,297	1.07%
Ribbon seal	NP	9,657.04	2.64%	159	0.04%	9,816	2.69%
Spotted seal	Alaska stock/Bering Sea DPS	49,526.87	10.76%	924	0.20%	50,451	10.96%
	Southern stock and DPS	0.27	0.02%	0	0.00%	0	0.02%

Table 4-9. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock***[31]	***Maximum Annual MMPA Level B Harassment: Alternative 1***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
Steller sea lion	Western/Asian stock, Western DPS	1.36	0.00%	0	0.00%	1	0.00%

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[32]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Antarctic minke whale	ANT	0.14	0.00%	0	0.00%	0	0.00%
Blue whale	CNP	3.12	2.39%	0	0.00%	3	2.39%
	NIND	0.43	0.00%	0	0.00%	0	0.00%
	WNP	6.58	0.07%	83	0.83%	90	0.90%
	SIND	0.81	0.07%	0	0.00%	1	0.07%
Bryde's whale	ECS	3.41	2.49%	11	7.79%	14	10.28%
	Hawaii	5.44	0.62%	0	0.00%	5	0.62%
	WNP	184.11	1.08%	194	0.86%	378	1.94%
	NIND	4.05	0.04%	4	0.04%	8	0.07%
	SIND	5.01	0.04%	2	0.02%	7	0.05%
Common minke whale	Hawaii	277.85	1.10%	294	1.19%	572	2.30%
	IND	816.07	0.28%	455	0.14%	1,271	0.43%
	WNP JW	3.31	0.12%	0	0.00%	3	0.12%
	WNP OE	1,053.71	4.29%	1,073	4.29%	2,127	8.59%
	YS	53.89	1.20%	135	2.99%	189	4.20%
Fin whale	ECS	1.88	0.37%	7	1.42%	9	1.80%
	Hawaii	3.49	2.30%	0	0.00%	3	2.30%
	IND	0.14	0.00%	0	0.00%	0	0.00%
	SIND	13.17	0.04%	9	0.02%	22	0.05%
	WNP	259.28	2.85%	2,299	24.70%	2,558	27.55%

32 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; JW=Sea of Japan; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[32]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Humpback whale	CNP stock and Hawaii DPS	175.75	1.74%	311	3.11%	487	4.85%
	WAU stock and DPS	0.85	0.00%	0	0.00%	1	0.00%
	WNP stock and DPS	315.07	23.82%	2,788	210.03%	3,103	233.84%
North Pacific right whale	WNP	3.65	0.33%	85	9.24%	89	9.57%
Omura's whale	NIND	4.05	0.04%	4	0.04%	8	0.07%
	SIND	5.01	0.04%	0	0.00%	5	0.04%
	WNP	13.68	0.81%	0	0.00%	14	0.81%
Sei whale	Hawaii	9.46	2.39%	9	2.39%	19	4.78%
	SIND	0.16	0.00%	0	0.00%	0	0.00%
	NP	114.31	1.63%	3,058	43.73%	3,172	45.37%
	NIND	3.93	0.04%	0	0.00%	4	0.04%
Western North Pacific gray whale	WNP stock and Western DPS	0.45	0.33%	0	0.00%	0	0.00%
Baird's beaked whale	WNP	2,746.60	48.26%	0	0.00%	2,747	48.26%
Blainville's beaked whale	Hawaii	35.06	1.83%	0	0.00%	35	1.83%
	WNP	269.35	3.30%	0	0.00%	269	3.30%
	IND	47.41	0.27%	0	0.00%	47	0.27%
Common bottlenose dolphin	4-Islands	4.68	2.48%	0	0.00%	5	2.48%
	Hawaii Island	0.41	0.34%	0	0.00%	0	0.00%
	Hawaii Pelagic	95.14	0.41%	0	0.00%	95	0.41%
	IA	104.12	0.11%	0	0.00%	104	0.11%
	IND	1,128.21	0.14%	0	0.00%	1,128	0.14%
	Japanese Coastal	1,686.43	47.94%	0	0.00%	1,686	47.94%

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[32]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Common bottlenose dolphin (Continued)	Kauai/Niihau	13.23	7.16%	0	0.00%	13	7.16%
	Oahu	38.16	5.17%	0	0.00%	38	5.17%
	WNP Northern Offshore	580.80	0.57%	0	0.00%	581	0.57%
	WNP Southern Offshore	2,725.54	6.63%	0	0.00%	2,726	6.63%
	WAU	634.90	21.16%	0	0.00%	635	21.16%
Common dolphin	IND	52.32	0.00%	0	0.00%	52	0.00%
	WNP	203,871.30	12.24%	0	0.00%	203,871	12.24%
Cuvier's beaked whale	Hawaii	21.91	3.03%	0	0.00%	22	3.03%
	IND	230.88	0.85%	0	0.00%	231	0.85%
	SH	76.96	0.11%	0	0.00%	77	0.11%
	WNP	6,945.66	7.78%	0	0.00%	6,946	7.78%
Dall's porpoise	SOJ *dalli* type	614.35	0.36%	0	0.00%	614	0.36%
	WNP *dalli* ecotype	22,056.04	13.62%	0	0.00%	22,056	13.62%
	WNP *truei* ecotype	487.28	0.28%	0	0.00%	487	0.28%
Deraniyagala's beaked whale	IND	157.76	0.92%	0	0.00%	158	0.92%
	NP	189.69	0.77%	0	0.00%	190	0.77%
Dwarf sperm whale	Hawaii	655.27	3.72%	0	0.00%	655	3.72%
	IND	3.04	0.05%	0	0.00%	3	0.05%
	WNP	486.15	0.14%	0	0.00%	486	0.14%
False killer whale	Hawaii Pelagic	57.73	3.72%	0	0.00%	58	3.72%
	IA	251.87	2.59%	0	0.00%	252	2.59%
	IND	11.73	0.00%	0	0.00%	12	0.01%

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[32]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
False killer whale (Continued)	Main Hawaiian Islands Insular stock and DPS	0.69	0.41%	0	0.00%	1	0.41%
	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%
	WNP	1,350.01	8.15%	0	0.00%	1,350	8.15%
Fraser's dolphin	CNP	546.45	3.24%	0	0.00%	546	3.24%
	Hawaii	1,944.18	3.79%	0	0.00%	1,944	3.79%
	IND	92.96	0.05%	0	0.00%	93	0.05%
	WNP	2,287.28	1.16%	0	0.00%	2,287	1.16%
Ginkgo-toothed beaked whale	IND	11.54	0.07%	0	0.00%	12	0.07%
	NP	283.49	1.21%	0	0.00%	283	1.21%
Harbor porpoise	WNP	365.94	1.17%	0	0.00%	366	1.17%
Hubbs' beaked whale	NP	26.20	0.11%	0	0.00%	26	0.11%
Indo-Pacific bottlenose dolphin	IND	11.31	0.14%	0	0.00%	11	0.14%
Killer whale	Hawaii	6.41	4.41%	0	0.00%	6	4.41%
	IND	396.85	3.15%	0	0.00%	397	3.15%
	WNP	10,470.13	85.37%	0	0.00%	10,470	85.37%
Kogia spp.	WNP	1,316.59	0.31%	0	0.00%	1,317	0.31%
Longman's beaked whale	Hawaii	739.32	5.01%	0	0.00%	739	5.01%
	IND	325.23	1.92%	0	0.00%	325	1.92%
	WNP	470.53	6.14%	0	0.00%	471	6.14%
Melon-headed whale	Hawaiian Islands	180.90	2.07%	0	0.00%	181	2.07%

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[32]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Melon-headed whale (Continued)	IND	401.65	0.64%	0	0.00%	402	0.64%
	Kohala Resident	9.23	0.41%	0	0.00%	9	0.41%
	WNP	1,605.35	2.87%	0	0.00%	1,605	2.87%
Mesoplodon spp.	WNP	10.38	0.05%	0	0.00%	10	0.05%
Northern right whale dolphin	NP	0.26	0.00%	0	0.00%	0	0.00%
Pacific white-sided dolphin	NP	9,530.41	1.05%	0	0.00%	9,530	1.05%
Pantropical spotted dolphin	4-Islands	31.69	14.40%	0	0.00%	32	14.40%
	Hawaii Island	22.60	10.26%	0	0.00%	23	10.26%
	Hawaiian Pelagic	297.46	0.55%	0	0.00%	297	0.55%
	IND	311.25	0.05%	0	0.00%	311	0.05%
	Oahu	23.15	10.54%	0	0.00%	23	10.54%
	WNP	5,104.81	3.95%	0	0.00%	5,105	3.95%
Pygmy killer whale	Hawaii	393.36	3.72%	0	0.00%	393	3.72%
	IND	59.52	0.27%	0	0.00%	60	0.27%
	WNP	901.17	2.87%	0	0.00%	901	2.87%
Pygmy sperm whale	Hawaii	266.12	3.72%	0	0.00%	266	3.72%
	IND	0.28	0.00%	0	0.00%	0	0.00%
	WNP	202.54	0.07%	0	0.00%	203	0.07%
Risso's dolphin	Hawaii	414.23	3.58%	0	0.00%	414	3.58%
	IA	1,045.41	0.70%	0	0.00%	1,045	0.70%
	WNP	4,347.00	3.07%	0	0.00%	4,347	3.07%
	IND	4,620.91	1.01%	0	0.00%	4,621	1.01%

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[32]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Rough-toothed dolphin	Hawaii	213.07	0.28%	0	0.00%	213	0.28%
	IND	41.44	0.00%	0	0.00%	41	0.00%
	WNP	1,439.43	28.74%	0	0.00%	1,439	28.74%
Short-finned pilot whale	Hawaii	395.90	2.00%	0	0.00%	396	2.00%
	IND	1,525.55	0.59%	0	0.00%	1,526	0.59%
	WNP Northern Ecotype	524.55	2.52%	0	0.00%	525	2.52%
	WNP Southern Ecotype	5,682.72	18.03%	0	0.00%	5,683	18.03%
Southern bottlenose whale	IND	22.44	0.00%	0	0.00%	22	0.00%
Spade-toothed beaked whale	IND	15.80	0.09%	0	0.00%	16	0.09%
Sperm whale	Hawaii	105.88	2.34%	0	0.00%	106	2.34%
	NIND	33.32	0.14%	0	0.00%	33	0.14%
	NP	1,429.07	1.28%	0	0.00%	1,429	1.28%
	SIND	15.70	0.07%	0	0.00%	16	0.07%
Spinner dolphin	Hawaii Island	1.24	0.21%	0	0.00%	1	0.21%
	Hawaii Pelagic	191.51	5.72%	0	0.00%	192	5.72%
	IND	239.68	0.05%	0	0.00%	240	0.05%
	Kauai/Niihau	83.08	13.85%	0	0.00%	83	13.85%
	Kure/Midway Atoll	0.00	0.00%	0	0.00%	0	0.00%
	Oahu/4-Islands	19.70	2.88%	0	0.00%	20	2.88%
	Pearl and Hermes Reef	0.00	0.00%	0	0.00%	0	0.00%
	WNP	574.02	0.00%	0	0.00%	574	0.00%
Stejneger's beaked whale	WNP	200.96	2.49%	0	0.00%	201	2.49%

Table 4-10. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[32]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Striped dolphin	Hawaii	269.01	0.41%	0	0.00%	269	0.41%
	IND	5,059.47	0.75%	0	0.00%	5,059	0.75%
	Japanese Coastal	3,365.96	17.18%	0	0.00%	3,366	17.18%
	WNP Northern Offshore	266.95	0.07%	0	0.00%	267	0.07%
	WNP Southern Offshore	3,282.31	6.28%	0	0.00%	3,282	6.28%
Hawaiian monk seal	Hawaii	9.71	0.69%	0	0.00%	10	0.69%
Northern fur seal	Western Pacific	8,475.02	1.71%	0	0.00%	8,475	1.71%
Ribbon seal	NP	15,451.27	4.23%	254	0.07%	15,705	4.30%
Spotted seal	Alaska stock/Bering Sea DPS	79,242.99	17.21%	1,479	0.32%	80,722	17.53%
	Southern stock and DPS	0.43	0.04%	0	0.00%	0	0.00%
Steller sea lion	Western/Asian stock, Western DPS	2.17	0.00%	0	0.00%	2	0.00%

Table 4-11. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[33]***	***Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
Antarctic minke whale	ANT	0.15	0.00%	0	0.00%	0	0.00%
Blue whale	CNP	3.73	2.85%	0	0.00%	4	2.85%
	NIND	0.59	0.00%	0	0.00%	1	0.00%
	WNP	8.44	0.00%	114	1.14%	123	1.14%
	SIND	0.81	0.07%	0	0.00%	1	0.07%
Bryde's whale	ECS	4.69	3.42%	15	10.71%	19	14.13%
	Hawaii	6.50	0.74%	0	0.00%	6	0.74%
	WNP	211.47	1.24%	226	1.02%	437	2.26%
	NIND	5.57	0.05%	5	0.05%	10	0.10%
	SIND	6.89	0.05%	2	0.02%	9	0.07%
Common minke whale	Hawaii	331.63	1.32%	351	1.43%	682	2.74%
	IND	1,122.10	0.39%	626	0.20%	1,748	0.59%
	WNP JW	4.55	0.17%	0	0.00%	5	0.17%
	WNP OE	1,191.15	4.85%	1,213	4.85%	2,404	9.71%
	YS	67.65	1.51%	183	4.06%	250	5.57%
Fin whale	ECS	2.59	0.51%	10	1.96%	12	2.47%
	Hawaii	4.17	2.74%	0	0.00%	4	2.74%
	IND	0.20	0.00%	0	0.00%	0	0.00%
	SIND	18.11	0.05%	12	0.02%	30	0.07%

33 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; JW=Sea of Japan; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table 4-11. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	Stock[33]	Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+					
		Behavior (Individuals)	Behavior (Percent Stock)	TTS (Individuals)	TTS (Percent Stock)	Total Level B (Individuals)	Total Level B (Percent Stock)
Fin whale (Continued)	WNP	347.52	3.81%	3,107	33.42%	3,455	37.23%
Humpback whale	CNP stock and Hawaii DPS	220.25	2.19%	391	3.91%	611	6.10%
	WAU stock and DPS	1.17	0.00%	0	0.00%	1	0.00%
	WNP stock and DPS	381.92	28.87%	3,884	292.62%	4,266	321.49%
North Pacific right whale	WNP	4.77	0.44%	117	12.71%	122	13.15%
Omura's whale	NIND	5.57	0.05%	5	0.05%	10	0.10%
	SIND	6.89	0.05%	0	0.00%	7	0.05%
	WNP	15.97	0.95%	0	0.00%	16	0.95%
Sei whale	Hawaii	11.29	2.85%	11	2.85%	22	5.70%
	SIND	0.22	0.00%	0	0.00%	0	0.00%
	NP	156.58	2.23%	4,204	60.13%	4,361	62.37%
	NIND	5.40	0.05%	0	0.00%	5	0.05%
Western North Pacific gray whale	WNP stock and Western DPS	0.59	0.44%	0	0.00%	1	0.44%
Baird’s beaked whale	WNP	3,776.57	66.36%	0	0.00%	3,777	66.36%
Blainville’s beaked whale	Hawaii	47.22	2.40%	0	0.00%	47	2.40%
	WNP	311.35	3.82%	0	0.00%	311	3.82%
	IND	65.19	0.37%	0	0.00%	65	0.37%
Common bottlenose dolphin	4-Islands	5.59	2.96%	0	0.00%	6	2.96%
	Hawaii Island	0.49	0.41%	0	0.00%	0	0.00%
	Hawaii Pelagic	113.55	0.49%	0	0.00%	114	0.49%
	IA	140.04	0.15%	0	0.00%	140	0.15%

Table 4-11. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[33]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Common bottlenose dolphin (Continued)	IND	1,551.29	0.20%	0	0.00%	1,551	0.20%
	Japanese Coastal	1,789.16	50.86%	0	0.00%	1,789	50.86%
	Kauai/Niihau	15.79	8.55%	0	0.00%	16	8.55%
	Oahu	45.55	6.17%	0	0.00%	46	6.17%
	WNP Northern Offshore	798.60	0.78%	0	0.00%	799	0.78%
	WNP Southern Offshore	3,062.72	7.45%	0	0.00%	3,063	7.45%
	WAU	872.98	29.09%	0	0.00%	873	29.09%
Common dolphin	IND	71.94	0.00%	0	0.00%	72	0.00%
	WNP	275,078.61	16.08%	0	0.00%	275,079	16.08%
Cuvier's beaked whale	Hawaii	26.15	3.62%	0	0.00%	26	3.62%
	IND	317.46	1.17%	0	0.00%	317	1.17%
	SH	105.82	0.15%	0	0.00%	106	0.15%
	WNP	8,980.39	10.04%	0	0.00%	8,980	10.04%
Dall's porpoise	SOJ *dalli* type	844.73	0.49%	0	0.00%	845	0.49%
	WNP *dalli* ecotype	30,327.05	18.72%	0	0.00%	30,327	18.72%
	WNP *truei* ecotype	670.01	0.39%	0	0.00%	670	0.39%
Deraniyagala's beaked whale	IND	216.92	1.27%	0	0.00%	217	1.27%
	NP	222.15	0.91%	0	0.00%	222	0.91%
Dwarf sperm whale	Hawaii	782.10	4.44%	0	0.00%	782	4.44%
	IND	4.18	0.07%	0	0.00%	4	0.07%
	WNP	635.07	0.18%	0	0.00%	635	0.18%
False killer whale	Hawaii Pelagic	68.90	4.44%	0	0.00%	69	4.44%

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Marine Mammal Species	*Stock*[33]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
False killer whale (Continued)	IA	341.17	3.51%	0	0.00%	341	3.51%
	IND	16.13	0.00%	0	0.00%	16	0.00%
	Main Hawaiian Islands Insular stock and DPS	0.82	0.49%	0	0.00%	1	0.49%
	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%
	WNP	1,596.09	9.63%	0	0.00%	1,596	9.63%
Fraser's dolphin	CNP	685.97	4.06%	0	0.00%	686	4.06%
	Hawaii	2,320.48	4.52%	0	0.00%	2,320	4.52%
	IND	127.82	0.07%	0	0.00%	128	0.07%
	WNP	2,558.59	1.29%	0	0.00%	2,559	1.29%
Ginkgo-toothed beaked whale	IND	15.86	0.10%	0	0.00%	16	0.10%
	NP	328.95	1.40%	0	0.00%	329	1.40%
Harbor porpoise	WNP	503.16	1.61%	0	0.00%	503	1.61%
Hubbs' beaked whale	NP	36.03	0.15%	0	0.00%	36	0.15%
Indo-Pacific bottlenose dolphin	IND	15.55	0.20%	0	0.00%	16	0.20%
Killer whale	Hawaii	7.65	5.26%	0	0.00%	8	5.26%
	IND	545.67	4.33%	0	0.00%	546	4.33%
	WNP	14,387.33	117.31%	0	0.00%	14,387	117.31%
Kogia spp.	WNP	1,494.11	0.35%	0	0.00%	1,494	0.35%
Longman's beaked whale	Hawaii	882.41	11.59%	0	0.00%	882	11.59%

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Marine Mammal Species	*Stock[33]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Longman's beaked whale (Continued)	IND	447.19	2.64%	0	0.00%	447	2.64%
	WNP	574.04	7.50%	0	0.00%	574	7.50%
Melon-headed whale	Hawaiian Islands	215.92	2.47%	0	0.00%	216	2.47%
	IND	552.27	0.88%	0	0.00%	552	0.88%
	Kohala Resident	11.02	0.49%	0	0.00%	11	0.49%
	WNP	1,823.43	3.27%	0	0.00%	1,823	3.27%
Mesoplodon spp.	WNP	14.28	0.07%	0	0.00%	14	0.07%
Northern right whale dolphin	NP	0.36	0.00%	0	0.00%	0	0.00%
Pacific white-sided dolphin	NP	12,890.33	1.41%	0	0.00%	12,890	1.41%
Pantropical spotted dolphin	4-Islands	37.82	17.18%	0	0.00%	38	17.18%
	Hawaii Island	26.97	12.25%	0	0.00%	27	12.25%
	Hawaiian Pelagic	355.04	0.66%	0	0.00%	355	0.66%
	IND	427.97	0.07%	0	0.00%	428	0.07%
	Oahu	27.63	12.58%	0	0.00%	28	12.58%
	WNP	5,883.15	4.53%	0	0.00%	5,883	4.53%
Pygmy killer whale	Hawaii	469.49	4.44%	0	0.00%	469	4.44%
	IND	81.84	0.37%	0	0.00%	82	0.37%
	WNP	1,035.09	3.30%	0	0.00%	1,035	3.30%
Pygmy sperm whale	Hawaii	317.62	4.44%	0	0.00%	318	4.44%
	IND	0.39	0.00%	0	0.00%	0	0.00%
	WNP	264.88	0.09%	0	0.00%	265	0.09%

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Marine Mammal Species	*Stock*[33]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Risso's dolphin	Hawaii	494.40	4.28%	0	0.00%	494	4.28%
	IA	1,374.49	0.92%	0	0.00%	1,374	0.92%
	WNP	4,914.00	3.47%	0	0.00%	4,914	3.47%
	IND	6,353.75	1.39%	0	0.00%	6,354	1.39%
Rough-toothed dolphin	Hawaii	254.31	0.33%	0	0.00%	254	0.33%
	IND	56.98	0.00%	0	0.00%	57	0.00%
	WNP	1,731.81	34.56%	0	0.00%	1,732	34.56%
Short-finned pilot whale	Hawaii	472.53	2.38%	0	0.00%	473	2.38%
	IND	2,097.63	0.81%	0	0.00%	2,098	0.81%
	WNP Northern Ecotype	721.26	3.47%	0	0.00%	721	3.47%
	WNP Southern Ecotype	6,302.66	19.99%	0	0.00%	6,303	19.99%
Southern bottlenose whale	IND	30.85	0.00%	0	0.00%	31	0.00%
Spade-toothed beaked whale	IND	21.73	0.12%	0	0.00%	22	0.12%
Sperm whale	Hawaii	126.38	2.80%	0	0.00%	126	2.80%
	NIND	45.81	0.20%	0	0.00%	46	0.20%
	NP	1,855.21	1.68%	0	0.00%	1,855	1.68%
	SIND	21.58	0.10%	0	0.00%	22	0.10%
Spinner dolphin	Hawaii Island	1.48	0.25%	0	0.00%	1	0.25%
	Hawaii Pelagic	228.58	6.82%	0	0.00%	229	6.82%
	IND	329.56	0.07%	0	0.00%	330	0.07%
	Kauai/Niihau	99.16	16.53%	0	0.00%	99	16.53%

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Marine Mammal Species	*Stock*[33]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Spinner dolphin (Continued)	Kure/Midway Atoll	0.00	0.00%	0	0.00%	0	0.00%
	Oahu/4-Islands	23.52	6.66%	0	0.00%	24	6.66%
	Pearl and Hermes Reef	0.00	0.00%	0	0.00%	0	0.00%
	WNP	720.54	0.00%	0	0.00%	721	0.00%
Stejneger's beaked whale	WNP	276.32	3.42%	0	0.00%	276	3.42%
Striped dolphin	Hawaii	321.08	0.49%	0	0.00%	321	0.49%
	IND	6,956.77	1.03%	0	0.00%	6,957	1.03%
	Japanese Coastal	3,571.00	18.23%	0	0.00%	3,571	18.23%
	WNP Northern Offshore	367.06	0.10%	0	0.00%	367	0.10%
	WNP Southern Offshore	3,728.63	7.13%	0	0.00%	3,729	7.13%
Hawaiian monk seal	Hawaii	12.75	0.91%	0	0.00%	13	0.91%
Northern fur seal	Western Pacific	11,653.16	2.35%	0	0.00%	11,653	2.35%
Ribbon seal	NP	21,245.50	5.82%	350	0.10%	21,595	5.92%
Spotted seal	Alaska stock/Bering Sea DPS	108,959.11	23.66%	2,034	0.44%	110,993	24.10%
	Southern stock and DPS	0.59	0.05%	0	0.00%	1	0.05%
Steller sea lion	Western/Asian stock, Western DPS	2.98	0.00%	0	0.00%	3	0.00%

To develop the overall potential impact from all SURTASS LFA sonar tranmsissions within a year to each marine mammal stock, the potential impacts to each stock from each individual activity are then summed to derive the total maximum potential impact on an annual basis for Alternative 1 (Table 4-9) and Alternative 2 in Years 1 to 4 (Table 4-10) and Years 5 and beyond (Table 4-11). This is a conservative estimate since it is based on the maximum potential impact to a stock across all model areas in which an activity may occur. Therefore, if the activity occurs in a different model area than the area where the maximum potential impact was predicted, the actual potential impact could be less than that estimated. However, since the Navy cannot forecast where a specific activity may be conducted this far in advance, this maximum estimate provides the Navy with the flexibility to conduct its training and testing activities across all model areas identified for each activity.

- **Summary**

Non-auditory impacts to marine mammals from active sonar transmissions may include direct acoustic impact on tissue, indirect acoustic impact on tissue surrounding a structure, and acoustically mediated bubble growth within tissues from supersaturated dissolved nitrogen gas. No existing research studies or observations in the past 16 years of LFA sonar operation provide evidence that LFA sonar has the potential to cause non-auditory impacts.

The potential for masking and physiological stress was assessed with the best available data. The potential for masking from LFA sonar signals is limited because continuous-frequency waveforms have durations of no longer than 10 seconds and frequency-modulated waveforms have limited bandwidths (30 Hz). Furthermore, when LFA sonar is in operation, the source is active only 7.5 to 10 percent of the time, with a maximum 20 percent duty cycle, which means that for 90 to 92.5 percent of the time, there is no potential for masking. Much more research is needed to begin to understand the potential for physiological stress in marine mammals during noise exposure scenarios. The existing data suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

The potential for auditory impacts (PTS and TTS) and behavioral change was quantitatively assessed. NMFS (2018) has published acoustic guidance that specifically identifies the received levels, or acoustic threshold levels, above which individual marine mammals are predicted to experience changes in their hearing sensitivity for acute, incidental exposure to underwater sound. The results of the LFS SRP were used to derive the LFA risk continuum function, from which the potential for biologically significant behavioral response is calculated.

The potential for PTS (MMPA Level A incidental harassment) is considered within the context of the mitigation and monitoring efforts that would occur whenever SURTASS LFA sonar is transmitting. Mitigation monitoring is designed to detect marine mammals before they are exposed to 180 dB SPL RLs. The NMFS (2018) acoustic guidance for estimating the potential for PTS defines weighted thresholds as sound exposure levels. The length of a nominal LFA sonar transmission is 60 sec, which lowers the thresholds by approximately 18 dB SEL (10xlog10 [60 sec] =17.8) if the assumption is made that all RLs are at the same SPL. In addition to signal duration, hearing sensitivity must be considered. If transmissions at 300 Hz are considered for this example, as it is in about the middle of the frequency range of LFA sonar transmissions (100 to 500 Hz), the thresholds must be appropriately weighted to account for each functional hearing group’s sensitivity. This results in an increase in the thresholds of approximately 1.5, 56, 56, 15, and 20 dB, respectively, for LF, MF, HF, PW, and OW groups when considering a signal at 300 Hz. Based on simple spherical spreading (i.e., a transmission loss [TL] based on 20 × log10 [range in meters]), all functional hearing groups except LF cetaceans would need to remain within 22 ft (7 m) for the entirety of an LFA sonar transmission (60 sec) to potentially experience PTS. An LF cetacean would need to remain within 135 ft (41 m) for the entirety of an LFA sonar transmission to potentially experience PTS. Based on the mitigation procedures used during SURTASS LFA sonar activities, the chances of this occurring are negligible. Therefore, no PTS (MMPA Level A harassment) is expected with the implementation of mitigation measures.

The impact to marine mammals anticipated from exposure to SURTASS LFA sonar transmissions is MMPA Level B harassment. For most stocks of marine mammal species, the maximum annual percent of the stock or population that may experience Level B incidental harassment is less than 15 percent. This means that during a year, less than 15 percent of the population may react to SURTASS LFA sonar during one 24-hr period by changing behavior or moving a small distance, or may experience TTS. Of the 139 stocks within the SURTASS LFA sonar study area, eight stocks under Alternative 1 and eleven stocks in years 1 to 4 and fifteen stocks in years 5 and beyond under Alternative 2 have the potential for MMPA Level B incidental harassment greater than 15 percent. The highest percentage of a population that may experience Level B harassment is the WNP stock and DPS of humpback whales at 157.68 percent under Alternative 1 and 233.84 percent and 321.49 percent in years 1 to 4 and years 5 and beyond, respectively, under Alternative 2. This means that each individual in the population may react behaviorally or have TTS one to three times during one year. The percentage of the WNP stock and DPS of humpback whales that may experience Level B harassment is influenced by the size of the population, which is small (1,328 individuals). The next highest stock is the WNP stock of killer whales, with 53.41 percent potentially experiencing Level B harassment under Alternative 1 and 85.37 percent and 117.31 percecnt in years 1 to 4 and years 5 and beyond, respectively, under Alternative 2.

4.5.2.2 Potential Impacts to Biological Resources: Protected Habitats

Marine habitats are protected for a variety of reasons including intrinsic ecological value; biological importance to specific marine species or taxa, which are often also protected by federal or international agreements; management of fisheries; and cultural or historic significance. As was discussed in Chapter 3, there are four types of marine and aquatic habitats protected under U.S. legislation or Presidential EO: critical habitat, EFH, MPAs, and NMSs. The potential impacts to these protected habitats are described in this section.

4.5.2.2.1 Critical Habitat

Of the marine mammals that have been listed as threatened or endangered under the ESA, critical habitat has been designated within the study area for two species, the Hawaiian monk seal and the Main Hawaiian Island (MHI) Insular DPS of the false killer whale. The key biological and/or physical features of the marine neritic and pelagic CH for the two species/DPSs under consideration include:

- Habitat areas:
  - sheltered nearshore marine areas for pupping and nursing
  - island-associated marine waters that are offshore, productive, and of varied water depths
- Prey: abundant and available prey in sufficient density, diversity, distribution, and abundance to support foraging;
- Bathymetry: marine waters up to 1,640 ft (500 m) in depth for juvenile and adult foraging;
- Water quality: free of pollutants or harmful substances;

- Anthropogenic
  - o low human disturbance
  - o low levels of anthropogenic noise such that the ability to detect, interpret, and utilize acoustic cues would not be affected.

➤ ***Hawaiian monk seal***

Critical habitat for the Hawaiian monk seal has been designated in the Northwestern (NWHI) and MHI and includes seafloor and marine neritic and pelagic waters within 33 ft (10 m) of the seafloor from the shoreline seaward to the 628-ft (200-m) depth contour at 10 areas in the NWHI on Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, Nihoa, Kaula Island and Niihau and Lehua Islands, and six areas in the MHI on Kaula, Niihau, Kauai, Oahu, Maui Nui (i.e., Kahoolawe, Lanai, Maui, and Molokai), and Hawaii (excluding National Security Exclusion zones off Kauai, Oahu, and Kahoolawe) (NOAA, 2015). The MHI critical habitat also includes specific terrestrial areas from the shoreline inland 16 ft (5 m).

The physical or biological features of the Hawaiian monk seal critical habitat that support the species' life history needs include 1) areas with characteristics preferred by monk seals for pupping and nursing; 2) shallow, sheltered nearshore marine areas preferred by monk seals for pupping and nursing; 3) marine areas up to 1,640 ft (500 m) in depth preferred by juvenile and adult monk seals for foraging; 4) areas with low levels of human disturbance; 5) marine areas with adequate prey quantity and quality; and 6) significant shore areas used by monk seals for hauling out, resting, or molting (NOAA, 2015). Nearly all of the critical habitat for the Hawaiian monk seal lies within the coastal standoff distance for SURTASS LFA sonar, wherein the sound field generated by LFA sonar cannot exceed 180 dB re 1 µPa (rms) (SPL) within 22 km (12 nmi) of any land, including islands. A small area of the monk seal's critical habitat at Penguin Bank extends beyond the 22-km coastal standoff distance. However, per the CZMA consultation with the State of Hawaii for SURTASS LFA sonar, the Navy agreed not to operate SURTASS LFA sonar in waters of Penguin Bank to the 600-ft (183-m) isobath, which is the boundary of the Penguin Bank OBIA for SURTASS LFA sonar. Thus, the critical habitat of the Hawaiian monk seal beyond the coastal standoff range would not be exposed to SURTASS LFA sonar activities.

- *Potential Effects to the Physical Features of Hawaiian Monk Seal Critical Habitat*

Use of SURTASS LFA sonar entails the periodic deployment of acoustic transducers and receivers into the water column from ocean-going ships. SURTASS LFA sonar is deployed from ocean surveillance ships that are U.S. Coast Guard-certified for operations and operate in accordance with all applicable federal, international, and U.S. Navy rules and regulations related to environmental compliance, especially for discharge of potentially hazardous materials. In particular, SURTASS LFA sonar ships comply with all requirements of the Clean Water Act (CWA) and Act to Prevent Pollution from Ships (APPS). SURTASS LFA sonar vessel movements are not unusual or extraordinary and are part of routine operations of seagoing vessels. Therefore, no discharges of pollutants regulated under the APPS or CWA would result from the operation of the SURTASS LFA sonar systems nor would unregulated environmental effects from the operation of the SURTASS LFA sonar vessels occur. In no way can the employment of the SURTASS LFA sonar systems affect the physical circulation processes or bathymetry of the waters in which the sonar would be operated. Thus, the Hawaiian monk seal critical habitat features of water quality, bathymetry, and physical circulation processes would not be affected by the use of SURTASS LFA sonar.

Deployment and use of the SURTASS LFA sonar systems result in no physical alterations to the marine environment other than the addition of ephemeral sound energy to the oceanic ambient noise environment when the sonar is transmitting. However, the power level of LFA sonar transmissions to which the critical habitat may be exposed would be low (< 180 dB re 1 µPa [rms]), while no LFA sonar transmissions would occur in the waters of Penguin Bank. When deployed and transmitting, transmissions from SURTASS LFA sonar would temporarily add to the ambient noise level in the frequency band (100 to 500 Hz) in which LFA sonar operates, but the effect on the overall noise levels in the ocean would be minimal. Anthropogenic sources of ambient noise that are most likely to contribute to increases in ambient noise levels are commercial shipping, offshore oil and gas exploration and drilling, and naval and other uses of sonar (ICES, 2005; MMC, 2007). The addition of even a small percentage to the ambient noise environment of the ocean would have no effect on the relevant physical features of the designated critical habitat. Thus, transmissions of SURTASS LFA sonar may effect but would not adversely affect the physical features of the Hawaiian monk seal critical habitat.

- *<u>Potential Effects to the Biological Features of Hawaiian Monk Seal Critical Habitat</u>*

The remaining potential for critical habitat effects associated with SURTASS LFA sonar activities would be to biological features of the habitat, namely to the availability and density of prey. Although the majority of the Hawaiian monk seal's prey would not be affected by SURTASS LFA sonar transmissions, marine fishes may be affected by exposure to LFA sonar transmissions, but only if they are within close proximity (<0.54 nmi [<1 km]) to the transmitting sonar source. The Navy's analysis indicates a minimal to negligible potential for an individual fish to experience non-auditory or auditory effects or a stress response from exposure to SURTASS LFA sonar transmissions. A low potential exists for minor, temporary behavioral responses or masking effects to an individual fish when LFA sonar is transmitting, but no potential is estimated for fitness level consequences to fish stocks. Since it is highly unlikely that a significant percentage of any fish stock would be in sufficient proximity during LFA sonar transmissions to experience such effects, there is minimal potential for LFA sonar to affect fish stocks. Thus, no adverse effects are reasonably expected on the availability of prey fishes or reproductive fish partners as the result of exposure to SURTASS LFA sonar. As a result, SURTASS LFA sonar activities would not affect the biological features of the Hawaiian monk seal's designated critical habitat.

➢ ***<u>Main Hawaiian Island Insular DPS of False Killer Whales</u>***

Critical habitat has been designated for the Main Hawaiian Island Insular DPS of the false killer whale (NOAA, 2018). The critical habitat for the Main Hawaiian Islands DPS of false killer whales includes waters from the 148- to 10,499-ft (45-to 3,200-m) depth contours around the Main Hawaiian Islands from Niihau east to Hawaii. Some Navy and other federal agency areas, such as the Pacific Missile Range Facility offshore ranges, are excluded from the proposed critical habitat designation (NOAA, 2018).

The physical or biological features of the designated critical habitat that are essential for the conservation of the MHI Insular DPS of false killer whales include: 1) island-associated marine habitat (productive, deeper, just offshore waters of varying water depths); 2) prey species (large pelagic fish and squid) of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; 3) waters free of pollutants of a type and amount harmful to MHI Insular false killer whales (i.e., good water quality) so that false killer whales can forage and reproduce free from disease and impairment; and 4) habitat free of anthropogenic noise that would significantly impair the value of the habitat for false killer whales' use or occupancy (i.e., no anthropogenic noise of a certain level, intensity, and duration that could alter the ability of false killer whales to detect, interpret, and utilize acoustic cues that support important life history functions, or can result in long-term habitat avoidance or abandonment) (NOAA, 2018).

In most areas of the waters surrounding the MHI, the coastal standoff range for SURTASS LFA (12 nmi [22 km]) is located closer to shore than the outer boundary of the CH for the MHI Insular DPS of the false killer whale, which is the 10,499-ft (3,200 m) isobath. The Penguin Bank OBIA encompasses some of the CH, but a small part of the CH lies beyond or in deeper waters than the OBIA. Additionally, as part of the CZMA stipulations for SURTASS LFA sonar use in Hawaiian waters, the Navy agreed not to operate SURTASS LFA sonar in the waters over Penguin Bank to a water depth of 600 ft (183 m).

- *Potential Effects to the Physical Features of False Killer Whale Critical Habitat*

The three physical features of the false killer whale critical habitat are island-associated habitat, waters free of pollutants, and habitat free of anthropogenic noise at a level that would cause masking, long-term habitat avoidance, or abandonment in false killer whales. SURTASS LFA sonar is deployed from ocean surveillance ships that are U.S. Coast Guard-certified for operations and operate in accordance with all applicable federal, international, and U.S. Navy rules and regulations related to environmental compliance, especially for discharge of potentially hazardous materials. In particular, SURTASS LFA sonar vessels comply with all requirements of the CWA and APPS. SURTASS LFA sonar vessel movements are not unusual or extraordinary and are part of routine operations of seagoing vessels. Therefore, no discharges of pollutants regulated under the APPS or CWA would result from the operation of the SURTASS LFA sonar systems nor would unregulated environmental effects from the operation of the SURTASS LFA sonar vessels occur. In no way can SURTASS LFA sonar activities affect the island-associated habitat features of bathymetry and productivity. Productivity is a cascading process regulated principally by available sunlight and nutrient concentrations at the lower trophic levels. Thus, the physical features of the false killer whale critical habitat of pollutant-free and island-associated habitat would not be affected by the operation of SURTASS LFA sonar.

The transmission of LF sound by SURTASS LFA sonar is the one stressor associated with SURTASS LFA sonar activities that may affect CH, particularly the physical feature of an anthropogenic noise-free environment such that masking, long-term habitat avoidance, or abandonment would not occur in false killer whales. Portions of the false killer whale habitat are located within the coastal standoff range for SURTASS LFA sonar while a portion of the critical habitat lies beyond the spatial extent of the coastal standoff range (Figure 3-8). When deployed and transmitting, transmissions from SURTASS LFA sonar would temporarily add to the ambient noise level in the frequency band (100 to 500 Hz) in which LFA sonar operates, but the effect on the overall noise levels in the ocean would be minimal. In the coastal standoff range, LFA sonar transmissions would be restricted to a lower power level, with transmissions less than 180 dB re 1 µPa [rms] SPL. With HFM3 monitoring and associated LFA source shutdown protocol in areas outside the coastal standoff zone, false killer whales would be detected before entering the mitigation zone, defined by a received level of 180 dB (rms). Therefore, at no time would animals experience a sound field greater than 180 dB (rms). The hearing and echolocation ability of false killer whales have been studied with captive animals (e.g., Kloepper et al., 2010; Yuen et al., 2005). Best sensitivity is found between 16 and 24 kHz, with echolocation clicks centered around 40 kHz. Therefore, the low-frequency and limited received levels that false killer whales may experience from SURTASS LFA sonar training and testing activities would not cause masking and are unlikely to result in long-term habitat avoidance or abandonment.

- *Potential Effects to the Biological Features of False Killer Whale Critical Habitat*

The availability of prey species (large pelagic fish and squid) for false killer whales is the one biological feature of the critical habitat for the Main Hawaiian Island Insular DPS of the false killer whale. The Navy has determined that no mortality of marine invertebrates is reasonably expected to occur from exposure to LFA sonar nor are population level effects likely. Thus, marine invertebrates such as squid would not reasonably be affected by SURTASS LFA sonar activities. Marine fishes, however, may be affected by exposure to LFA sonar transmissions, but only if they are located within close proximity (<0.54 nmi [<1 km]) to the transmitting sonar source. The Navy's analysis indicates a minimal to negligible potential for an individual fish to experience non-auditory or auditory effects or a stress response from exposure to SURTASS LFA sonar transmissions. A low potential exists for minor, temporary behavioral responses or masking effects to an individual fish when LFA sonar is transmitting, but no potential is estimated for fitness level consequences to fish stocks. Since it is highly unlikely that a significant percentage of any prey stock would be in sufficient proximity during LFA sonar transmissions to experience such effects, there is minimal potential for LFA sonar to affect prey fish stocks. Thus, no adverse effects are reasonably expected on the quantity, quality, and availability of prey fishes as the result of exposure to SURTASS LFA sonar activities. As a result, SURTASS LFA sonar activities would not affect the biological features of the Main Hawaiian Island Insular DPS of the false killer whale's designated critical habitat.

4.5.2.2.2 Essential Fish Habitat

In recognition of the critical importance that habitat plays in all lifestages of fish and invertebrate species, the MSFCMA, as amended, protects habitat essential to the production of federally managed marine and anadromous species within the U.S. EEZ. Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. §1802[10]). Information on EFH occurring within the SURTASS LFA sonar study area is provided in Chapter 3.

Adverse impacts to EFH are defined as "any impact that reduces quality and/or quantity of EFH"; adverse impacts include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH (50 CFR §600).

As discussed above, the one stressor of the action alternatives is the transmission of LF sound. There is no potential for physical or chemical alterations of the water or substrate from sound transmissions (Chapter 4.4). In addition, there is no potential for loss of, or injury to, benthic organisms or prey species since they have little or no sensitivity to LF sound (Chapter 4.5). Therefore, there is little to no potential for impacts to EFH from either action alternative and thus, the quality nor quantity of EFH would not be reasonably affected and no adverse impacts on any type of EFH is expected from exposure to SURTASS LFA sonar activities as described in Alternatives 1 or 2. The Navy is reassessing its Proposed Action relative to the MSFCMA's provisions on EFH to determine if supplemental consultation under the MSFCMA is required.

4.5.2.2.3 Marine Protected Areas

The term "marine protected area" is very generalized and is used to describe specific regions of the marine and aquatic environments that have been set aside for protection, usually by individual nations within their territorial waters, although a small number of internationally recognized MPAs exist. The variety of names and uses of MPAs has led to confusion over what the term really means and where MPAs are used. The IUCN defines a protected area as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values" (International Union for the Conservation of Nature [IUCN], 2012). In the U.S., a MPA is defined by EO 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Although the objectives for establishing protection of marine areas vary widely, MPAs are typically used to achieve two broad objectives: 1) habitat protection, and 2) fisheries management and protection (McCay & Jones, 2011). The reader is referred to Chapter 3 for a review of MPAs within the study area.

As discussed above, the one stressor of the action alternatives is the transmission of LF sound. There is no potential for physical or chemical alterations of the water or substrate from sound transmissions. There is a potential for SURTASS LFA sonar to temporarily add to the ambient noise levels when it is transmitting (Chapter 4.3). Increases in ambient noise levels would only occur during SURTASS LFA sonar transmissions (nominal 60-sec duration wavetrain every 10 min) and within the narrow bandwidth of the signal (duration of each continuous-frequency sound transmission within the wavetrain is no longer than 10 sec). Therefore, there is little to no potential for impacts to MPAs under either action alternative.

4.5.2.2.4 National Marine Sanctuaries

The only NMS within the study area is the Hawaiian Islands Humpback Whale NMS, for which the humpback whale is the sole sanctuary resource (Chapter 3). Only Penguin Bank in Hawaiian Islands Humpback Whale NMS is located outside the coastal standoff range of SURTASS LFA sonar. Penguin Bank is an OBIA for SURTASS LFA sonar (OBIA 16), with an effective period from November through April. As a result, LFA sonar transmissions cannot exceed 180 dB re 1 µPa (rms) year round in any part of the sanctuary except Penguin Bank, which is protected from November through April.

Marine mammals exposed to SURTASS LFA sonar may experience auditory impacts (i.e., PTS and TTS), behavioral change, acoustic masking, or physiological stress, but there is no evidence to suggest that LFA sonar has the potential to cause non-auditory impacts. Due to the operational characteristics of LFA sonar transmissions, a limited potential exists for masking. Existing data on physiological stress in marine mammals suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal. The potential for auditory impacts (PTS and TTS) and behavioral change associated with exposure of marine mammals to SURTASS LFA sonar has been quantitatively assessed. With the application of the full suite of mitigation measures that are employed whenever SURTASS LFA sonar is transmitting, there is no expectation of PTS (MMPA Level A harassment) to any marine mammals or stocks. For these reasons, no Level A incidental harassment takes have been requested for SURTASS LFA sonar operations. The analysis results (Tables 4-8, 4-9, and 4-10) show that the potential for TTS occurring is low; the most likely response, if any, following exposure to SURTASS LFA sonar transmissions is behavioral responses, which vary in magnitude by species. In accordance with Section 304 (d) of the NMSA, federal agencies are required to consult with the ONMS on actions internal or external to a Sanctuary that are likely to destroy, cause the loss of, or injure any sanctuary resource. The Navy has determined that the planned use of SURTASS LFA sonar pursuant to this SEIS/SOEIS does not require consultation under Section 304(d) of the NMSA.

4.6 Economic Resources

Analysis of impacts to economic resources is focused on potential impacts to commercial fisheries, subsistence harvesting of marine mammals, and recreational marine activities.

Economic Resource Potential Impacts:

- Commercial fisheries: minimal potential to affect individual fish or fish species; therefore, negligible impacts on commercial fisheries.
- Subsistence harvesting of marine mammals: the study area of training and testing activities does not overlap in time or space with subsistence hunts; therefore, no unmitigable adverse impacts.
- Recreational marine activities primarily occur within the coastal geographic restriction of SURTASS LFA sonar and therefore will not be affected.

4.6.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to economic resources. Therefore, no significant impacts to economic resources would occur with implementation of the No Action Alternative.

4.6.2 Alternative 1/Alternative 2

The study area for the analysis of impacts to economic resources associated with Alternative 1 and Alternative 2/Preferred Alternative includes the western and central North Pacific and eastern Indian oceans. SURTASS LFA sonar training and testing activities will not occur in polar regions or the territorial seas of foreign nations. Additional geographical restrictions include maintaining received levels for SURTASS LFA sonar below established levels within OBIA boundaries and recreational and commercial dive sites, as described in Chapter 5. The only difference between Alternatives 1 and 2 is the number of hours of LF sound transmision per year.

4.6.2.1 Potential Impacts to Marine Economic Resources

4.6.2.1.1 Commercial Fisheries

SURTASS LFA sonar training and testing activities will not occur within the territorial seas of foreign nations and are geographically restricted such that received levels are less than 180 dB re 1 µPa (rms) SPL within 12 nmi (22 km) from coastlines where fisheries productivity is generally high. If SURTASS LFA sonar training and testing activities occur in proximity to fish stocks, members of some fish species could potentially be affected by the low frequency sounds, but there is no potential for fitness level consequences. Given the studies of sound exposure to fishes, the potential for impacts is restricted to within close proximity of LFA sonar while it is transmitting. A summary of the thresholds defined by Popper et al. (2014), and modified by DoN (2017c) to add a type of fishes with high-frequency hearing sensitivity, shows that the probability of an impact is low to moderate and would require fishes to be within close proximity (<0.54 nmi [<1 km]) of the LFA sonar. Since this would represent a minimal to negligible portion of any fish stock, there is minimal potential for SURTASS LFA sonar to affect fish species. Due to the negligible impacts on fish from the operation of SURTASS LFA sonar within the required guidelines and restrictions, there will be negligible impacts on commercial fisheries.

4.6.2.1.2 Subsistence Harvest of Marine Mammals

The study area of SURTASS LFA sonar training and testing activities does not overlap in time or space with subsistence hunts of marine mammals. Therefore, SURTASS LFA sonar training and testing activities would not lead to unmitigable adverse impacts on the availability of marine mammal species or stocks for subsistence use.

4.6.2.1.3 Recreational Marine Activities: Diving, Swimming, Snorkeling, and Fishing

There will be no significant impacts on recreational divers, swimmers, or snorkelers that submerge themselves below the ocean's surface from training and testing activities of SURTASS LFA sonar. This is due to the geographic restrictions imposed on LFA sonar that limit the received level at known recreational and commercial dive sites to no greater than 145 dB re 1 µPa (rms). Received levels at or below this limit will not have an adverse impact on recreational or commercial divers.

SURTASS LFA sonar training and testing activities would not occur in the territorial seas of foreign nations and would be geographically restricted such that received levels are less than 180 dB re 1 µPa (rms) SPL within 12 nmi (22 km) from coastlines where recreational fishing activity is generally high. A summary of the thresholds defined by Popper et al. (2014), and modified by DoN (2017c) to add a type of fishes with high-frequency hearing sensitivity, shows that the probability of an impact is low to moderate and would require fishes to be within close proximity (<0.54 nmi [<1 km]) of the LFA sonar. Since this would represent a minimal to negligible portion of any fish stock, there is minimal potential for LFA sonar to affect fish species. Due to the negligible impacts on fish from the use of LFA sonar within the required guidelines and restrictions, there will be negligible impacts on recreational fisheries.

The vast majority of recreational swimming, snorkeling, diving, and fishing occurs within 12 nmi (22 km) of shore. Since SURTASS LFA sonar training and testing activities would not occur in the territorial seas of foreign nations and would be restricted from transmitting received levels of greater than 180 dB re 1 µPa (rms) within 12 nmi (22 km) from shore there is no reasonably foreseeable likelihood that operation of SURTASS LFA sonar will affect recreational diving, snorkeling, swimming, or fishing.

4.6.2.1.4 Whale Watching

There will be no significant impacts on whale watching activities as a result of SURTASS LFA sonar training and testing activities due to the imposed geographic restrictions. These geographic restrictions were designed such that SURTASS LFA sonar training and testing activities would not impact regions that may contain high concentrations of marine mammals, which correlate to prime whale watching areas. Therefore SURTASS LFA sonar use will have no impact on whale watching activities since exposures would be limited in areas where these activities occur.

4.7 Summary and Comparison of Significant Environmental Impacts of the Proposed Action and Alternatives

A summary of the potential impacts associated with each of the action alternatives and the No Action Alternative is presented in Table 4-12.

4.8 Cumulative Impacts

This section 1) defines the scope of the cumulative impacts analysis, 2) describes past, present, and reasonably foreseeable future actions relevant to cumulative impacts, 3) analyzes the incremental interaction the Proposed Action may have with other actions, and 4) evaluates cumulative impacts potentially resulting from these interactions. The approach taken in the analysis of

Table 4-12. Summary of Potential Impacts to Resource Areas[34]

<table>
<tr><th>Resource Area</th><th>No Action Alternative</th><th>Alternative 1</th><th>Alternative 2</th></tr>
<tr><td colspan="4">Air Quality</td></tr>
<tr><td></td><td>No impact</td><td colspan="2">Minor, localized, and intermittent air emissions, principally in the atmosphere of the global commons with a negligible impact on the concentration of air pollutants.</td></tr>
<tr><td colspan="4">Water Resources</td></tr>
<tr><td></td><td>No impact</td><td>Intermittent increase in ambient noise level during LFA sonar transmissions for 360 hr per year</td><td>Intermittent increase in ambient noise level during LFA sonar transmissions for 496 hr per year in years one to four and 592 hr per year in year 5 and beyond</td></tr>
<tr><td colspan="4">Biological Resources</td></tr>
<tr><td>Marine fishes</td><td>No impact</td><td colspan="2">Low to moderate probability of non-auditory, auditory, behavioral, masking, or physiological stress impacts may result when fish are in close proximity (<0.54 nmi [<1 km]) of the transmitting SURTASS LFA sonar source</td></tr>
<tr><td>Sea turtles</td><td>No impact</td><td colspan="2">Low to moderate potential of non-auditory, auditory, behavioral, masking, or physiological stress impacts when turtles are in close proximity (<0.54 nmi [<1 km]) of the transmitting SURTASS LFA sonar source</td></tr>
<tr><td>Marine mammals</td><td>No impact</td><td colspan="2">Potential for auditory or behavioral impacts evaluated quantitatively with the best available science; low to moderate probability of non-auditory, masking, or physiological stress assessed with best available scientific information and data</td></tr>
<tr><td>Marine Habitats</td><td>No impact</td><td colspan="2">Small, intermittent, and transitory increase in overall acoustic environment of marine habitats resulting in a negligible impact</td></tr>
<tr><td colspan="4">Economic Resources</td></tr>
<tr><td>Commercial fisheries</td><td>No impact</td><td colspan="2">Minimal potential for impacts to fish species and no potential for fitness level consequences resulting in negligible impacts on commercial fisheries</td></tr>
<tr><td>Subsistence harvest of marine mammals</td><td>No impact</td><td colspan="2">SURTASS LFA sonar training and testing activities do not overlap in time or space with subsistence hunts of marine mammals, therefore no adverse impacts on the availability of marine mammal species or stocks for subsistence use</td></tr>
<tr><td>Recreational marine activities</td><td>No impact</td><td colspan="2">Geographic restrictions limit the received level at known recreational dive sites to no greater than 145 dB re 1 µPa (rms) (SPL) and no greater than 180 dB re 1 µPa within 12 nmi (22 km) of emerged lands, resulting in no impact on recreational diving, swimming, or snorkeling. Minimal potential for impacts to fish species and no potential for fitness level consequences resulting in negligible impacts on recreational fisheries. Geographic restrictions limit the sonar levels in coastal waters in which higher concentrations of marine mammals may occur, which correlates to areas of prime whale watching and thus, would result in no impact to whale watching activities</td></tr>
</table>

34 If the conclusions for Alternative 1 and 2 were the same, one conclusion was presented for both alternatives.

cumulative impacts follows the objectives of NEPA, CEQ regulations, and CEQ guidance. Cumulative impacts are defined in 40 CFR section 1508.7 as the following:

> "The impact on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

To determine the scope of environmental impact statements, agencies shall consider cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

In addition, CEQ and USEPA have published guidance addressing implementation of cumulative impact analyses—Guidance on the Consideration of Past Actions in Cumulative Effects Analysis (Council on Environmental Quality (CEQ), 2005) and Consideration of Cumulative Impacts in EPA Review of NEPA Documents (U.S. Environmental Protection Agency (USEPA), 1999). CEQ guidance entitled *Considering Cumulative Impacts Under NEPA* (1997) states that cumulative impact analyses should

> "…determine the magnitude and significance of the environmental consequences of the Proposed Action in the context of the cumulative impacts of other past, present, and future actions...identify significant cumulative impacts…[and]…focus on truly meaningful impacts."

As per NEPA, CEQ regulations, and CEQ guidance, cumulative impacts are most likely to arise when a relationship or synergism exists between a Proposed Action and other actions expected to occur in a similar location or during a similar time period. Actions overlapping with or in close proximity to the Proposed Action would be expected to have more potential for a relationship than those more geographically separated. Similarly, relatively concurrent actions would tend to offer a higher potential for cumulative impacts. To identify cumulative impacts, the analysis needs to address the following three fundamental questions.

- Does a relationship exist such that affected resource areas of the Proposed Action might interact with the affected resource areas of past, present, or reasonably foreseeable actions?
- If one or more of the affected resource areas of the Proposed Action and another action could be expected to interact, would the Proposed Action affect or be affected by impacts of the other action?
- If such a relationship exists, then does an assessment reveal any potentially significant impacts not identified when the Proposed Action is considered alone?

4.8.1 Scope of Cumulative Impacts Analysis

The scope of the cumulative impacts analysis involves both the geographic extent of the impacts and the time frame in which the impacts could be expected to occur, which are then coupled with other past, present, and reasonably foreseeable future actions. For this SEIS/SOEIS, the study area delimits the geographic extent of the cumulative impacts analysis. In general, the study area will include those areas previously identified in this chapter for the respective resource areas. The time frame of the Proposed Action centers the timing for considering cumulative impacts.

The scope of cumulative impacts analysis also involves identifying other actions to consider. Beyond determining that the geographic scope and time frame for the actions are coincident to the Proposed Action, the analysis employs the measure of "reasonably foreseeable" to include or exclude other actions. For the purposes of this analysis, public documents prepared by federal, state, and local government agencies form the primary sources of information regarding reasonably foreseeable actions. Documents used to identify other actions include notices of intent for EISs and EAs, management plans, land use plans, and other planning related studies.

4.8.2 Past, Present, and Reasonably Foreseeable Actions

This section will focus on past, present, and reasonably foreseeable future projects in the western and central North Pacific and eastern Indian oceans. In determining which projects to include in the cumulative impacts analysis, a preliminary determination was made regarding the past, present, or reasonably foreseeable action. Specifically, it was determined if a relationship exists such that the affected resource areas of the Proposed Action might interact with the affected resource areas of a past, present, or reasonably foreseeable action. If no such potential relationship exists, the project was not carried forward into the cumulative impacts analysis. In accordance with CEQ guidance (CEQ, 2005), those actions considered but excluded from further cumulative impacts analysis are not catalogued here as the intent is to focus the analysis on the meaningful actions relevant to inform decision-making. Activities included in this cumulative impacts analysis are briefly described in the following subsections (Table 4-13).

Table 4-13. Cumulative Impacts Evaluation

Action	Location	Timeframe
Maritime traffic	All of study area	Past, present, and future
Seismic exploration	All of study area	Past, present, and future
Alternative energy developments	All of study area	Past, present, and future
Naval and other sonar activity	All of study area	Past, present, and future

4.8.2.1 Maritime Traffic

The dominant source of anthropogenic sound in the ocean stems from the propulsion of ships (Tyack, 2008). At the lower frequencies, the dominant source of this noise is the cumulative impact of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background. Shipping noise centers in the 20 to 200 Hz frequency band and is increasing yearly (Ross, 2005). Ross (1976) estimated that between 1950 and 1975 shipping had caused a rise of 10 dB in ambient ocean noise levels, and he predicted that the level would increase by another 5 dB by the beginning of the 21st century. Andrew et al. (2002) collected ocean ambient sound data from 1994 to 2001 using a receiver on the continental slope off Point Sur, California. These data were compared to measurements made from 1963 to 1965 by an identical receiver. The data demonstrated an increase in ambient noise over the 33-year period of approximately 10 dB in the frequency range of 20 to 80 Hz primarily due to commercial shipping; there were also increases as large as 9 dB in the frequency ranges 100 Hz up to 400 Hz, for which the cause was less obvious (Andrew et al., 2002). In the Indian Ocean, noise in the LF band of 5 to 115 Hz has increased 2 to 3 dB over the past decade, principally attributable to distant shipping noise (Miksis-Olds et al., 2016). However, studies of the ambient sound around Wake Island, in the equitorial Pacific, showed a decrease in sound level over the past five to eight years across all frequency band examined (5-115 Hz) (Miksis-Olds & Nichols, 2016). Ship movements have remained relatively constant, but it is hypothesized that ship quieting technologies have resulted in a reduction of the ambient sound level.

4.8.2.2 Seismic Exploration

Seismic surveys are performed to obtain information on subsurface geologic formations to identify potential oil and gas reserves. Deep seismic surveys are used to more accurately assess potential hydrocarbon reservoirs. High-resolution seismic surveys are used in the initial site evaluation for drill rig emplacement and platform design. Seismic surveying operations are conducted from ships towing an array of acoustic instruments, including air guns, which release compressed air into the water, creating acoustic energy that penetrates the sea floor. The acoustic signals are reflected off the subsurface sedimentary layers and recorded near the ocean surface on hydrophones spaced along streamer cables. Alternatively, cable grids are laid on the ocean floor to act as receivers and are later retrieved. In addition to air guns, seismic surveys utilize numerous other MF and HF acoustic instruments including multi-beam bathymetric sonar, side-scan sonar, and sub-bottom profilers.

Major offshore oil and gas production regions in the SURTASS LFA sonar study area include waters off Western Australia (Geoscience Australia, 2018) and southeast Asia, including Vietnam, Indonesia, and the Philippines. Deepwater (greater than 1,000 ft [305 m]) oil and gas exploration activities are on the rise due to improved technology spurred by the discovery of high production reservoirs in deeper waters. As such, oil and gas production activities are extending to greater depths and associated greater distances from the coastline.

4.8.2.3 Alternative Energy Developments

Marine alternative energy developments focus on extracting energy from renewable sources such as wind, waves, and tides. Many of these technologies are in initial stages of research and development. In the SURTASS LFA study area, ocean current technologies are focusing on the Kuroshio Current, since it flows close to Japan's coast and maintains a consistently strong flow. For example, a consortium of IHI Corporation, Toshiba Corporation, the University of Tokyo, and Mitsui Global Strategic Studies Institute is developing a floating type, twin turbine system for use in the East China Sea (IHI Corporation, 2014). China is also investing heavily in marine alternative energy, focusing on the east China regions of Shanghai, Zhejiang, and Fujian (Wang et al., 2011). The East China Sea has the greatest tidal range and therefore the highest potential for energy extraction from tidal technologies, which are more mature than other marine renewable energy developments. There has been limited investment in offshore wind technologies or in alternative energy projects in the Indian Ocean.

4.8.2.4 Naval and Other Sonar Activity

NMFS has issued incidental take authorizations for U.S. Navy activities within identified training and testing ranges. Within the study area of SURTASS LFA sonar training and testing activities, the Mariana Islands Training and Testing authorization occurs from 2015 to 2020. This authorization includes the use of naval sonar to support and conduct current, emerging, and future training and testing activities. The Hawaii-Southern California Training and Testing (HSTT) Draft EIS was released by the Navy in October 2017 (DoN, 2017c), which is a follow-on to the previous NEPA documentation and associated MMPA authorizations (NMFS, 2013a, 2013b) and ESA incidental take statement (NMFS, 2014).

In addition to U.S. naval activities, other foreign navies are known to utilize acoustic sound sources within the study area. The People's Liberation Army Navy (PLAN) is the naval branch of the armed forces of the People's Republic of China. Their sonar systems were originally based on Soviet supplied equipment, but they have also imported sonar systems from other foreign countries. South Korea and North Korea are also known to have sonar systems, used primarily within approximately 200 nmi of their coastlines. Russia also maintains a Pacific fleet that has conducted anti-submarine warfare exercises with sonar systems.

Marine acoustic surveys are fundamental tools guiding explorations of this planet. Sound can be used to measure bathymetry and to map geology, ocean temperatures, and currents. Numerous scientific research vessels from around the world are engaged in studying the Earth's ocean and the underlying seafloor. The data that are being collected are critical to informed decision making regarding future uses of the marine environment. Researchers use ship-mounted equipment and unmanned and manned submersible vehicles. For example, several U.S. institutions, including the Woods Hole Oceanographic Institution, Scripps Institution of Oceanography at the University of California-San Diego, Lamont-Doherty Earth Observatory at Columbia University, and several science centers operated by NMFS, conduct research each year over the world's oceans.

4.8.3 Cumulative Impacts Analysis

Where feasible, the cumulative impacts were assessed using quantifiable data; however, for many of the activities included for analysis, quantifiable data are not available and a review of the best available information was undertaken. In addition, where an analysis of potential environmental impacts for future actions has not been completed, assumptions were made regarding cumulative impacts related to this SEIS/SOEIS where possible. The analytical methodology presented earlier in Chapter 4, which was used to determine potential impacts to the various resources analyzed in this document, was also used to determine cumulative impacts. In general, long-term rather than short-term impacts and widespread rather than localized impacts were considered more likely to contribute to cumulative impacts. For example, for biological resources, population-level impacts were considered more likely to contribute to cumulative impacts than were individual-level impacts. Negligible impacts were not considered further in the cumulative impacts analysis. The vast majority of impacts expected from sonar exposure and underwater detonations are behavioral in nature, temporary and comparatively short in duration, relatively infrequent, and not of the type or severity that would be expected to be additive for the small portion of the stocks and species likely to be exposed either annually or in the reasonably foreseeable future.

4.8.3.1 Air Quality

Low levels of air pollutants and greenhouse gases would be generated by SURTASS LFA sonar vessels during the conduct of training and testing activities, with the greater proportion of those emissions occurring in the atmosphere over the global commons, as that is where 95 percent of the activites have been estimated to occur. Under various scenarios these emissions could intermix with emissions from other ocean-going vessels. The incremental additive impacts from combined emissions occurring in the atmosphere of either U.S. territorial seas or in the global commons would be minor, localized, intermittent, and unlikely to contribute to future degradation of the ocean atmosphere in a way that would harm ocean ecosystems or nearshore communities. The Proposed Action, when added to the impacts of all other past, present and reasonably foreseeable future actions, would not result in measurable additional impacts on air quality in the study area or beyond.

4.8.3.2 Marine Water Resources

Cumulative water resources impacts from past, present, and future actions would be less than significant because of the operational profile of LFA sonar. As described in Chapter 2, LFA sonar will transmit 60-sec signals at up to a 20 percent duty cycle, but more often at a 7.5-10 percent duty cycle. Considering the number of proposed transmission hours, the percentage of the total anthropogenic acoustic energy budget added by each LFA source is estimated to be 0.21 percent under Alternative 1 and 0.29 and 0.34 percent, respectively for years 1 to 4 and year 5 and beyond, under Alternative 2 (Hildebrand, 2005). Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would not result in significant impacts. Cumulative water resources impacts that would occur with implementation of either alternative would include elevation in level of ambient noise. Since the impact of elevated ambient noise increase would be transitory and of a very brief duration, no cumulative impacts on water resources will result from the implementation of the proposed action.

4.8.3.3 Biological Resources

Cumulative biological resources impacts from past, present, and future actions would not be significant since the contribution of potential impacts anticipated from SURTASS LFA sonar training and testing activities are not estimated to result in significant impacts to the biological environment. The potential impacts on any marine animal species or stock from non-auditory impacts is vanishingly small. TTS and behavioral change to marine mammals exposed to SURTASS LFA sonar transmissions may result but the impacts are not anticipated to be of biological significance to any stock or result in population level consequences. No mortality or injury is expected due to marine mammal, sea turtle, or fishes exposure to SURTASS LFA sonar transmissions.

For seismic exploration, direct impacts may include auditory impacts, behavioral change, and masking. In the western and central North Pacific and eastern Indian oceans, seismic exploration efforts are primarily focused off Western Australia and in nearshore waters in southeast Asia. Tethys, developed by the Pacific Northwest National Laboratory to support the U.S. Department of Energy (https://tethys.pnnl.gov), has consolidated information on the potential environmental effects of wind and marine renewable energy techonologies. In addition, BOEM is supporting research to quantify the potential impacts that may occur with alternative energy facilities, but it is expected that impact would include auditory impacts and behavioral change during construction and masking at short ranges during operation.

For the U.S. Navy training and testing activities, the vast majority of impacts expected from sonar exposure and underwater detonations are behavioral in nature, temporary and comparatively short in duration, relatively infrequent, and not of the type or severity that would be expected to be additive for the small portion of the stocks and species likely to be exposed either annually or in the reasonably foreseeable future. Estimates of the level of activity of foreign navies is difficult to quantify, but it is anticipated that the majority of their activities would occur within their EEZs. Similar to U.S. Navy activities, potential impacts are likely to be behavioral in nature, temporary and comparatively short in duration, and relatively infrequent.

Therefore, implementation of the action alternative combined with the past, present, and reasonably foreseeable future projects, are not anticipated to result in significant impacts.

4.8.3.4 Economic Resources

Cumulative economic resource impacts from past, present, and future actions would be less than significant because of the negligible impact of LFA sonar on economic resources. There is a negligible potential for impacts on fishes from SURTASS LFA sonar training and testing activities, which results in negligible impacts on commercial fisheries (DoN, 2012). There is no potential to impact subsistence harvest of marine mammals. The geographic restrictions associated with SURTASS LFA sonar training and testing activities would limit impacts on recreational marine activities. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would not result in significant impacts within the potential operating areas for SURTASS LFA sonar.

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5 MITIGATION, MONITORING, AND REPORTING

5.1 Mitigation Overview

Mitigation includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. Three alternatives for the use of SURTASS LFA sonar are presented in this SEIS/SOEIS (No Action Alternative, Alternative 1, and Alternative 2), two of which would meet the Navy's purpose and need and include mitigation measures that would minimize potential impacts to the greatest extent practicable, furthering NMFS's purpose and need and its statutory obligations under MMPA. These mitigation measures would apply to both action alternatives so that the Navy would achieve the maximum possible mitigation under either action alternative. Navy and NMFS have coordinated to develop these mitigation measures, and Navy will continue to work with NMFS to finalize mitigation measures through the NEPA and MMPA permitting processes.

Consistent with NMFS' purpose and need to analyze the impacts of Navy's proposed activities and prescribe mitigation and monitoring requirements that meet the statutory thresholds under the MMPA, the objective of the mitigation measures for SURTASS LFA sonar's training and testing activities is the reduction or avoidance of potential effects to marine animals and marine habitat. This mitigation objective is met by ensuring that the activities under the Proposed Action:

- Do not expose coastal waters within 12 nmi (22 km) of emergent land to SURTASS LFA sonar RLs ≥180 dB re 1 µPa (rms) (SPL];
- Do not expose OBIAs to SURTASS LFA sonar RLs ≥180 dB re 1 µPa (rms) (SPL) during biologically important seasons;
- Minimize exposure of marine mammals and sea turtles to RLs of SURTASS LFA sonar transmissions above 180 dB re 1 µPa (rms) (SPL) by monitoring for their presence and delaying/suspending LFA sonar transmissions when one of these animals enters the LFA mitigation zone; and
- Do not expose known recreational or commercial dive sites to RLs from SURTASS LFA sonar signals >145 dB re 1 µPa (rms) (SPL).

As described in the 2017 SEIS (Department of the Navy (DoN), 2017), the Navy proposes to retain the 180 dB re 1 µPa (rms) isopleth as the basis for mitigation of SURTASS LFA sonar transmissions. In the past, this mitigation zone was designed to reduce or alleviate the likelihood that marine mammals would be exposed to levels of sound that may result in injury (PTS). However, due to the revised criteria in the NMFS (2016) acoustic guidance, this mitigation zone precludes not only PTS, but also TTS, and some more severe forms of behavioral harassment. Thus, while not an expansion of the mitigation zone, this measure is now considered more protective at reducing an even broader range of impacts compared to prior authorizations.

In addition, the Navy implements a three-part monitoring protocol that is highly effective at detecting marine animals, with detection resulting in the suspension or delay of LFA sonar transmissions. The combination of visual, passive acoustic, and active acoustic (HF/M3) monitoring results in near 100 percent detection probability for a medium-sized (approximately 33 ft [10 m]) marine mammal swimming towards the system (Ellison & Stein, 1999, updated 2001). The HF/M3 system substantially increases the probability of detecting a medium- to large-sized marine mammal within 1.1 to 1.3 nmi (2 to 2.5 km) where PTS, TTS, and some more severe forms of behavioral harassment are predicted to occur. The following describes the mitigation measures that would be implemented during covered SURTASS LFA sonar activities.

5.2 Re-evaluation of Mitigation Basis

The 180 dB re 1 µPa (rms) threshold for the onset of potential injury has been used for SURTASS LFA sonar since 2001 (DoN, 2001, 2007, 2012, 2015, 2017). However, the NMFS (2018) acoustic guidance defines a new method for estimating onset of permanent threshold shift, therefore, the basis for the mitigation threshold was re-evaluated. The results of the new guidance are such that, based on simple spherical spreading (i.e., TL based on 20 × $\log_{10}$ [range {m}]), all hearing groups except LF cetaceans would need to remain within 22 ft (7 m) for the duration of an entire LFA sonar ping (60 sec) to potentially experience PTS. LF cetaceans would need to remain at the greatest distance from the transmitting LFA sonar before experiencing the onset of injury, 135 ft (41 m) for this example. If an LF cetacean were exposed to two full pings of SURTASS LFA sonar, the resulting SPL would be 179.7 dB re 1 µPa (rms). This exposure scenario is unlikely, as a marine mammal would have to remain close, <200 ft (61 m), to the transmitting LFA sonar array for about 20 minutes to experience two full pings (one ping every 10 min). However, to be conservative, the Navy intends to retain the existing mitigation basis of 180 dB re 1 µPa (rms) for SURTASS LFA sonar transmissions. Further details on these calculations follow.

The NMFS (2018) acoustic guidance specifies auditory weighted (SEL_{cum}) values for the onset of PTS, which is considered the onset of injury. The NMFS guidance (2018) also categorized marine mammals into five hearing groups for which generalized hearing ranges were defined, with the LF cetacean group including all mysticete or baleen whales.

- Low-frequency (LF) Cetaceans—mysticetes (baleen whales)
- Mid-frequency (MF) Cetaceans—includes most dolphins, all toothed whales except *Kogia* spp., and all beaked and bottlenose whales
- High-frequency (HF) Cetaceans—consists of all true porpoises, river dolphins, *Kogia* spp., *Cephalorhynchid* spp. (genus in the dolphin family Delphinidae), and two species of *Lagenorhynchus* (Peale's and hourglass dolphins)
- Phocids Underwater (PW)—consists of true seals
- Otariids Underwater (OW)—includes sea lions and fur seals

NMFS's (2018) guidance presents the auditory weighting functions developed for each of these functional hearing groups that reflect the best available data on hearing, impacts of sound on hearing, and data on equal latency. When estimating the onset of injury (PTS), the NMFS guidance (2018) defines weighted thresholds as sound exposure levels (SELs) (Table 4-4). To determine the SEL for each hearing group when exposed to a 60-sec (length of a nominal LFA sonar transmission or 1 ping), 300 Hz (the center frequency in the possible transmission range of 100 to 500 Hz) SURTASS LFA sonar transmission, the auditory weighting functions must be applied to account for each hearing group's sensitivity. Applying the auditory weighting functions to the nominal LFA sonar signal results in the thresholds increasing by approximately 1.5, 56, 56, 15, and 20 dB for LF, MF, HF, PW, and OW groups, respectively. Based on simple spherical spreading (i.e., TL based on 20 × $\log_{10}$ [range {m}]), all hearing groups except LF cetaceans would need to remain within 22 ft (7 m) for the duration of an entire LFA sonar ping (60 sec) to potentially experience PTS. LF cetaceans would need to remain at the greatest distance from the transmitting LFA sonar before experiencing the onset of injury, 135 ft (41 m) for this example.

Consequently, the distance at which SURTASS LFA sonar transmissions should be mitigated for marine mammals would be the distance associated with LF cetaceans (baleen whales), as the mitigation ranges would be greatest for this group of marine mammals. Thus, any mitigation measure developed for LF cetaceans would be highly conservative for any other marine mammals potentially exposed to SURTASS LFA sonar transmissions.

The following illustrates what the SPL RL would be at the distance to which an LF cetacean would begin to experience PTS from transmitting LFA sonar. Per NMFS (2018) acoustic guidance, the LF cetacean threshold is 199 dB re 1 μPa^2-sec (weighted). The magnitude of the LF auditory weighting function at 300 Hz for SURTASS LFA sonar is 1.5 dB, with the equivalent unweighted SEL_{cum}[35] value of 200.5 dB re 1 μPa^2-sec. To convert this value into an SPL value, total duration of sound exposure is needed:

$$SPL = SEL_{cum} - 10 \times \log_{10}(T)$$

Where T is the duration in seconds.

Applying the duration of a single ping of SURTASS LFA sonar, or 60 sec, would result in 17.8 dB being subtracted from the unweighted SEL_{cum} value of 200.5 dB, for an SPL of 182.7 dB re 1 µPa (rms). The mitigation distance to the 182.7 dB re 1 µP (rms) isopleth would be somewhat smaller than that associated with the previously used 180 dB re 1 µPa (rms) isopleth. If an LF cetacean were exposed to two full pings of SURTASS LFA sonar, the resulting SPL would be 179.7 dB re 1 µPa (rms). This exposure scenario is unlikely, as a marine mammal would have to remain close, <200 ft (61 m), to the transmitting LFA sonar array for an extended period, approximately 20 minutes, to experience two full pings (one ping every 10 min). Since the RL in this unlikely scenario (179.7 dB re 1 µP [rms]) is so close to the 180 dB re 1 µP (rms) RL on which previous mitigation measures for SURTASS LFA sonar have been based, the Navy intends to retain the existing mitigation basis for SURTASS LFA sonar transmissions of 180 dB re 1 µPa (rms).

5.3 Mitigation Measures for SURTASS LFA Sonar

5.3.1 Operational Parameters

The SURTASS LFA sound signals would be maintained between 100 and 500 Hz with a SL for each of the 18 projectors of no more than 215 dB re 1 µPa m (rms) and a maximum duty cycle of 20 percent. Under Alternative 1, the Navy would transmit up to a total of 360 hours of LFA sonar transmissions per year pooled across all SURTASS LFA equipped vessels, while under Alternative 2, the Navy would transmit 496 hours per year across all SURTASS LFA sonar equipped vessels in the first four years, with an increase in transmission hours to 592 hours per year in year five and continuing into the foreseeable future, regardless of the number of vessels employing SURTASS LFA sonar. The LFA sonar transmission hours of Alternative 1 and 2 both reflect a significant reduction in sonar transmit time compared to the existing authorization for sonar transmit hours (1,020 total transmission hours per year) under the NDE.

5.3.2 Mitigation Zone

Both prior to and during SURTASS LFA sonar transmissions, the propagation of LFA sonar signals and the distance from the SURTASS LFA sonar source to the 180 dB re 1 µPa isopleth would be determined. A mitigation zone around the LFA sonar array that is equal in size to the 180 dB re 1 µPa isopleth (i.e., the volume subjected to SPLs of 180 dB or greater) would be established.

35 SEL_{cum}=cumulative sound exposure level

5.3.3 Buffer Zone

In the SURTASS LFA 2002 to 2007 Final Rule under the MMPA (NOAA, 2002), NMFS added a mitigation measure to further preclude the potential for injury to marine mammals from resonance impacts by establishing a 0.54-nmi (1-km) buffer zone surrounding the LFA mitigation zone. In the second five-year Rule (2007 to 2012) and third five-year Rule (2012 to 2017), NMFS once more required that the 0.54-nmi (1-km) buffer zone be implemented (NOAA, 2007, 2012). Additionally, NMFS imposed a 0.54-nmi (1-km) buffer zone seaward of OBIA boundaries.

The LFA mitigation zone and buffer zone comprise the entire mitigation area to be monitored for the presence of marine mammals or sea turtles, and wherein suspension or delay of LFA sonar transmissions would occur, should a marine mammal or sea turtle enter either zone. Implementation of the buffer zones has proven to be practical for the Navy, but the analysis provided in Subchapter 2.5.1 of the SURTASS LFA Sonar FSEIS (DoN, 2007) demonstrated that the addition of the buffer zone did not appreciably minimize adverse impacts below 180 dB re 1 µPa (rms) RL. Thus, the removal of the buffer zone mitigation measure would not generate a change of any significance in the percentage of marine animals potentially affected. However, the Navy intends to adhere to the 0.54-nmi (1-km) buffer zone surrounding the LFA mitigation and OBIA boundaries if implemented by NMFS in the forthcoming MMPA Rulemaking for SURTASS LFA sonar. Subchapter 2.5.1 of the 2007 FSEIS is incorporated herein by reference.

5.3.4 Ramp-up of High Frequency Marine Mammal Monitoring (HF/M3) Sonar

The ramp-up procedure for the HF/M3 sonar system would be implemented to ensure that no inadvertent exposures of marine animals to RLs ≥180 dB re 1 µPa (rms) would occur if an animal were to occur in close proximity to the HF/M3 sonar system. Prior to full-power transmissions, the HF/M3 sonar power level will be ramped up over a period of no less than 5 minutes from a SL of 180 dB re 1 µPa @ 1 m (rms) (SPL) in 10 dB increments until full power (if required) is attained. This ramp-up procedure would commence at least 30 minutes prior to initiation of any SURTASS LFA sonar transmissions, prior to any sonar calibrations or testing that are not part of the regularly planned transmissions, and any time after the HF/M3 sonar has been powered down for more than two minutes. The HF/M3 active sonar system's SPL may not increase once a marine mammal is detected. The ramp-up process may resume once marine animals are no longer detected by any of the monitoring methods.

5.3.5 LFA Sonar Suspension/Delay

During training and testing activities, SURTASS LFA sonar transmissions would be delayed or suspended if the Navy detects a marine mammal or sea turtle entering or already located within the LFA mitigation zone (i.e., the 180 dB re 1 µPa isopleth). The suspension or delay of LFA sonar transmissions would occur if the marine animal is detected by any of the monitoring methods: visual, passive acoustic, or active acoustic monitoring. During the delay/suspension, active acoustic, visual, and passive acoustic monitoring for marine mammals and sea turtles would continue. LFA sonar transmissions would be allowed to commence/resume no sooner than 15 minutes after all marine mammals/sea turtles are no longer detected within the SURTASS LFA sonar mitigation zone and no further detections of marine animals by visual, passive acoustic, and active acoustic monitoring have occurred within the mitigation zone.

5.3.6 Geographic Sound Field Operational Constraints

The Navy intends to continue applying the following geographic restrictions during training and testing activities using SURTASS LFA sonar:

- SURTASS LFA sonar-generated sound field below RLs of 180 dB re 1 µPa (rms) (SPL) within 12 nmi (22 km) of any emergent land (including islands);
- SURTASS LFA sonar-generated sound field below RLs of 180 dB re 1 µPa (rms) (SPL) from the outer boundary of OBIAs during the biologically important period that have been determined by NMFS and the Navy;
- When in the vicinity of known recreational or commercial dive sites or in Hawaii State waters, SURTASS LFA sonar would be operated such that the sound fields at those sites would not exceed RLs of 145 dB re 1 µPa (rms) (SPL);
- SURTASS LFA sonar would not be used in the waters over Penguin Bank, Hawaii, to a water depth of 600 ft (183 m); and
- SURTASS LFA sonar operators would estimate LFA sound field RLs (SPL) prior to and during active sonar operations so that the distance from the LFA sonar system to the 180 dB re 1 µPa (rms) and 145 dB re 1 µPa (rms) isopleths are known.

NMFS and Navy would consider additional geographic restrictions, as appropriate, based on newly available information or data and the operational practicability of implementing additional mitigation.

5.3.6.1 Coastal Standoff Range

The coastal standoff range refers to the distance of 12 nmi (22 km) from any emergent land wherein the sound field generated by SURTASS LFA sonar during training and testing activities would not exceed 180 dB re 1 µPa (rms) SPL. Since many areas of biological importance to marine species, particularly protected species, occur in coastal waters, the Navy established the policy of the coastal standoff range to lower the risk to many marine animals such as marine mammals and especially sea turtles, which aggregate in coastal waters. In a review of existing and proposed marine protected areas, approximately 80 percent were found to be located in the coastal standoff range. Coastal waters are heavily used seasonally for important biologically important behaviors such as nesting, calving, foraging, and migrating. Some species of sea turtles spend entire life stages in coastal waters. In addition to the coastal standoff range, SURTASS LFA sonar training and testing activities would not occur within the territorial seas (12 nmi [22km]) of foreign nations.

The Navy analyzed the differences in potential impacts from increasing the coastal standoff from 12 nmi (22 km) to 25 nmi (46 km), a difference of 13 nmi (24 km), in the 2007 FSEIS for SURTASS LFA sonar. Based on this analysis of the potential impacts to marine mammals, the Navy concluded that although increasing the coastal standoff range distance decreases exposure to higher sonar RLs for coastal species, pelagic marine mammal species (including those species that inhabit the outer continental shelf and shelf-break waters) actually would be predicted to be exposed to increased sonar RLs (DoN, 2007). Though counter-intuitive, this result is due to an increase in exposure area, with less ensonification overlapping land for the 25 nmi (46 km) standoff distance. The Navy's impact analysis showed that overall, a greater risk of potential impacts to marine mammals resulted with an increase of the coastal standoff from 12 nmi (22 km) to 25 nmi (46 km), which did not meet the standard for effecting the least practicable adverse impact on marine mammal species or stocks under the MMPA. Details of this analysis are presented in Subchapter 4.8.6 of the 2007 FSEIS. Thus, the Navy will continue to employ the 12 nmi (22 km) coastal standoff distance for the use of SURTASS LFA sonar.

5.3.6.2 OBIAs

Given the unique transmission characteristics of SURTASS LFA sonar, and recognizing that certain areas of biological importance lie outside of the coastal standoff range (i.e., 12 nmi from any emergent land) for SURTASS LFA sonar, Navy and NMFS developed the concept of marine mammal OBIAs for SURTASS LFA sonar. OBIAs for SURTASS LFA sonar are not intended to apply to any other Navy activities and were established solely as a mitigation measure to reduce incidental takings of marine mammals associated with the use of SURTASS LFA sonar (NOAA, 2007). OBIAs only pertain to marine mammals since the potential for impacts to other protected marine species (such as sea turtles or marine fishes) from exposure to SURTASS LFA sonar transmissions would be low to moderate, necessitating no additional preventative measures for these taxa beyond those already established for SURTASS LFA sonar. Further details about the development of OBIAs and the OBIA process over the history of SURTASS LFA sonar may be found in Chapter 3 of the 2017 SEIS/SOEIS for SURTASS LFA sonar (DoN, 2017). Pertinent information is incorporated by reference herein.

Associated with each OBIA is an effective period during which the marine mammal(s) for which the OBIA was designated carry out biologically significant activities. NMFS has required an additional 0.54-nmi (1-km) buffer zone be implemented around the OBIA boundary. Thus, during the effective period for each OBIA, the sound field generated by SURTASS LFA sonar cannot exceed RLs of 180 dB re 1 µPa (rms) at a distance of 0.54-nmi (1-km) of an OBIA boundary. Additional information about the marine areas reviewed by the Navy and NMFS as possible OBIAs and the status of the OBIA designation process relative to this SEIS/SOEIS may be found in Appendix C.

5.3.6.2.1 <u>OBIA Selection Criteria</u>

The process of identifying potential marine mammal OBIAs involves an assessment by both NMFS and the Navy to identify marine areas that meet established criteria. In their comprehensive reassessment of potential OBIAs for marine mammals conducted for the 2012 SEIS/SOEIS, NMFS and the Navy established geographical and biological criteria as the basis for consideration of an area's eligibility as a candidate OBIA.

➢ ***Geographic Criteria for OBIA Eligibility***

For a marine area to be eligible for consideration as an OBIA for marine mammals, the area must be located where training and testing activities of SURTASS LFA sonar would occur (Figure 1-1, Chapter 1), but cannot be located in:

- Coastal Standoff Zone or Range—the area within 12 nmi (22 km) of any emergent land including islands or island systems. This part of the study area already receives the same protection as OBIAs where sound levels would not exceed 180 dB re 1 µPa (rms) SPL.
- Polar Regions—including the Arctic (e.g., Bering Sea) and Antarctic (south of 60°S latitude) waters. Polar regions are outside the study area.

➢ ***Low-Frequency Hearing Sensitivity Criterion***

SURTASS LFA sonar transmissions are well below the range of best hearing sensitivity for most odontocetes and most pinnipeds based on the measured hearing thresholds (Au and Hastings, 2008; Houser et al., 2008; Kastelein et al., 2009; Mulsow and Reichmuth, 2010; Nedwell et al., 2004;

Richardson et al., 1995; Southall et al., 2007). The intent of OBIAs is to protect those marine mammal species, such as baleen whales, most likely to hear and be affected by LFA sonar transmissions and to provide them additional protections during periods when they are conducting biologically significant activities. Thus, the primary focus of the OBIA mitigation measure is on LF hearing sensitive species. Two OBIAs have, however, been designated to provide additional mitigation protection for non-LF hearing specialists, such as elephant seals and sperm whales, since the available hearing data for these species indicate an increased sensitivity to LF sound (compared to most odontocetes and pinnipeds).

➢ ***Biological Criteria for OBIA Eligibility***

In addition to meeting the geographical criteria, a marine area must also meet at least one of the following biological criteria to be considered as a marine mammal OBIA for SURTASS LFA sonar. When direct data relevant to one of the following biological criteria are limited, other available data and information may be used if those data and information, either alone or in combination with the limited direct data, are sufficient to establish that the biological criteria are met:

- *High Densities*: an area of high density for one or more species of marine mammals. High density areas are those marine waters where the density within a definable area (and potentially, time) measurably and meaningfully exceeds the average density of the species or stock within the region. The exact basis for the identification of "high density areas" may differ across species/stocks and regions, depending on the available information and should be evaluated on a stock-by-stock or species-by-species basis, although combining species or stocks may be appropriate in some situations. The best source of data for this determination is publically-available, direct measurements from survey data.
- *Known Breeding/Calving or Foraging Ground or Migration Route:* an area representing a location of known biologically important activities including defined breeding or calving areas, foraging grounds, or migration routes. Potential designation under this criterion is indicative that these areas are concentrated areas for at least one biologically important activity. For the purpose of this SEIS/SOEIS, "concentrated" means that more of the animals are engaged in the particular behavior at the location (and perhaps time) than are typically engaged in that behavior elsewhere.
- *Small, Distinct Populations of Marine Mammals with Limited Distributions:* geographic areas in which small, distinct populations of marine mammals occur and whose distributional range are limited.
- *U.S. ESA-designated Critical Habitat for an ESA-listed Marine Mammal Species or Stocks:* areas designated as critical habitat under the ESA for listed marine mammal species. Effective seasonal periods are consistent with that designated for the critical habitat area. As with the other biological criteria, critical habitat is considered as one of the possible factors in the OBIA process.

➢ ***Navy Practicability Criterion***

If an area meets the geographic, biological, and hearing criteria, it is considered a candidate OBIA and the Navy conducts a practicability assessment, including consideration of personnel safety, practicality of implementation, and impacts on the effectiveness of SURTASS LFA active sonar testing and training activities. If no issues are found during the Navy's practicability review of a candidate OBIA, then the marine area is considered to meet all criteria for designation as a SURTASS LFA sonar OBIA for marine mammals. If the Navy determines that it is not practicable to designate the area as an OBIA, the Navy would identify the concerns that lead to this conclusion and discuss with NMFS whether modifications could be made to the proposed OBIA to alleviate the Navy's practicability concerns.

5.3.6.2.2 Existing Marine Mammal OBIAs for SURTASS LFA Sonar

The 2017 NDE for SURTASS LFA sonar lists 29 marine mammal OBIAs and their effective periods as one of the geographic mitigation measures with which all military readiness activities using SURTASS LFA sonar must comply (Table 5-1; Figures 5-1 and 5-2; DoN, 2017). The effective period specified for each OBIA is the season or length of time in which important biological activity is conducted annually by a specific marine mammal species or group of marine mammals in that area. Of these 29 OBIAs, four occur in the current study area for SURTASS LFA sonar (Figure 5-2), including OBIA #16 (Penguin Bank, Hawaiian Island Humpback Whale NMFS), OBIA #20 (Northern Bay of Bengal and Head of Swatch-of-No-Ground [SoNG]), OBIA #26 (Offshore Sri Lanka), and OBIA #27 (Camden Sound/Kimberly Region).

5.3.6.2.3 Potential Marine Mammal OBIAs for SURTASS LFA Sonar

Since the 2017 SEIS/SOEIS and MMPA NDE for SURTASS LFA sonar, consideration and assessment of marine areas as potential OBIAs has continued as described in this section. The Navy and NMFS are conducting a comprehensive assessment of scientific literature, data, and information that may support potential marine areas as potential OBIAs. Since this SEIS/SOEIS has a narrowed geographic scope for training and testing activities, review of OBIAs was similarly scoped to reflect the current study area. Navy and NMFS's comprehensive assessment of marine areas as potential OBIAs included review of the OBIA Watchlist for areas located within the study area as well as a thorough review of the Important Marine Mammal Areas (IMMAs), Ecologically or Biologically Significant Marine Areas (EBSAs), and IUCN Green List of Protected and Conserved Areas that are located within the study area for SURTASS LFA sonar.

The initial assessment step for each marine area was the geospatial analysis to resolve whether the marine area was located within the study area and outside the coastal standoff range for SURTASS LFA sonar (i.e., >12 nmi [22 km] from emergent land). The geospatial analysis was conducted using a geographic information system (GIS) and the best available spatial data to most accurately analyze the boundary positions of the potential marine areas relative to the study area and coastal standoff range. Spatial boundary data for all assessed marine areas were publicly available for import into GIS.

A key step in the assessment of marine areas is determining the area's relevance specifically to marine mammals, as many areas are identified for their importance or relevance to other marine taxa, such as coral reefs, or for general marine conservation factors. This step is not the evaluation of a marine area against the OBIA biological criteria, but merely separates out those marine areas in which marine mammal species potentially conduct biologically important activities.

In the current assessment process, twenty-one marine areas were determined to have met the geographic criteria and relevance to one or more species of marine mammals (Table 5-2; Appendix Table C-2). The Navy and NMFS are currently conducting a thorough review of all information and data available to assess whether these twenty-one areas meet the OBIA biological and hearing criteria. If these marine areas pass the biological and hearing criteria screening, the resulting OBIA candidates would undergo the final step in the OBIA designation process, which is the Navy practicability review.

The following describes the types of marine areas assessed by the Navy and NMFS as potential marine mammal OBIAs for SURTASS LFA sonar. The complete list of marine areas assessed by the Navy and

Table 5-1. Twenty-nine Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant Low-Frequency Marine Mammal Species, and the Effective Seasonal Period for each OBIA.

OBIA Number	*Name of OBIA*	*Location/Water Body*	*Relevant Low-Frequency Marine Mammal Species*	*Effectiveness Seasonal Period*
1	Georges Bank	Northwest Atlantic Ocean	North Atlantic right whale	Year-round
2	Roseway Basin Right Whale Conservation Area	Northwest Atlantic Ocean	North Atlantic right whale	June through December, annually
3	Great South Channel, U.S. Gulf of Maine, and Stellwagen Bank NMS	Northwest Atlantic Ocean/ Gulf of Maine	North Atlantic right whale	January 1 to November 14, annually; year-round for Stellwagen Bank NMS
4	Southeastern U.S. Right Whale Critical Habitat	Northwest Atlantic Ocean	North Atlantic right whale	November 15 to April 15, annually
5	Gulf of Alaska	Gulf of Alaska	North Pacific right whale	March through August, annually
6	Navidad Bank	Caribbean Sea/Northwest Atlantic Ocean	Humpback whale	December through April, annually
7	Coastal Western Africa (Cameroon to Angola)	Southeastern Atlantic Ocean	Humpback whale and Blue whale	June through October, annually
8	Patagonian Shelf Break	Southwestern Atlantic Ocean	Southern elephant seal	Year-round
9	Southern Right Whale Seasonal Habitat	Southwestern Atlantic Ocean	Southern right whale	May through December, annually
10	Central California	Northeastern Pacific Ocean	Blue whale and Humpback whale	June through November, annually
11	Antarctic Convergence Zone	Southern Ocean	Blue whale, Fin whale, Sei whale, Minke whale, Humpback whale, and Southern right whale	October through March, annually
12	Offshore Piltun and Chayvo	Sea of Okhotsk	Western Pacific gray whale	June through November, annually
13	Eastern Madagascar Coastal Waters	Western Indian Ocean	Humpback whale and Blue whale	July through September, annually for humpback whale breeding, November through December for migrating blue whales

Table 5-1. Twenty-nine Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant Low-Frequency Marine Mammal Species, and the Effective Seasonal Period for each OBIA.

OBIA Number	*Name of OBIA*	*Location/Water Body*	*Relevant Low-Frequency Marine Mammal Species*	*Effectiveness Seasonal Period*
14	Southern Madagascar (Madagascar Plateau, Madagascar Ridge, and Walters Shoal)	Western Indian Ocean	Pygmy blue whale, Humpback whale, and Bryde's whale	November through December, annually
15	Ligurian-Corsican-Provençal Basin and Western Pelagos Sanctuary	Northern Mediterranean Sea	Fin whale	July to August, annually
16	Penguin Bank, Hawaiian Islands Humpback Whale NMS	North-Central Pacific Ocean	Humpback whale	November through April, annually
17	Costa Rica Dome	Eastern Tropical Pacific Ocean	Blue whale and Humpback whale	Year-round
18	Great Barrier Reef	Coral Sea/Southwestern Pacific Ocean	Humpback whale and Dwarf minke whale	May through September, annually
19	Bonney Upwelling	Southern Ocean	Blue whale, Pygmy blue whale, and Southern right Whale	December through May, annually
20	Northern Bay of Bengal and Head of Swatch-of-No- Ground (SoNG)	Bay of Bengal/Northern Indian Ocean	Bryde's whale	Year-round
21	Olympic Coast NMS and The Prairie, Barkley Canyon, and Nitinat Canyon	Northeastern Pacific Ocean	Humpback whale	Olympic NMS: December, January, March, April, and May, annually; The Prairie, Barkley Canyon, and Nitinat Canyon: June through September, annually
22	Abrolhos Bank	Southwest Atlantic Ocean	Humpback whale	August through November, annually
23	Grand Manan North Atlantic Right Whale Critical Habitat	Bay of Fundy	North Atlantic right whale	June through December, annually
24	Eastern Gulf of Mexico	Gulf of Mexico	Bryde's whale	Year-round
25	Southern Coastal Chile	Gulf of Corcovado, Southeast Pacific Ocean	Blue whale	February to April, annually
26	Offshore Sri Lanka	North-Central Indian Ocean	Blue whale	December through April, annually

Table 5-1. Twenty-nine Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant Low-Frequency Marine Mammal Species, and the Effective Seasonal Period for each OBIA.

OBIA Number	Name of OBIA	Location/Water Body	Relevant Low-Frequency Marine Mammal Species	Effectiveness Seasonal Period
27	Camden Sound/Kimberly Region	Southeast Indian Ocean; northwestern Australia	Humpback whale	June through September, annually
28	Perth Canyon	Southeast Indian Ocean; southwestern Australia	Pygmy blue whale/Blue whale; Sperm whale	January through May, annually
29	Southwest Australia Canyons	Southern Ocean; southwestern Australia	Sperm whale	Year-round

NMFS and additional details of the assessment process of potential marine areas may be found in Appendix C.

➢ ***OBIA WatchList Marine Areas***

The Navy and NMFS have maintained the OBIA Watchlist, which is a list of potential marine areas already identified and reviewed as potential OBIAs but for which documentation on the importance of the area to marine mammals has not been established or is lacking in detail. These areas, however, continue to be periodically assessed as additional information becomes available.

The vast majority of the marine areas on the OBIA Watchlist are not located in the current study area for SURTASS LFA sonar in the eastern Indian Ocean or central or western North Pacific Ocean. Those few OBIA Watchlist areas that are located within the study area for SURTASS LFA sonar have been re-evaluated as part of the comprehensive assessment to support this SEIS/SOEIS and associated consultations. The OBIA Watchlist areas located within the study area that were re-considered include the British Indian Ocean Territory-Chagos Islands MPA, the Pacific Remote Islands (PRI) Marine NM (MNM), Marianas Trench MNM, and the Papahānaumokuākea MNM. Only one unit of the Marianas Trench MNM and only two of the units of the PRI MNM and a very small strip of the northern part of a third unit, Kingman Reef/Palmyra Atoll, were within the boundary of the study area (Appendix Figure C-1). Thus, only those areas of the MNMs coincident with the study area were further assessed.

Of these Watchlist areas, basic information indicates that marine mammals occur in the waters of all the assessed MNM units. Scientific data and information on the important biological activities conducted by a marine mammal species were most available for the Papahānaumokuākea MNM (Appendix Figure C-2), where the majority of the very small population of the critically endangered Hawaiian monk seal resides, reproduces, and forages, and where critical habitat for this species has been designated out to the 656-ft (200-m) isobath. Although little information and data are readily available on marine mammals in the waters of the Marianas Trench MNM Islands Unit or in the waters of Wake, Johnson, Palmyra atolls or Kingman Reef units of the PRI MNM, the Navy and NMFS will continue to thoroughly research the marine mammal information for these areas. Thus, specific units of the three MNMs

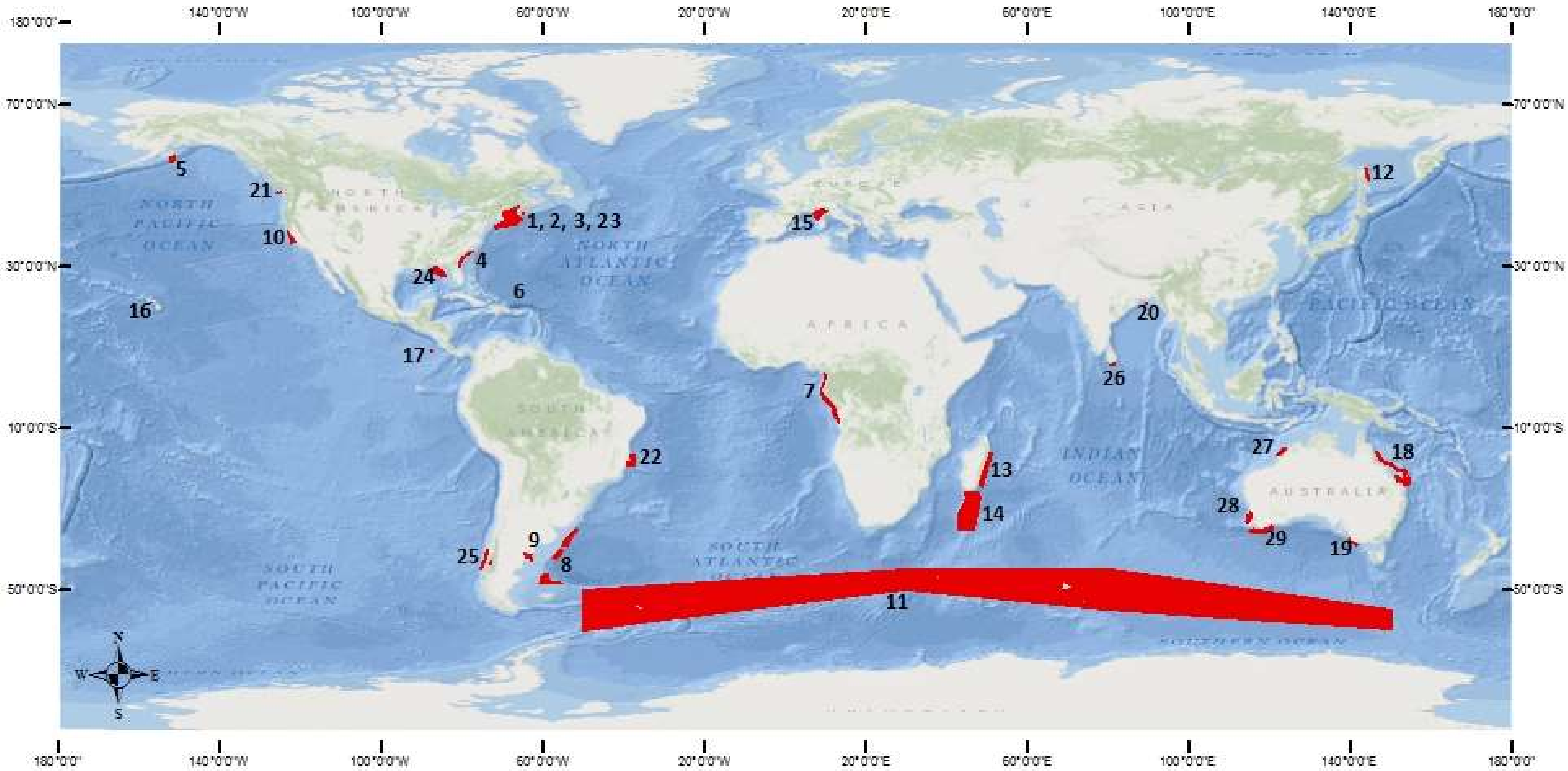

Figure 5-1. Locations of the 29 Existing Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar (the Names of OBIAs by Number Follows).

FIGURE 5-1: EXISTING OBIA NAMES BY NUMBER

1. Georges Bank
2. Roseway Basin Right Whale Conservation Area
3. Great South Channel, U.S. Gulf of Maine, and Stellwagen Bank National Marine Sanctuary
4. Southeastern U.S. Right Whale Critical Habitat
5. Gulf of Alaska
6. Navidad Bank
7. Coastal Western Africa (Cameroon to Angola)
8. Patagonian Shelf Break
9. Southern Right Whale Seasonal Habitat
10. Central California
11. Antarctic Convergence Zone
12. Offshore Piltun and Chayvo
13. Eastern Madagascar Coastal Waters
14. Southern Madagascar (Madagascar Plateau, Madagascar Ridge, and Walters Shoal)
15. Ligurian-Corsican- Provençal Basin and Western Pelagos Sanctuary
16. Penguin Bank, Hawaiian Islands Humpback Whale National Marine Sanctuary
17. Costa Rica Dome
18. Great Barrier Reef
19. Bonney Upwelling
20. Northern Bay of Bengal and Head of Swatch-of-No-Ground (SoNG)
21. Olympic Coast National Marine Sanctuary, The Prairie, Barkley Canyon, and Nitinat Canyon
22. Abrolhos Bank
23. Grand Manan North Atlantic Right Whale Critical Habitat
24. Eastern Gulf of Mexico
25. Southern Coastal Chile
26. Offshore Sri Lanka
27. Camden Sound/Kimberly Region
28. Perth Canyon
29. Southwest Australia Canyons

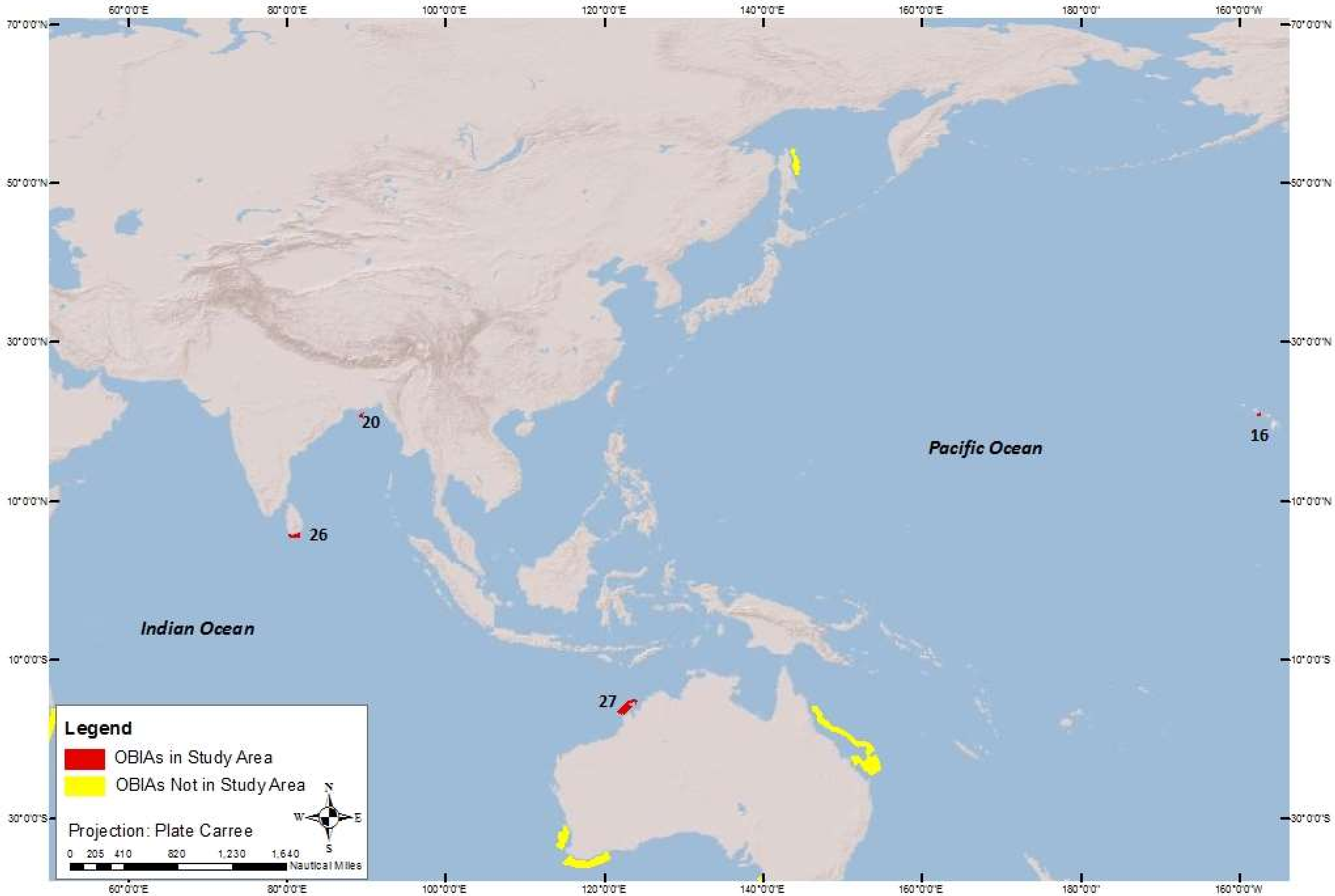

Figure 5-2. Locations of the Four OBIAs (16, 20, 26, and 27) in the SURTASS LFA Sonar Study Area.

located in the study area for SURTASS LFA sonar have been carried forward for further evaluation of the available biological and hearing data and information (Table 5-2).

The British Indian Ocean Territory-Chagos Islands MPA is a large MPA with a considerable area of marine waters outside the LFA coastal standoff range around the islands of the Chagos Archipelago. However, as was noted when this area was previously assessed by the Navy and NMFS, little information is available on the marine mammals of these waters and, more importantly, if marine mammals conduct biologically important activities in the area. Due to the lack of supporting information and data on the importance of these waters to any marine mammal species, the British Indian Ocean Territory-Chagos

Islands MPA is retained on the OBIA Watchlist for future re-evaluation pending availability of additional supporting information or data.

- ***ESA Critical Habitat***

Since one of the biological criteria for marine mammal OBIAs is critical habitat, the ESA-designated critical habitat in the Hawaiian waters of the central North Pacific study area for two species of marine mammals, the Hawaiian monk seal (NOAA, 2015) and the Main Hawaiian Islands Insular DPS of false killer whales (NOAA, 2018) are eligible for consideration as OBIAs due to the documented importance of these waters. Accordingly, these areas are amongst the marine areas the Navy and NMFS are considering for marine mammal OBIAs for SURTASS LFA sonar (Table 5-2).

- ***IUCN WCPA-SSC Important Marine Mammal Areas (IMMAs)***

IMMAs are marine areas identified and defined by the Marine Mammal Protected Area Task Force (MMPATF), which is a joint effort of the IUCN World Commission of Protected Areas (WCPA) and Species Survival Commission (SSC) and the International Committee on Marine Mammal Protected Areas (ICMMPA). IMMAs are defined as discrete portions of habitat that are important to one or more marine mammal species; represent priority sites for marine mammal conservation worldwide without management implications; and merit protection and monitoring (IUCN WCPA-SSC Joint Task Force on Biodiversity and Protected Areas and IUCN WCPA-SSC Joint Task Force on Marine Mammal Protected Areas, 2015). MMPATF's goal is to create a global network of IMMAs that are essentially MPAs for marine mammals. To achieve this goal, the task force has convened workshops focused on specific ocean basins using regional experts to identify IMMAs. The MMPATF has developed geospatial tools and a standardized process for the identification of IMMA data that ensure the consistent and comprehensive identification of areas important to marine mammals.

To date, IMMAs have been identified and made publically available only for the western and central Pacific Ocean and Mediterranean Sea (MMPATF, 2018). Only those areas designated as IMMAs in the western and central North Pacific Ocean were assessed, as sufficient data and information on marine mammal occurrence and behavior were not available for candidate IMMAs or areas of interest. Of the six IMMAs designated in the North Pacific Ocean, three are located in the western and central North Pacific study area for SURTASS LFA sonar but only two have been carried forward for further evaluation, as one is located wholly within the coastal standoff range for SURTASS LFA sonar (Table 5-2; Appendix Figure C-5).

- ***IUCN Green List of Protected and Conserved Areas***

The IUCN Green List of Protected and Conserved Areas has been generated as part of an IUCN program that aims to encourage, achieve, and promote effective, equitable, and successful protected areas with a principal goal of increasing the number of protected and conserved areas that are effectively and

Table 5-2. Marine Areas for Further Consideration as Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, with Each Area having Met the OBIA Geographic Criteria (at Least Part of Area Outside Coastal Standoff Range (CSR) and Located Within the LFA Study Area) and Which Appear to have Biological Relevance to One or More Marine Mammal Species; Further Review of Available Scientific Literature and Information is Required by the Navy and NMFS to determine if OBIA Biological and Hearing Criteria are Met for One or More Marine Mammal Species in these Areas.

Name of Marine Area	*Ocean Basin*	*Relevant Marine Mammal*	*Geographic Criteria*	*Biological Activity (Subject to Verification)**	*Type of Marine Area**
Papahānaumokuākea Marine National Monument	Central North Pacific Ocean	Hawaiian monk Seal	Majority of area outside CSR	Reproduction; foraging; limited distribution population	Marine National Monument; ESA Designated Critical Habitat for the Hawaiian monk seal also is located in these waters
Marianas Trench Marine National Monument (Island Unit Only)	Western North Pacific Ocean	29 species potentially inhabit islands' waters	38 nmi outside CSR surrounding each of three islands	TBD	Marine National Monument
Pacific Remote Islands MNM (Wake/Johnson/Palmyra atolls and Kingman Reef units only)	Western North Pacific Ocean	Spinner and bottlenose dolphins, baleen and beaked whales	Part of area outside CSR	TBD	Marine National Monument
Hawaiian Monk Seal Critical Habitat	Central North Pacific Ocean	Hawaiian monk seal	Part of area outside CSR	Foraging, reproduction, limited population	ESA Critical Habitat
Main Hawaiian Island Insular DPS of False Killer Whale Critical Habitat	Central North Pacific Ocean	False killer whale	Part of area outside CSR	Limited population/distribu tion, foraging	ESA Critical Habitat
Trincomalee Canyon and Associated Ecosystems	Northeast Indian Ocean	Sperm and blue (pygmy) whales	Part of area outside CSR	Foraging	EBSA
Southern Coastal/Offshore Waters between Galle and Yala National Park	Northeast Indian Ocean	Blue whale	Part of area outside CSR; OBIA #26 overlaps with part of area outside CSR	Foraging, small limited distribution population	EBSA

Table 5-2. Marine Areas for Further Consideration as Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, with Each Area having Met the OBIA Geographic Criteria (at Least Part of Area Outside Coastal Standoff Range (CSR) and Located Within the LFA Study Area) and Which Appear to have Biological Relevance to One or More Marine Mammal Species; Further Review of Available Scientific Literature and Information is Required by the Navy and NMFS to determine if OBIA Biological and Hearing Criteria are Met for One or More Marine Mammal Species in these Areas.

Name of Marine Area	*Ocean Basin*	*Relevant Marine Mammal*	*Geographic Criteria*	*Biological Activity (Subject to Verification)**	*Type of Marine Area**
Coastal and Offshore Gulf of Mannar	Northeast Indian Ocean	Dugong	Small part of area outside CSR	Foraging	EBSA
Lower Western Coastal Sea	Northeast Indian Ocean	Dugong	Small part of area outside CSR	Foraging	EBSA
Bluefin Spawning Area	Western North Pacific Ocean	Humpback whale	Part of area outside CSR	Reproduction	EBSA
Kyushu Palau Ridge	Western North Pacific Ocean	Sperm whale	Outside CSR	NR	EBSA
Convection Zone East of Honshu	Western North Pacific Ocean	Baleen whales	Outside CSR	Foraging	EBSA
Ogasawara Islands	Western North Pacific Ocean	Humpback whale	Inside CSR; examine area surrounding islands >CSR[36]	Reproduction	EBSA
Raja Ampat and Northern Bird's Head	Western North Pacific Ocean	Bryde's, false killer, killer, and sperm whales; dolphins (Indo Pacific humpback, pantropical spotted, Fraser's)	Partially in study area and CSR	Migration, foraging, small/limited distribution population	EBSA

36 Even though this EBSA boundary is inside the coastal standoff range, since this is such an important reproduction area for the endangered WNP humpback whale, the Navy and NMFS are further evaluating the waters beyond 12 nmi.

Table 5-2. Marine Areas for Further Consideration as Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, with Each Area having Met the OBIA Geographic Criteria (at Least Part of Area Outside Coastal Standoff Range (CSR) and Located Within the LFA Study Area) and Which Appear to have Biological Relevance to One or More Marine Mammal Species; Further Review of Available Scientific Literature and Information is Required by the Navy and NMFS to determine if OBIA Biological and Hearing Criteria are Met for One or More Marine Mammal Species in these Areas.

Name of Marine Area	*Ocean Basin*	*Relevant Marine Mammal*	*Geographic Criteria*	*Biological Activity (Subject to Verification)**	*Type of Marine Area**
Upper Gulf of Thailand	Western North Pacific Ocean	Bryde's whale, dolphins (finless, Irrawaddy, Indo-Pacific humpback, Indo-Pacific bottlenose)	Part of area outside CSR	Foraging and Reproduction	EBSA
North Pacific Transition Zone	Western to Central North Pacific Ocean	Elephant seal	Part in study area; all outside CSR	Foraging	EBSA
Peter the Great Bay	Western North Pacific Ocean	Ringed and spotted seals	Small part outside CSR	Reproduction and foraging	EBSA
Moneron Island Shelf	Western North Pacific Ocean	Steller sea lion; bearded seal	Small part outside CSR	Reproduction	EBSA
Southeast Kamchatka Coastal Waters	Western North Pacific Ocean	Killer whale; harbor seal; Steller sea lion	Very small part outside CSR	Foraging	EBSA
Kuroshio Current South of Honshu	Western North Pacific Ocean	Finless porpoise	Part of area outside CSR	Reproduction	EBSA
Northwestern Hawaiian Islands	Central North Pacific Ocean	Hawaiian monk seal; spinner dolphin	Part of area outside CSR	Small isolated and vulnerable populations, critical habitat, reproduction	IMMA

Table 5-2. Marine Areas for Further Consideration as Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, with Each Area having Met the OBIA Geographic Criteria (at Least Part of Area Outside Coastal Standoff Range (CSR) and Located Within the LFA Study Area) and Which Appear to have Biological Relevance to One or More Marine Mammal Species; Further Review of Available Scientific Literature and Information is Required by the Navy and NMFS to determine if OBIA Biological and Hearing Criteria are Met for One or More Marine Mammal Species in these Areas.

Name of Marine Area	*Ocean Basin*	*Relevant Marine Mammal*	*Geographic Criteria*	*Biological Activity (Subject to Verification)**	*Type of Marine Area**
Main Hawaiian Archipelago	Central North Pacific Ocean	False killer, pygmy killer, short-finned pilot, dwarf sperm, Blainville's beaked, Cuvier's beaked, and melon-headed whales; common bottlenose, pantropical spotted, rough-toothed, spinner dolphins	About half of area outside CSR	Island-associated/isolated small populations, vulnerable population	IMMA

*EBSA=ecologically or biologically significant area; NR=no information recorded; IMMA=important marine mammal area equitably managed and deliver conservation outcomes. The heart of the IUCN Green List Programme is the Green List Standard, which is a set of components, criteria, and indicators for successful protected area conservation and international benchmarks for quality to provide improved performance and achievement of conservation objectives (IUCN, 2018b). The criteria of the global Sustainability Standard are focused on four areas: good governance, sound design and planning, and effective management. Being designated on the IUCN Green List of Protected and Conserved Areas is a three-phase process, consisting of application, candidate, and Green List phases (IUCN, 2017). The IUCN Green List Programme has recognized 25 protected and conserved areas in eight countries around the world (IUCN, 2018a). Eleven of the 25 Green List areas are located within the study area for SURTASS LFA sonar, but all are terrestrial parks or reserves, and none of the IUCN Green List Protected or Conserved Areas encompass any marine waters (Appendix C). For this reason, no IUCN Green List areas are further considered as potential OBIAs.

- ***UNEP Ecologically or Biologically Significant Marine Areas (EBSAs)***

EBSAs are an effort of the Convention on Biological Diversity, which was initiated by the United Nations Environment Programme (UNEP). The Convention on Biological Diversity is an international legal instrument for the conservation and sustainable use of biological diversity. EBSAs are special marine areas that serve important purposes that ultimately support the healthy functioning of oceans and thus should have increased protection and sustainable management. To support effective policy action by countries and competent international and regional organizations, it is critical to build a sound understanding of the most ecologically and biologically important ocean areas that support healthy marine ecosystems.

The Convention on Biological Diversity has developed 277 EBSAs in nine geographic regions of the world. The Navy and NMFS evaluated all 277 EBSAs to determine if they were located in the study area for SURTASS LFA sonar. Five of the nine EBSA geographic regions are located in the Indian and North Pacific oceans (North-East Indian Ocean, Southern Indian Ocean, East Asian Seas, North Pacific Ocean, and Western South Pacific Ocean) and were examined in more detail to determine which EBSAs occurred within the study area for SURTASS LFA sonar and their relevance to marine mammals. In all, about 130 EBSAs were assessed (Appendix Table C-1), with 45 of the EBSAs being relevant to marine mammals, and 21 EBSAs located within the study area for SURTASS LFA sonar (Appendix Table C-2; Figures C-4 and C-5). Fourteen of these EBSAs have been carried forward for further review of the OBIA hearing and biological criteria (Table 5-2). One additional EBSA, the Ogasawara Island EBSA, is also being carried forward, even though its EBSA boundary was located entirely within the coastal standoff range for SURTASS LFA sonar. The Ogasawara area is an important reproductive area for the endangered WNP DPS and stock of humpback whales, so the waters beyond the coastal standoff range would be assessed to determine if an areal extent can be defined in which the important reproductive behavior occurs and if sufficient data supports the determination.

- ***Marine Areas Further Considered as Potential OBIAs for SURTASS LFA Sonar***

Twenty-one marine areas had some relevance to marine mammals and met the geographic criteria of being located within the study area and outside the coastal standoff range for SURTASS LFA sonar (Table 5-2). While initial review of these areas identified them as being relevant to one or more species of marine mammals, further evaluation of the LF hearing and biological criteria by Navy and NMFS must be completed before these marine areas become candidate OBIAs that would then be evaluated by the Navy for practicability of implementation.

5.3.6.3 Dive Sites

SURTASS LFA sonar transmissions would be constrained in the vicinity of known recreational and commercial dive sites to ensure that the sound field at such sites does not exceed RLs of 145 dB re 1 µPa (rms). Recreational dive sites are generally located in coastal/island waters of about 130 ft (40 m) in depth, although dive sites that may be located in other areas.

5.3.7 Sound Field Modeling

SURTASS LFA sonar operators would estimate the extent of the sound field RLs (SPL) of LFA sonar transmissions prior to the commencement of and during LFA sonar transmissions to provide the information necessary to modify activities, including the delay or suspension of transmissions, so that the sound field limit of 180 dB re 1 µPa (rms) would not be exceeded. Sound field limits would be estimated using near real-time environmental data and underwater acoustic performance prediction models, which are an integral part of the SURTASS LFA sonar processing system. The acoustic models would be used to predict the SPLs or RLs at various distances from the SURTASS LFA sonar source. Acoustic model updates would nominally be made every 12 hours or more frequently, depending upon the variance in meteorological or oceanographic conditions.

5.4 Monitoring for SURTASS LFA Sonar

The Navy would cooperate with NMFS and other federal agencies to monitor impacts on marine mammals and to designate qualified on-site personnel to conduct mitigation monitoring and reporting activities in support of SURTASS LFA sonar. The Navy would continue to conduct the following monitoring measures whenever SURTASS LFA sonar is transmitting during training and testing activities:

- Visual monitoring for marine mammals and sea turtles from the SURTASS LFA sonar vessels during daylight hours by personnel trained to detect and identify sea turtles and marine mammals at sea;
- Passive acoustic monitoring using the passive SURTASS towed array to listen for sounds generated by marine mammals as an indicator of their presence; and
- Active acoustic monitoring using the HF/M3 sonar, which is a Navy-developed, enhanced HF commercial sonar, to detect, locate, and track marine mammals and, to some extent, sea turtles, that may pass close enough to the SURTASS LFA sonar's transmit array to enter the LFA mitigation zone.

5.4.1 Visual Monitoring

Visual monitoring would include daytime observations of the sea surface for the presence of marine mammals and sea turtles from the bridge of SURTASS LFA sonar vessels. Daytime is defined as 30 minutes before sunrise until 30 minutes after sunset. Visual monitoring would begin 30 minutes before sunrise or 30 minutes before SURTASS LFA sonar begins to transmit and would continue until 30 minutes after sunset or until the SURTASS LFA sonar transmissions cease. Observations would be made by civilian ship personnel trained in detecting and identifying marine mammals and sea turtles from the ship's bridge using standard binoculars (7x) and the naked eye. The objective of visual monitoring would be to ensure that no marine mammal or sea turtle approaches the ship or transmitting sonar array close enough to enter the LFA mitigation zone.

Visual observers would maintain a watch for marine mammals and sea turtles at the sea surface and log all detections of marine animals during SURTASS LFA sonar transmissions. The number, identification, bearing, and range of observed marine mammals or sea turtles, as well as any unusual behavior they may exhibit, would be recorded; marine mammals and sea turtles would be identified to the lowest taxonomic level possible, which sometimes is only dolphin or large whale. A designated ship's officer would monitor the conduct of the visual watches and would periodically review the observation log. If a potentially affected marine mammal or sea turtle would be sighted anywhere within the LFA mitigation zone, the bridge officer would notify the officer-in-charge (OIC)[37] of the military crew (MILCREW) onboard the SURTASS LFA sonar vessel who would order the immediate delay or suspension of SURTASS LFA sonar transmissions. Similarly, if a marine mammal or sea turtle were sighted outside the LFA mitigation zone, the bridge officer would notify the MILCREW OIC of the estimated range and bearing of the observed marine mammal or sea turtle. The MILCREW OIC would notify the HF/M3 sonar operator to verify or determine the range and projected track of the detected marine mammal/sea turtle. If the sonar operator determines that the marine mammal or sea turtle would pass into the LFA mitigation zone, the MILCREW OIC would order the immediate delay or suspension of SURTASS LFA sonar transmissions when the marine animal enters the LFA mitigation zone. The visual observer would continue visual observations until the marine mammal or sea turtle is no longer observed. SURTASS LFA sonar transmissions would commence/resume 15 minutes after there would be no further detection of marine mammals or sea turtles by visual, active acoustic (HF/M3 sonar), or passive acoustic monitoring within the LFA mitigation zone. If a detected marine mammal were exhibiting abnormal behavior, visual monitoring of the detected animal would continue until the behavior returns to normal or conditions did not allow monitoring to continue.

5.4.2 Passive Acoustic Monitoring

Passive acoustic monitoring would be conducted using the SURTASS towed HLA to listen for vocalizing marine mammals as an indicator of their presence. If a detected sound were estimated to be from a vocalizing marine mammal, the sonar technician would notify the MILCREW OIC, who would alert the HF/M3 sonar operator and visual observers (during daylight). Delay or suspension of SURTASS LFA sonar transmissions would be ordered when the HF/M3 sonar and/or visual observers verify the presence of a marine mammal to be within the LFA mitigation zone. Passive acoustic sonar technicians are trained to identify the detected vocalizations to marine mammal species whenever possible. Passive acoustic monitoring would begin 30 minutes prior to the first LFA sonar transmission, continue throughout all LFA sonar transmissions, and cease 15 minutes after LFA sonar transmissions have concluded.

5.4.3 Active Acoustic/HF/M3 Monitoring

HF active acoustic monitoring uses the HF/M3 sonar to detect, locate, and track marine mammals that could pass close enough to the SURTASS LFA sonar array to enter the LFA mitigation zone. Detection of sea turtles by the HF/M3 sonar system is possible due to the position of the HF/M3 sonar system above the LFA sonar array, since a sea turtle would have to swim from the surface through the HF/M3 sonar detection zone to enter into the 180-dB LFA mitigation zone, making an acoustic detection of a sea turtle highly likely.

HF/M3 sonar monitoring would begin 30 minutes before the first SURTASS LFA sonar transmission is scheduled to commence and continue until 15 minutes after LFA sonar transmissions are terminated.

37 Or senior military personnel in charge of the watch.

Prior to full-power operations of the HF/M3 sonar, the power level would be ramped up over a period of 5 minutes from the SL of 180 dB re 1 µPa @ 1 m (rms) (SPL) in 10 dB increments until full power (if required) would be attained. This ramp-up procedure would ensure that sea turtles and marine mammals would not be inadvertently exposed to HF/M3 transmissions at RLs ≥180 dB re 1 µPa (rms).

If a marine mammal or sea turtle were detected during HF/M3 monitoring within the LFA mitigation zone, the sonar operator would notify the MILCREW OIC, who would order the immediate delay or suspension of LFA sonar transmissions. Likewise, if HF/M3 monitoring were to detect a possible marine mammal or sea turtle outside the LFA mitigation zone, the HF/M3 sonar operator would determine the range and projected track of the marine mammal or sea turtle and notify the MILCREW OIC that a detected animal would pass within the LFA mitigation zone. The MILCREW OIC would notify the bridge and passive sonar operator of the potential presence of a marine animal projected to enter the mitigation zone. The MILCREW OIC would order the delay or suspension of LFA sonar transmissions only when the marine mammal/sea turtle would enter the LFA mitigation zone, as detected by any of the three monitoring methods. SURTASS LFA sonar transmissions would commence/resume 15 minutes after there are no further detections of the animal within the LFA mitigation zone were made by the HF/M3 sonar, visual, or passive acoustic monitoring.

The effectiveness of the HF/M3 sonar system to monitor and detect marine mammals has been described in the Navy's 2001 FOEIS/EIS (Chapters 2 and 4) for SURTASS LFA sonar (DoN, 2001) in addition to the technical report by Ellison and Stein (2001). To summarize the effectiveness of the HF/M3 sonar system, the Navy's testing and analysis of the HF/M3 sonar system's capabilities indicated that the system:

- Substantially increased the probability of detecting a marine mammal within the LFA mitigation zone;
- Provides a superior monitoring capability, especially for medium- to large-sized marine mammals to a distance of 1.1 to 1.3 nmi (2 to 2.5 km) from the system (DoN, 2001);
- Would result in several detections of a marine mammal before it even entered the LFA mitigation zone (DoN, 2001)—based on the scan rate of the HF/M3 sonar system, most animals would receive at least eight pings from the sonar (i.e., eight sonar returns or detections) before even entering the LFA mitigation zone;
    - based on this scan rate, the probability of any marine mammal being detected prior to even entering the LFA mitigation zone approaches 100 percent (Ellison and Stein, 2001);
    - the probability of the HF/M3 sonar system detecting a medium- to large-sized (~33 to 98 ft [10 to 30 m]) marine mammal (humpback to blue whale) swimming towards the system in the LFA mitigation zone with only one HF/M3 ping would be near 100 percent (Ellison and Stein, 2001);
    - for a small (~8 ft (2.5 m]) marine mammal such as a dolphin, the detection probability is 55 percent from one HF/M3 ping when the sonar is located at a distance of 2,625 to 3,051 ft (800 to 930 m) from the animal, while the detection probability increases to 90 percent for four HF/M3 pings; and
- May result in higher detection probabilities in a typical at-sea operating environment—during HF/M3 testing, analysts noted that in the expected at-sea conditions of reduced clutter

interference in the open ocean and small marine mammals traveling in their typical group configurations (i.e., in pods), the detection rate would be higher (Ellison and Stein, 2001).

The information on the HF/M3 sonar system remains valid and is incorporated herein by reference. Qualitative and quantitative assessments of the HF/M3 system's ability to detect marine mammals of various sizes were verified by 170 hours of at-sea testing (Ellison and Stein, 2001).

5.4.4 Visual and Passive Acoustic Observer Training

The ship's lookouts would conduct visual monitoring for marine animals at the sea surface. A marine mammal biologist qualified in conducting at-sea visual monitoring of marine mammals from surface vessels would train and qualify designated personnel aboard the Navy's ocean surveillance vessels to conduct at-sea visual monitoring for marine mammals and sea turtles. Training of the civilian ship personnel would include effective and swift communication within the observer's command structure to facilitate quick execution of protective measures if marine mammals or other marine animals are observed at the sea surface (NOAA, 2012). The visual training may be accomplished either in-person or via video training.

In addition, the Navy routinely conducts training of the MILCREWs stationed aboard SURTASS LFA sonar vessels to augment their sonar detection capabilities. Senior marine acousticians and a senior marine biologist conduct passive acoustic training of the MILCREWs to increase their ability as sonar operators to distinguish biological sounds from those of mission-directed sounds.

5.4.5 Monitoring To Increase Knowledge of Marine Mammals

The MMPA requires that entities authorized to take marine mammals conduct monitoring that increases knowledge of the species as well as the impacts of the activity on the affected marine mammals. As such, the Navy has undertaken several monitoring efforts designed to increase knowledge of the marine mammal species potentially affected during use of SURTASS LFA sonar.

5.4.5.1 Ambient Noise Monitoring

The Navy collects ambient noise data on the marine environment when the SURTASS passive towed HLA is deployed. However, because the collected ambient noise data may also contain sensitive acoustic information, the Navy classifies the data, and thus, does not make these data publicly available. The ambient noise data, especially from areas of the ocean for which marine ambient noise data may be lacking, would be a beneficial addition to the comprehensive ocean noise budget (i.e., an accounting of the relative contributions of various underwater sources to the ocean noise field) and would increase knowledge of the ambient noise environment of the world's oceans. Ocean noise budgets are an important component of varied marine environmental analyses, including studies of masking in marine animals, marine habitat characterization, and marine animal impact analyses.

In acknowledgement of the valuable data the Navy routinely collects, NMFS has recommended that the Navy continue to explore the feasibility of declassifying and archiving the ambient noise data for incorporation into appropriate ocean noise budget efforts. Due to national security concerns, these data currently remain classified. The Navy continues to study the feasibility of declassifying portions of these data after all related security concerns have been resolved. As an initial step in this process, SURTASS LFA sonar's Marine Mammal Monitoring (M3) program has compiled information on the ambient noise data that have been collected by various underwater acoustic systems and is assessing the range of and usable content of the data prior to further discussions on data dissemination, either at a classified or unclassified level.

5.4.5.2 Marine Mammal Monitoring (M3) Program

SURTASS LFA sonar's M3 program uses the Navy's fixed and mobile passive acoustic monitoring systems to enhance the Navy's collection of long-term data on individual and population levels of acoustically active marine mammals, principally baleen and sperm whales. The data that the M3 program collects are classified, however, M3 analysts are working to develop reports that can be declassified and result in scientific papers that are peer-reviewed publications in scientific journals. Progress has been achieved on addressing security concerns and declassifying data on fin whale singing and swimming behaviors from which a scientific paper has been prepared and submitted to a scientific journal for review (DoN, 2018). In addition, information on detections of Western North Pacific gray whale vocalizations in the East China Sea has been shared with marine mammal researchers participating in discussions with the IUCN and the IWC about the Western North Pacific gray whale's status and determination of possible wintering areas for this critically endangered marine mammal (DoN, 2016). The Navy (OPNAV N2/N6F24) continues to assess and analyze M3 data collected from Navy passive acoustic monitoring systems and is working toward making some portion of that data, after appropriate security reviews, available to scientists with appropriate clearances and ultimately made publicly available.

5.4.5.3 Stranding Incident Monitoring

Over the sixteen years of SURTASS LFA sonar use, no injured or disabled marine mammals have been observed either during or after SURTASS LFA sonar activities nor have any mass or individual strandings been associated with SURTASS LFA sonar activities. Under either action alternative, the Navy would continue to monitor for injured or disabled marine mammals and monitor the principal marine mammal stranding networks and media for correlative strandings that overlap in time and space with SURTASS LFA sonar operations.

5.5 Other Mitigation and Monitoring Measures Considered

The following includes discussion of additional mitigation measures considered by the Navy and NMFS. In previous documentation for SURTASS LFA sonar, other mitigation measures, including the use of small boats, underwater gliders, or aircraft for pre-operational surveys were considered, but not carried forward (DoN, 2007, 2012, 2017). The Navy concluded that boat, glider, or aircraft pre-operational surveys were not feasible because they were not practicable, not effective, might increase the harassment of marine mammals, and were not safe to the human performers (DoN, 2007, 2017). Other discussions of recommended mitigation measures may be found in Chapter 10 of the 2007 FSEIS (DoN, 2007), Chapter 7 of the 2012 SEIS/SOEIS (DoN, 2012), and Chapter 5 of the 2017 SEIS/SOEIS (DoN, 2017).

5.5.1 Longer Suspension/Delay Period

Navy has considered whether a longer clearance time of 30 minutes before LFA sonar transmissions are allowed to commence or resume after an animal is detected in the LFA mitigation zone would be more be protective than the current 15-minute clearance time. The 30-minute timeframe is more widely used in other mitigation plans where marine mammals are principally detected by visual monitoring and this time period allows for the visual detection of marine mammals that are longer-duration divers. However, given the high effectiveness of the HF/M3 sonar system in detecting marine mammals underwater, in which the probability of any marine mammal being detected prior to even entering the LFA mitigation zone approaches 100 percent (Ellison and Stein, 2001), in addition to the use of the SURTASS passive system, the Navy concluded that such a long clearance time to detect deeper diving marine mammals was not necessary or warranted. HF/M3 sonar used in combination with passive acoustic and visual monitoring would effectively detect marine mammals present in the mitigation zone within the 15 minute timeframe.

5.5.2 Restrict Transmissions to Daylight Hours

The Navy assessed the requirements for the use of SURTASS LFA sonar for the proposed training and testing activities. Training and testing at night in addition to during daylight hours is a necessity for Navy and civilian personnel to participate in realistic at-sea scenarios that best replicate activities as they may be encountered in real-world scenarios. To do so otherwise would lessen the effectiveness of training and testing, reduce crews' abilities, and potentially introduce an increased safety risk to personnel. The civilian and MILCREWs aboard SURTASS LFA sonar vessels must be capable of operating and deploying all SURTASS LFA sonar systems in all environments that may be experienced year-round, including night conditions. Training and testing during night hours are vital because environmental differences between day and night affect the detection capabilities of sonar. Consequently, personnel must train and test during all hours of the day and night to ensure they identify and respond to changing environmental conditions. Avoiding or reducing active sonar use at night for the purpose of mitigation would result in an unacceptable impact on military readiness.

The Navy implements two other mitigation monitoring methods (passive acoustic and active acoustic monitoring) in addition to visual monitoring, so that if SURTASS LFA sonar were transmitting during the night, marine mammals or sea turtles could still be efficiently detected, and LFA sonar transmissions suspended or delayed, accordingly, upon detection of a marine animal in the mitigation or buffer zones. Therefore, the mitigation measure to restrict sonar transmissions to daylight hours was eliminated from further consideration.

5.5.3 Reduce Training and Testing Activities

Under the NDE, the Navy is currently approved to transmit 1,020 hours of LFA sonar transmissions per year for all four vessels. After careful consideration of the Proposed Action and Alternatives presented in this SEIS/SOEIS, the Navy is proposing to reduce its transmissions to a maximum of 496 hours in the first four years of the effective period and to a maximum of 592 hours in year five and beyond (Alternative 2, Preferred Alternative). In Chapter 2, the Navy detailed the six types of training and testing activities that comprise their proposed use of SURTASS LFA sonar. The Navy carefully considered the total sonar transmission hours that are necessary to meet its purpose and need. The ability to efficiently and effectively deploy and operate the SURTASS LFA sonar systems and vessels are skills that must be repeatedly practiced under realistic conditions. Training and testing during varied weather, light, and sea-state conditions is critical since the associated environmental conditions affect sound propagation and the detection capabilities of LFA sonar.

The Navy uses computer simulation to augment at-sea training and testing whenever possible. Computer simulation is intended to augment, not replace, at-sea training and testing since computer simulations cannot provide the fidelity and level of training necessary nor replicate all possible environmental scenarios that routinely occur in the marine environment. While the Navy would continue to use simulation to augment training and testing capabilities, a reduction in at-sea training and testing that would subsequently result from a further reduction in LFA sonar transmission hours would not meet the Navy’s need for combat-ready naval forces. For this reason, this mitigation measure was eliminated from further consideration.

5.5.4 Increased Coastal Standoff Range

The Navy analyzed an increased coastal standoff range of 25 nmi (46 km) in Section 4.7.6 of the 2007 FSEIS/SOEIS (DoN, 2007), which is incorporated by reference. To summarize the analysis results and Navy's conclusion, increasing the coastal standoff range from 12 nmi (22 km) to 25 nmi (46 km) decreased the exposures of coastal shelf species to SURTASS LFA sonar transmissions but increased the exposures of marine mammal species that occurred in deeper, pelagic waters. This result is due to the reduced overlap of the LFA sonar exposure area with land when the sound source moves farther offshore, resulting in greater overlap of the LFA sonar exposure area with pelagic species. Since there was no overall benefit to protected species from changing the coastal standoff range, the Navy did not implement this option and it has not been further considered.

5.5.5 Expanded Geographic Sound Field Operational Constraints

The Navy considered reducing the sonar-generated sound field produced by SURTASS LFA sonar transmissions in the coastal standoff range and at OBIA boundaries from below RLs of 180 dB re 1 µPa to below RLs of 150 dB re 1 µPa. The selection of the 180 dB re 1 µPa isopleth was reconfirmed with NMFS (2018) acoustic guidance to encompass the zone within which onset of potential injury (PTS) could occur, as well as most of the non-injurious physiological (TTS) and exposure levels that could be associated with potentially more severe behavioral responses. Considering the 60-sec duration of a SURTASS LFA sonar pulse at a frequency of 300 Hz, the PTS SEL threshold (199 dB SEL) with frequency weighting for an LF cetacean is equivalent to a SPL RL of the LFA sonar transmission of 182.7 dB re 1 µPa (rms) SPL. Therefore, using a threshold of 180 dB re 1 µPa (rms) SPL at the coastal standoff range and OBIA boundary is conservative.

In addition, LFA sonar vessels are in constant motion when LFA sonar is transmitting, so any sonar transmission RLs within an OBIA or the coastal standoff range that could potentially cause behavioral disruption would likely be experienced briefly as the ship moves by and likely perceived as occurring in the distance, which are important contextual factors to consider. Furthermore, the range to the 150 dB (rms) isopleth would vary from tens of kilometers to over 54 nmi (100 km) based on propagation conditions. Increasing the mitigation zone to such sizes would impact the effectiveness of military readiness activities by reducing the acoustic regions in which training and testing of the SURTASS LFA sonar could occur, due to the standoff distance LFA sonar vessels would have to operate off these areas. Since the current suite of mitigation measures is implemented to lessen or avoid injury, most TTS, and most biologically significant behavioral responses, constraining the geographic sound field to a lower RL would not provide a significant reduction in the anticipated impact to marine mammals to sufficiently offset the associated decrease in military readiness. For these reasons, this potential mitigation measure was eliminated from additional consideration.

5.6 Reporting

Under either action alternative, the Navy would continue to report on SURTASS LFA sonar activities, including the locations in which LFA sonar transmissions occurred, the duration of LFA sonar transmissions, the species of marine mammals that may have been exposed to SURTASS LFA sonar transmissions, the associated taking of marine mammals from exposure to LFA sonar transmissions, and the potential population or stock level impacts that occurred due to the use of SURTASS LFA sonar. The Navy would continue to track and report the cumulative number of SURTASS LFA sonar transmission hours associated with training and testing activities throughout each annual period to ensure that the maximum approved level of transmission hours and associated impacts to marine mammals is not exceeded.

5.6.1 Incident Reporting

The crews of the SURTASS LFA sonar vessels systematically observe the sea surface during and after SURTASS LFA sonar transmissions for the presence of injured or disabled marine mammals or sea turtles. The Navy must notify NMFS immediately, or as soon as clearance procedures allow, if an injured, stranded, or dead marine mammal or sea turtle is found during, shortly after (within 24 hr), or in the vicinity of any SURTASS LFA sonar training or testing activities or anytime an injured, stranded, or dead marine mammal is observed at sea. In the event that an injured, stranded, or dead marine mammal is observed by the SURTASS LFA sonar vessel crew during transit or during normal ship activities not related to training or testing of SURTASS LFA sonar, the Navy would report the incident as soon as operationally feasible and clearance procedures allow. In addition, the Navy would immediately, or as soon as clearance procedures allow, report any ship strikes of marine mammals or sea turtles by one of the SURTASS LFA sonar vessels, including all pertinent information on the strike and associated vessel. In the history of the use of SURTASS LFA sonar, no marine mammal or sea turtles have been struck by SURTASS LFA sonar vessels nor have any injured or disabled marine mammals or sea turtles been observed during or following SURTASS LFA sonar activities.

The Navy also routinely monitors the principal marine mammal stranding networks, the Internet, and social media to compile stranding data for the regions in which SURTASS LFA sonar activities were conducted and evaluate the temporal and spatial correlation of SURTASS LFA sonar transmissions with marine mammal strandings, particularly mass strandings. The Navy would report to NMFS any marine mammal strandings that were correlated in time and space with the training or testing activities of any SURTASS LFA sonar vessels.

5.6.2 Annual and Comprehensive Reports

Annually, the Navy would submit a synthesis report of the SURTASS LFA sonar training and testing activities conducted during the annual effective period to the NMFS Office of Protected Resources' Director no later than 60 days after the anniversary of the date on which the Navy's LOA for SURTASS LFA sonar becomes effective. The report would contain summaries of the dates, times, locations, and durations of LFA sonar activity as well as the time and date of any marine mammal or sea turtle detections. The report would include summaries on the extent of the LFA mitigation zone (i.e., distance to the 180 dB [rms] isopleth in relation to the LFA sonar array); mitigation monitoring detections of marine mammal or sea turtle detections from visual, passive acoustic, and active acoustic monitoring; and delays or suspensions of LFA sonar transmissions due to mitigation monitoring protocol. Information reported on marine mammal detections would include general type of marine mammals (i.e., whales, dolphins) and/or species identifications, if possible; number of marine mammals detected; range and bearing of the detected animal from the vessel; detection method (visual, passive acoustic, HF/M3 sonar); description of abnormal behavior (if any); and remarks/narrative (as necessary).

The annual report would include the Navy's estimates of the percentage of marine mammal stocks and number of individual marine mammals affected by exposure to the actual SURTASS LFA sonar transmissions during the annual period as well as an analysis of the effectiveness of the employed mitigation measures for SURTASS LFA sonar activities.

At the end of the effective period of the MMPA rule and LOA, a final comprehensive annual report would be submitted to NMFS that includes a cumulative synthesis of all LFA sonar training and testing activities that occurred during the effective period as well as the associated annual and cumulative impacts on marine mammal stocks. Additionally, the final comprehensive report would include an overall assessment of the mitigation monitoring and its effectiveness in detecting and thus reducing risk to marine mammals and sea turtles.

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6 OTHER CONSIDERATIONS REQUIRED BY NEPA

6.1 Consistency with Other Applicable Federal, State, and Local Plans, Policies, and Regulations

In accordance with 40 CFR section 1502.16(c), analysis of environmental consequences shall include discussion of possible conflicts between the Proposed Action and the objectives of federal, regional, state, and local policies and regulations (Table 6-1). SURTASS LFA sonar is operating under an NDE to the MMPA (DoN, 2017b) and a BO and ITS pursuant to the ESA (NMFS, 2017), but the Navy has applied for an updated rulemaking and LOA under the MMPA and programmatic BO and ITS under the ESA. All permits, approvals, and authorizations required for the operation of SURTASS LFA sonar have been obtained and are current.

Table 6-1. Summary of this SEIS/SOEIS's Environmental Compliance With Applicable Federal, State, Regional, and Local Laws, Policies, and Regulations.

Federal, State, Local, and Regional Policies, and Controls	***Status of Compliance***
National Environmental Policy Act (NEPA) (42 USC §§4321, et. seq.) Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR §§1500-1508) DoN Procedures for Implementing NEPA (32 CFR §775)	This SEIS/SOEIS has been prepared in accordance with NEPA, CEQ regulations, and the Navy's NEPA implementation procedures. Additionally, public participation in reviewing the Draft SEIS/SOEIS has been provided in accordance with NEPA and CEQ requirements. The Navy has concluded that the proposed action would not result in significant impacts to the marine environment.
EO 12114, Environmental Effects Abroad of Major Federal Actions	The Navy has considered potential environmental effects outside of U.S. territorial waters associated with the employment of SURTASS LFA sonar and has prepared this SEIS/SOEIS in accordance with EO 12114. The Navy concludes that the proposed action would not result in significant harm to the marine environment.
Endangered Species Act (ESA) (16 USC §§1531, et seq.)	Potential effects to marine species listed under the ESA as well as designated critical habitats of those species have been assessed in this SEIS/SOEIS. Additionally, the Navy initiated consultation under ESA's Section 7 with NMFS and submitted a Biological Evaluation that described the potential of the Proposed Action to affect ESA-listed marine species and critical habitat (DoN, 2018a).
Marine Mammal Protection Act (16 USC §§1431, et seq.)	Analyzed in this SEIS/SOEIS are the potential impacts to marine mammals resulting from execution of the Navy's Proposed Action. An application for rulemaking and a Letter of Authorization under the MMPA has been submitted to the NMFS (DoN, 2018b).

Table 6-1. Summary of this SEIS/SOEIS's Environmental Compliance With Applicable Federal, State, Regional, and Local Laws, Policies, and Regulations.

Federal, State, Local, and Regional Policies, and Controls	***Status of Compliance***
The National Marine Sanctuaries Act (16 USC §§1431, et seq.)	The Navy has determined that its planned use of SURTASS LFA sonar pursuant to this SEIS/SOEIS does not require consultation under Section 304(d) of the NMSA for the one NMS, the Hawaiian Islands Humpback Whale NMS, located within the Navy's study area for SURTASS LFA sonar.
Coastal Zone Management Act (16 USC section 1451 et seq.)	Pursuant to the CZMA (15 CFR Part 930) regulations, as part of the analyses for the 2001 FOEIS/EIS, the Navy determined that its Proposed Action would be consistent to the maximum extent practicable with the relevant enforceable policies of the one state and two territories that are located in the current study area for SURTASS LFA sonar: Hawaii, Guam, and the CNMI. The Navy is reassessing whether its Proposed Action remains consistent and if additional consultation under the CZMA is required.
Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (16 U.S.C. § 1801 et seq.)	Consultation/coordination under the MSFCMA was conducted as part of the analyses for the Navy's 2001 FOEIS/EIS (DoN, 2001) for SURTASS LFA sonar. The Navy concluded that implementation of its Proposed Action would result in no adverse effects to designated EFH. The Navy is reassessing its Proposed Action relative to the MSFCMA's provisions on EFH to determine if supplemental consultation under the MSFCMA is required for EFH designated in the waters of one state and two territories that are located in the current study area for SURTASS LFA sonar: Hawaii, Guam, and the CNMI.
Act to Prevent Pollution from Ships (APPS) (33 USC §§1901, et seq.)	The Navy and all SURTASS LFA sonar vessels comply with the discharge regulations set forth under the requirements of the APPS.
Clean Air Act (CAA) (42 U.S.C. §7401 et seq.)	The Navy's study area for SURTASS LFA sonar includes three U.S. states and territories (Hawaii, CNMI, and Guam, respectively) that would potentially be subject to the provisions of the CAA General Conformity Rule. However, due to Title 10 exemptions for the Navy's SURTASS LFA sonar vessels, SURTASS LFA sonar vessels would not go into port in Hawaii, Guam, nor CNMI. Given the limited SURTASS LFA sonar activities conducted in the territorial seas of Hawaii, CNMI, or Guam, the resulting air quality emissions from SURTASS LFA sonar vessels meet the General Conformity standards, and no conformity determinations under the CAA are required.

Table 6-1. Summary of this SEIS/SOEIS's Environmental Compliance With Applicable Federal, State, Regional, and Local Laws, Policies, and Regulations.

Federal, State, Local, and Regional Policies, and Controls	***Status of Compliance***
EO 12962, Recreational Fisheries	Since the Proposed Action would have no significant harm to fishes or fisheries and would in no way impair access to recreational fishing areas, the Navy concluded that it has fulfilled its EO 12962 responsibilities regarding recreational fishing uses and resources.
EO 13158, Marine Protected Areas (MPAs)	The Proposed Action would not harm nor affect the natural or cultural resources of any MPAs, as specified under EO 13158.
EO 13175, Consultation and Coordination with Indian Tribal Governments	The Proposed Action does not entail employment of SURTASS LFA sonar in U.S. waters except for potentially those of Hawaii, Guam, and the CNMI, where no federally-recognized Indian or Native Alaskan tribes or organizations are located. Therefore, no consultation or coordination under EO 13175 is required.
EO 13840, Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States	EO 13840 calls for improved public access to marine data and information as well as efficient federal agency coordination on ocean related matters. This and other mandates of EO 13840 have been met in this SEIS/SOEIS by using and presenting the best available data for all analyses, particularly on marine mammal populations and marine areas. The Navy's coordination with the various offices and agencies of NMFS and NOAA, particularly with NMFS as a cooperating agency on the preparation of this SEIS/SOEIS, demonstrates the Navy's strong commitment to efficient federal agency coordination.

6.2 Irreversible or Irretrievable Commitment of Resources

Section 102(c)(v) of NEPA requires that an EIS identify any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented. Resources that are irreversibly or irretrievably committed to a project are those that are used on a long-term or permanent basis, including the use of non-renewable resources.

Although operating SURTASS LFA sonar immeasurably enhances national security by enabling the Navy to ascertain ASW threats at long-range, implementation of the Proposed Action would involve the use of human labor and non-renewable resources such as petroleum-based fuel and steel (used in SURTASS LFA sonar vessels and sonar systems). However, implementation of the Proposed Action would not result in significant irreversible or irretrievable commitment of resources.

6.3 Relationship between Short-Term Use of the Environment and Maintenance and Enhancement of Long-Term Productivity

The NEPA requires analysis of the relationship between a proposed action's short-term effects on the environment and any effects on the maintenance and enhancement of the long-term productivity of the affected environment. The Navy supports research that increases knowledge of marine mammals, sea turtles, and marine fishes and develops methods to reduce or eliminate the potential for effects on these species that may be associated with the operation of SURTASS LFA sonar. While some short-term environmental effects may be associated with the use of SURTASS LFA sonar, no long-term environmental effects that would lead to decreased productivity; permanently reduce the range of beneficial environmental uses; or pose long-term risk to the health, safety, or general welfare of the public are reasonably expected.

6.4 Unavoidable Adverse Environmental Impacts

Unavoidable adverse impacts associated with the proposed action include potential effects to marine mammals, sea turtles, and fish stocks. Nearly all potential effects on these marine taxa can be avoided due to the mitigation and monitoring methods implemented by the Navy to prevent injury or harm. Additionally, the geographic restrictions on SURTASS LFA sonar employment would result in negligible impacts to fish stocks on an annual basis and no impacts to commercial or recreational fisheries.

6.5 Literature Cited

DoN. (2018a). Biological evaluation for activities associated with use of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar; Reinitiation of Section 7 consultation, June 2018. Washington, D.C.: Chief of Naval Operations, Department of the Navy.

DoN. (2018b). Application for rulemaking and letter of authorization under the Marine Mammal Protection Act for activities associated with use of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar, June 2018. Washington, D.C.: Chief of Naval Operations, Department of the Navy.

7 PUBLIC INVOLVEMENT AND DISTRIBUTION

CEQ regulations implementing NEPA (40 CFR §1503.1) require that federal agencies such as the Navy make their Draft SEISs available for review and solicit comments from the public, federal and appropriate state agencies, and other interested parties. Pursuant to Section 102(2) of NEPA, as implemented by CEQ regulations (40 CFR §§ 1500 to 1508) and EO 12114, the Navy filed the Draft SEIS/SOEIS for the continued use of SURTASS LFA sonar with the U.S. Environmental Protection Agency (EPA) in August 2018 to document the supplemental analyses and updated information associated with the continued use of SURTASS LFA sonar. This chapter describes the distribution, review, and comment process associated with the Draft SEIS/SOEIS for SURTASS LFA sonar.

7.1 Public Review Process

7.1.1 Public Notification

In the Notice of Intent (NOI), published in the *Federal Register* on June 5, 2015 (DoN, 2015), the Navy, with NMFS as a cooperating agency, announced its intention to prepare an SEIS/SOEIS for the employment of SURTASS LFA sonar. Although the Navy published a Final SEIS/SOEIS in July 2017 on the worldwide use of SURTASS LFA sonar, no ROD for that proposed action was ever promulgated by the Navy.

Pursuant to NEPA and EO 12114, the Navy, with NMFS as a cooperating agency, has prepared and released this Draft SEIS/SOEIS on the use of SURTASS LFA sonar in the western and central North Pacific and eastern Indian oceans. The Draft SEIS/SOEIS is available for review and download on the Navy's website for SURTASS LFA sonar (<http://www.surtass-lfa-eis.com/>). The Navy plans to publish the Final SEIS/SOEIS for SURTASS LFA sonar in July 2019.

7.1.2 Public Review Period

Per CEQ regulation (40 CFR §1506.10), a 45-day comment and review period would commence when the U.S. Environmental Protection Agency (EPA) publishes its Notice of Availability for the Draft SEIS/SOEIS for SURTASS LFA sonar use in the *Federal Register* in September 2018. The *Federal Register* notice included the announcement of the Draft SEIS/SOEIS's availability and where it can be accessed; an overview of the Proposed Action and its purpose and need; and public commenting information. The Navy would accept comments on the Draft SEIS/SOEIS from federal and state agencies, organizations, as well as interested members of the public for the duration of this 45-day comment period. Comments would be accepted via mail or the website for SURTASS LFA sonar (<http://www.surtass-lfa-eis.com/>).

7.2 Distribution of SEIS/SOEIS

In conjunction with filing the Draft SEIS/SOEIS for SURTASS LFA sonar with the EPA and announcing its public availability, correspondence notifying appropriate federal and state government agencies and organizations as well as other interested parties has been sent by the Navy. To ensure public availability, copies of the Draft SEIS/SOEIS for SURTASS LFA sonar have also been supplied to appropriate public libraries.

7.2.1 Federal Organizations

Edward Boling
Associate Director of NEPA Oversight
Executive Office of the President
Council on Environmental Quality
736 Jackson Place, N.W.
Washington, DC 20503

U.S. EPA, Region 9
Environmental Review Section
75 Hawthorne Street
San Francisco, CA 94105

Jeffrey Wood, Acting Assistant Attorney General
U.S. Department of Justice
Environment and Natural Resources Division
Law and Policy Section
950 Pennsylvania Avenue, NW
Washington, DC 20530-0001

Director, Office of Environmental Policy and Compliance
Attn: Michaela Noble
U.S. Department of the Interior
1849 C Street, NW
Washington, DC 20240

Office of Environmental Policy and Compliance
Department of Defense Environmental Review
Attn: Cheryl Kelly
U.S. Department of the Interior
1849 C Street, NW
Washington, DC 20240

U.S. Fish and Wildlife Service
Headquarters, Ecological Services
5275 Leesburg Pike
Falls Church, VA 22041-3803

U.S. Fish & Wildlife Service
Pacific Region
Ecological Services
911 NE 11th Avenue
Portland, OR 97232
Pacific Islands Fish and Wildlife Office

U.S. Fish and Wildlife Service
Environmental Review
300 Ala Moana Boulevard, Room 3-122
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Jolie Harrison
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NMFS, NOAA
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National Marine Sanctuaries Program, NOAA
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Allen Tom
Director, Pacific Islands Region
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Kihei, HI 96753

Leila Hatch
Gerry E. Studds Stellwagen Bank National Marine Sanctuary
175 Edward Foster Road
Scituate, MA 02066

Sara Thompson
Acting Superintendent, Hawaiian Islands Humpback Whale National Marine Sanctuary
NOAA / DKIRC
Attn: NOS/HIHWNMS
1845 Wasp Boulevard, Building 176
Honolulu, HI 96818-5007

Peter Thomas
Executive Director, Marine Mammal Commission
4340 East West Highway, Suite 700
Bethesda, MD 20814

Commanding Officer (MSC)
Environmental Protection Branch
U.S. Coast Guard, Stop 7430
Department of Homeland Security
2703 Martin Luther King Jr. Ave SE
Washington, DC 20593-7430

Western Pacific Regional Fishery Management Council
1164 Bishop Street, 1400
Honolulu, HI 96813

7.2.2 State and Territory Organizations

Samuel Lemmo
Administrator, Office of Conservation and Coastal Lands
Hawaii Department of Land and Natural Resources
1151 Punchbowl Street, Room 131
Honolulu HI 96813

Justine W. Nihipali
Planning Program Manager
Hawaii Coastal Zone Management Program
Hawaii Office of Planning
P.O. Box 2359
Honolulu, HI 96804

Bruce Anderson
Administrator, Division of Aquatic Resources
Hawaii Department of Land and Natural Resources
1151 Punchbowl Street, Room 330
Honolulu HI 96813

Walter Leon Guerrero
Administrator, Guam Environmental Protection Agency
Building 17-3304, Mariner Avenue
Tiyan, Barrigada, Guam 96913

Janet Castro
Director, Coastal Resources Management
Commonwealth of the Northern Mariana Islands
Caller Box 10007
Saipan, MP 96950

Manny Pangelinan
Director, Division of Fish and Wildlife
Department of Lands and Natural Resources
Commonwealth of the Northern Mariana Islands
P.O. Box 10007
Saipan, MP 96950

7.2.3 Other Organizations and Interested Parties

Michael Jasny
Natural Resources Defense Council
Director, Marine Mammal Protection Project
1314 Second Street
Santa Monica, CA 90401

Michael Wall

Natural Resources Defense Council
111 Sutter Street, 20th Floor
San Francisco, CA 94104

Joel Reynolds
Natural Resources Defense Council
1314 Second Street
Santa Monica, CA 90401

The Humane Society of the United States
Animal Protection Litigation
2100 L Street NW
Washington, DC 20037

David Kaplan
Cetacean Society International
P.O. Box 330298
West Hartford, CT 06133-0298

Jean-Michel Cousteau
Ocean Futures Society
513 De La Vina Street
Santa Barbara, CA 93101

Michael Stocker
Ocean Conservation Research
P.O. Box 559
Lagunitas, CA 94938

7.2.4 Public Libraries

Hawaii Documents Center
Hawaii State Library
478 South King Street
Honolulu, HI 96813

Nieves M. Flores Memorial Public Library
Reference Department, Federal Documents
254 Martyr Street
Hagåtña, Guam 96910

Joeten-Kiyu Public Library
The State Library of the Commonwealth of the Northern Mariana Islands
Pacific Reference, Federal Documents
P.O. Box 501092
Saipan, MP 96950

7.3 Literature Cited

Department of the Navy (DoN). (2015). Notice of intent to prepare a supplemental environmental impact statement/supplemental overseas environmental impact statement for employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar. Department of the Navy, Department of Defense. *Federal Register 80,* (108):32097. <http://www.surtass-lfa-eis.com/docs/NOI_FR_2015.pdf>.

8 LIST OF PREPARERS

This SEIS/SOEIS was prepared collaboratively by Navy, National Marine Fisheries Service, and contractors.

U.S. Department of the Navy

CDR Patrick Havel, U.S. Navy (Chief of Naval Operations, Warfare Integration for Information Dominance Division, OPNAV N974B)
M.S. Meteorology and Physical Oceanography
B.S. Environmental Sciences
Years of Experience: 18
Responsible for: SEIS/SOEIS review and endorsement

Danielle Kitchen (Chief of Naval Operations, Energy and Environmental Readiness Division OPNAV N454)
M.E.M. Coastal Environmental Management
B.S. Biological Sciences
Years of Experience: 10
Responsible for: MMPA and ESA requirements coordination; marine mammal impact technical oversight; and SEIS/SOEIS review

Ronald Carmichael (Chief of Naval Operations, Energy and Environmental Readiness Division OPNAV N454)
M.S. Program Management
B.S. Ocean Engineering
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National Marine Fisheries Service

Jolie Harrison (Office of Protected Resources, Permits and Conservation Division)
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Dale Youngkin (Office of Protected Resources, Permits and Conservation Division)
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Contractors

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B.S. Education
Years of Experience: 22
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Cheryl L. Schroeder (Marine Acoustics, Inc.)
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B.S. Biology
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Responsible for: acoustic impact modeling and analysis

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B.S. Ocean Engineering
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Responsible for: acoustic impact modeling and analysis

Brian Ward (Science Applications International Corporation, contracted under OPNAV N454)
M.S. Fisheries
B.S. Biology
Years of Experience: 6
Responsible for: ESA requirements coordination and SEIS/SOEIS review

APPENDIX A: CORRESPONDENCE

NATIONAL MARINE FISHERIES SERVICE: COOPERATIVE AGENCY

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

5090
Ser N45/15U132387
May 28, 2015

Ms. Jolie Harrison
Chief, Division of Permits and Conservation
National Marine Fisheries Service
1315 East West Highway
Silver Spring, MD 20910

Dear Ms. Harrison:

SUBJECT: COOPERATING AGENCY REQUEST FOR THE SUPPLEMENTAL ENVIORNMENTAL IMPACT STATEMENT/SUPPLEMENTAL OVERSEAS ENVIRONMENTAL IMPACT STATEMENT (SEIS/SOEIS) FOR THE SURVEILLANCE TOWED ARRAY SENSOR SYSTEM (SURTASS) LOW FREQUENCY ACTIVE (LFA) SONAR

In accordance with the National Environmental Policy Act (NEPA) and to support a new 5-Year Final Rule under the Marine Mammal Protection Act (MMPA) and Incidental Take Statement-Biological Opinion under the Endangered Species Act for employment of SURTASS LFA sonar, the Department of the Navy is initiating the preparation of a SEIS/SOEIS.

Navy requests that the National Marine Fisheries Service (NMFS) Office of Protected Resources (OPR) continue to serve as a cooperating agency in accordance with NEPA regulations (40 CFR 1501.6) and the Council on Environmental Quality cooperating agency guidance, issued on 30 January 2002. The respective responsibilities of Navy and NMFS OPR will be consistent with those described in and agreed upon in the cooperative agency correspondence between the two agencies for the 2012 SURTASS LFA Sonar SEIS/SOEIS (dated 24 November 2008 and 6 February 2009) and the 2015 SURTASS LFA Sonar SEIS/SOEIS (dated 30 June 2014 and 3 November 2014).

Navy, as lead agency, will be responsible for overseeing preparation of the SEIS/SOEIS that will include, but not be limited to, the following:

- Gathering the necessary background information and preparing the SEIS/SOEIS and the necessary rulemaking and permit applications associated with the employment of SURTASS LFA sonar.
- Working with NMFS personnel in determining the best available science in the analysis of potential effects to protected marine species, including threatened and endangered species.
- Determining the scope and alternatives of the SEIS/SOEIS.
- Responding to NMFS requests for information in a timely manner.
- Circulating the appropriate NEPA/Executive Order 12114 documentation to the general public and other interested parties.

5090
Ser N45/15U132387
May 28, 2015

- Maintaining the SEIS/SOEIS schedule and supervising meetings held in support of the NEPA/Executive Order 12114 process. A notional schedule for the preparation of the 2017 SEIS/SOEIS for SURTASS LFA sonar as well as the associated MMPA and ESA documentation has been included in enclosure (1).
- Compiling and drafting responses to comments received on the Draft SEIS/SOEIS.
- Maintaining an administrative record and responding to any Freedom of Information Act requests related to the SEIS/SOEIS.

As a cooperating agency, Navy requests NMFS provide support as follows:

- Provide timely comments on working drafts of the SEIS/SOEIS.
- Coordinate closely with the Navy to analyze potential additional new or modified marine mammal Offshore Biologically Important Areas (greater than 12 NM offshore) for SURTASS LFA sonar.
- Respond to Navy requests for information in a timely manner.
- Coordinate, to the maximum extent practicable, any public comment periods required by the MMPA permitting process, with the Navy's NEPA public comment periods on the SEIS/SOEIS.
- Assist Navy in responding to public comments.
- Participate in meetings hosted by the Navy for discussions on the SEIS/SOEIS and permitting-related issues.
- Adhere, to the maximum extent possible, to the overall schedule, as agreed upon by Navy and NMFS.

Navy views this agreement as important to the successful completion of the SEIS/SOEIS for SURTASS LFA sonar employment. NMFS participation as a cooperating agency will be invaluable in this endeavor. A formal, written response is requested.

NEPA point of contact for this action is Dawn Schroeder (OPNAV N454), (703) 695-5219, email: dawn.schroeder@navy.mil and the technical point of contact is LCDR Mark Murnane (OPNAV N2/N6F24), (703) 695-8266, email: mark.murnane2@navy.mil.

Sincerely,

K. H. OHANNESSIAN
Deputy Director, Energy and
Environmental Readiness Division

2

5090
Ser N45/15U132387
May 28, 2015

Enclosure: 1. Notional schedule for SURTASS LFA sonar 2017 SEIS/SOEIS, MMPA, and ESA documentation

Copy to: OPNAV (N2/N6F24)

3

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

SEP 2 1 2015

K. H. Ohannessian
Deputy Director,
Energy and Environmental Readiness Division
United States Navy
Office of the Chief of Naval Operations
2000 Navy Pentagon
Washington, D.C. 20350-2000

Dear Mr. Ohannessian,

Thank you for inviting the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service, Office of Protected Resources (OPR), Permits and Conservation Division to participate as a cooperating agency in the development of a Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (Supplemental EIS/OEIS) for the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar.

We support,the Navy's decision to prepare this Supplemental EIS/OEIS on this activity and agree to be a cooperating agency, due, in part, to our responsibilities under section 101(a)(5)(A) of the Marine Mammal Protection Act and section 7 of the Endangered Species Act.

We agree with the list of responsibilities itemized in the Navy's letter and request that that the Navy work with NMFS OPR staff to discuss updating the proposed scheduled milestones shown in the Navy's Enclosure 1 to ensure successful and timely completion of the 2017 Supplemental SEIS/OEIS.

If you need any additional information, please contact Jolie Harrison or Jeannine Cody, (301-427-8401), who will be the NOAA OPR points of contact for this SEIS/OEIS.

Sincerely,

PERRY GAYALDO
for Donna S. Wieting
Director, Office of Protected Resources

Printed on Recycled Paper

NATIONAL DEFENSE EXEMPTION FOR SURTASS LFA SONAR, AUGUST 2017

DEPUTY SECRETARY OF DEFENSE
1010 DEFENSE PENTAGON
WASHINGTON, DC 20301-1010

AUG 1 0 2017

MEMORANDUM FOR SECRETARY OF THE NAVY

SUBJECT: National Defense Exemption from Requirements of the Marine Mammal Protection Act for Department of Defense Surveillance Towed Array Sensor System Low Frequency Active Sonar Military Readiness Activities

Pursuant to Title 16, Section 1371(f), of the United States Code, and having conferred with the Secretary of Commerce, I have determined that it is necessary for the national defense to exempt all military readiness activities that employ Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar from compliance with the requirements of the Marine Mammal Protection Act, Title 16, Sections 1361-1421h, of the United States Code. A military readiness activity is defined in Section 315(f) of Public Law 107-314.

This exemption is effective August 13, 2017, and shall remain in force for a period of two years from that date or until such time as the National Marine Fisheries Service issues Regulations and Letters of Authorization under Title 16, Section 1371 for SURTASS LFA sonar military readiness activities, whichever is earlier. During the exemption period, all military readiness activities that involve the use of SURTASS LFA sonar shall comply with the parameters and mitigation, monitoring, and reporting measures set forth in Attachment 1.

Attachment:
As stated

Attachment 1

Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) Sonar Mitigation, Monitoring and Reporting Measures

I. PARAMETERS

1. This exemption covers use of SURTASS LFA sonar onboard the USNS VICTORIOUS (T-AGOS 19), the USNS ABLE (T-AGOS 20), the USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23). The sound signals transmitted by the SURTASS LFA sonar source must be between 100 and 500 Hertz (Hz) with a source level for each of the 18 projectors of no more than 215 decibels (dB) re: 1 micro Pascal at 1 meter (m) root mean square (rms) and a maximum duty cycle of 20 percent.

2. The Navy will carry out an estimated total of 20 nominal active sonar missions annually among these four vessels (or equivalent number of shorter missions), but shall not exceed a total of 255 hours of sonar transmit time per vessel per year during the period of this exemption within the following areas:

   (a) Up to 16 nominal missions annually in the western North Pacific Ocean, which includes the following mission areas: east of Japan; the north Philippine Sea; the west Philippine Sea; offshore Guam; the Sea of Japan; the East China Sea; the South China Sea; offshore Japan (25° to 40° N and 10° to 25° N), and northeast of Japan.

   (b) Up to two nominal missions annually in the central North Pacific Ocean that include the Hawaii North and Hawaii South mission areas.

   (c) Up to two nominal missions annually in the Indian Ocean that include the Arabian Sea, the Andaman Sea and northwest of Australia mission areas.

II. MITIGATION

1. SURTASS LFA sonar military readiness activities must be conducted in a manner that minimizes, to the greatest extent practicable, adverse impacts on marine mammals, their habitats, and the availability of marine mammals for subsistence uses. When conducting the military readiness activities, the following mitigation measures must be implemented:

   (a) **Personnel Training—Lookouts**:
      (1) The Navy shall train the lookouts in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if they spot marine mammals.
      (2) The Navy will employ one or more marine mammal biologists qualified in conducting at-sea marine mammal visual monitoring from surface vessels to train and qualify designated ship personnel to conduct at-sea visual monitoring. This training may be accomplished either in-person, or via video training.

   (b) **General Operating Procedures**:
      (1) Prior to SURTASS LFA sonar operations, the Navy will promulgate executive guidance for the administration, execution, and compliance with this exemption.
      (2) SURTASS LFA sonar signals must not be transmitted at a frequency greater than 500 Hertz (Hz).
      (3) The Navy must ensure, to the greatest extent practicable, that no marine mammal is subjected to a sound pressure level of 180 dB re: 1 µPa (rms) or greater from SURTASS LFA sonar operations.

   (c) **Commercial and Recreational SCUBA Diving Mitigation Zone**

1

Attachment 1

(1) The Navy will establish a mitigation zone for human divers at 145 dB re: 1 μPa at 1 m around all known human commercial and recreational diving sites. Although this geographic restriction is intended to protect human divers, it will also reduce the LFA sound levels received by marine mammals located in the vicinity of known dive sites

(d) **LFA Sonar Mitigation Zone and Additional 1-Kilometer (km) Buffer Zone:**

(1) Prior to commencing and during SURTASS LFA sonar transmissions, the Navy will use near real-time environmental data and underwater acoustic prediction models to determine the propagation of the SURTASS LFA sonar signals in the mission area and the distance from the SURTASS LFA sonar source to the 180-decibel (dB) re: 1 μPa isopleth (*i.e.*, the LFA sonar mitigation zone).

(2) The Navy will establish a180-dB LFA sonar mitigation zone around the surveillance vessel that is equal in size to the 180-dB re: 1 μPa isopleth (i.e., the volume subjected to sound pressure levels of 180 dB or greater) as well as establish a one-kilometer (1-km) buffer zone around the LFA sonar mitigation zone.

(3) The Navy will update these sound field estimates every 12 hours or more frequently depending upon changing meteorological or oceanographic conditions; and at least 30 minutes prior to any SURTASS LFA sonar transmission.

(e) **Ramp-Up Procedures for the HF/M3 System:**

(1) The Navy will ramp up the High Frequency/Marine Mammal Monitoring (HF/M3) active sonar from a power level beginning at a maximum source sound pressure level of 180 dB re: 1 μPa @ 1 m (rms) in 10-dB increments to operating levels over a period of no less than five minutes:

(A) At least 30 minutes prior to any SURTASS LFA sonar transmission,

(B) Prior to any SURTASS LFA sonar calibrations or testing that are not part of regular SURTASS LFA sonar transmissions; and

(C) Any time after individuals have powered down the HF/M3 active sonar source for more than two minutes.

(2) The Navy will not increase the HF /M3 active sonar system's sound pressure level once HF /M3 operators detect a marine mammal. Resumption of the ramp-up of HF/M3 sonar system would not occur until marine mammals are no longer detected by the HF /M3 active sonar system, passive acoustic monitoring, or visual monitoring.

(f) **Suspension/Delay for SURTASS LFA Sonar Transmissions:**

If a marine mammal is detected through monitoring within either the LFA sonar mitigation zone or the 1-km buffer zone, the Navy will immediately suspend or delay SURTASS LFA sonar transmissions.

(g) **Resumption of SURTASS LFA Sonar Transmissions:**

The Navy may resume/commence SURTASS LFA sonar transmissions 15 minutes after:

(1) All marine mammals have left the area of the LFA sonar mitigation zone and the 1- km buffer zone; and/or

(2) There is no further detection of any marine mammal within the LFA sonar mitigation zone plus the 1-km buffer zone as determined by the passive or active acoustic or visual monitoring protocols.

(h) **Geographic Restrictions:**

(1) The Navy will not operate SURTASS LFA sonar such that: the SURTASS LFA sonar sound field exceeds 180 dB re: 1 μPa (rms):

(A) At a distance of less than or equal to 12 nautical miles (nmi) (22 km (14 miles (mi)); from any coastline, including offshore islands; and

(B) At a distance of less than 1 km (0.62 mi; 0.54 nmi) seaward of the outer perimeter of any Offshore Biologically Important Area (OBIA) for marine mammals designated in the table below ,or

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identified through the Adaptive Management Process, specified herein, within the period of the NDE's effectiveness.

(2) The OBIAs for marine mammals (with specified periods of effectiveness) for SURTASS LFA sonar routine training, testing, and military operations are:

Name of Area	Location of Area	Months of Importance
Georges Bank	Northwest Atlantic Ocean	Year-round
Roseway Basin Right Whale Conservation Area	Northwest Atlantic Ocean	June through December, annually
Great South Channel, U.S. Gulf of Maine, and Stellwagen Bank National Marine Sanctuary (NMS)	Northwest Atlantic Ocean/ Gulf of Maine	January 1 to November 14, annually Year-round for Stellwagen Bank NMS
Southeastern U.S. Right Whale Habitat	Northwest Atlantic Ocean	November 15 to January 15, annually
Gulf of Alaska	Gulf of Alaska	March through September, annually
Navidad Bank	Caribbean Sea/ Northwest Atlantic Ocean	December through April, annually
Coastal waters of Gabon, Congo and Equatorial Guinea	Southeastern Atlantic Ocean	June through October, annually
Patagonian Shelf Break	Southwestern Atlantic Ocean	Year-round
Southern Right Whale Seasonal Habitat	Southwestern Atlantic Ocean	May through December, annually
Central California	Northeastern Pacific Ocean	June through November, annually
Antarctic Convergence Zone	Southern Ocean	October through March, annually
Piltun and Chayvo offshore feeding grounds	Sea of Okhotsk	June through November, annually
Coastal waters off Madagascar	Western Indian Ocean	July through September, annually for humpback whale breeding and November through December, annually for migrating blue whales.
Madagascar Plateau, Madagascar Ridge, and Walters Shoal	Western Indian Ocean	November through December, annually
Ligurian-Corsican-Provencal Basin and Western Pelagos Sanctuary	Northern Mediterranean Sea	July to August, annually
Penguin Bank, Hawaiian Islands Humpback Whale NMS	North-Central Pacific Ocean	November through April, annually
Costa Rica Dome	Eastern Tropical Pacific Ocean	Year-round
Great Barrier Reef	Coral Sea/ Southwestern Pacific Ocean	May through September, annually
Bonney Upwelling	Southern Ocean	December through May, annually
Northern Bay of Bengal and Head of Swatch-of-No-Ground (SoNG)	Bay of Bengal/ Northern Indian Ocean	Year-round

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Olympic Coast NMS and Prairie, Barkley Canyon, and Nitnat Canyon	Northeastern Pacific Ocean	Olympic NMS: December, January, March, and May annually. Prairie, Barkley Canyon, and Nitnat Canyon: June through September annually
Abrolhos Bank	Southwest Atlantic Ocean	August through November, annually
Grand Manan North Atlantic Right Whale Critical Habitat	Bay of Fundy, Canada	June through December, annually
Eastern Gulf of Mexico	Eastern Gulf of Mexico	Year-round
Southern Chile Coastal Waters	Gulf of Corcovado, Southeast Pacific Ocean; Southwestern Chile	February to April, annually
Offshore Sri Lanka	North-Central Indian Ocean	December through April, annually
Camden Sound/Kimberly Region	Southeast Indian Ocean; northwestern Australia	June through September, annually
Perth Canyon	Southeast Indian Ocean; southwestern Australia	January through May, annually
Southwest Australia Canyons	Southeast Indian Ocean; southwestern Australia	Year-round

Note: The boundaries and periods of OBIAs will be kept on file in NMFS' Office of Protected Resources and its website at http://www/nmfs.noaa.gov/pr/permits/incidental/military.htm.

(i) **Operational Exception for SURTASS LFA Sound Field in OBIAs.** During military operations, SURTASS LFA sonar transmissions may exceed 180 dB re: 1 µPa (rms) within the boundaries of an OBIA, including operating within an OBIA, when the Navy determines that it is: 1) operationally necessary to continue tracking an existing underwater contact; or 2) operationally necessary to detect a new underwater contact within the OBIA. This exception does not apply to routine training and testing with the SURTASS LFA sonar systems.

(j) **Mission Planning.** The Navy must maintain a running calculation/estimation of takes of each species and stocks over the effective period of these regulations. The Navy will plan all SURTASS LFA sonar missions to ensure that no more than 12 percent of any marine mammal species or stock would be taken by Level B harassment annually. This annual per-stock cap of 12 percent applies regardless of the number of SURTASS LFA sonar vessels operating. The Navy must coordinate to ensure that this condition is met for all vessels combined.

III. MONITORING

1. The Navy must perform:

(a) **Visual Mitigation Monitoring:**

(1) Marine mammal biologists qualified in conducting at-sea marine mammal visual monitoring from surface vessels will train and qualify designated ship personnel as lookouts to conduct at-sea visual monitoring. This training may be accomplished either in-person, or via video training.

(2) Marine mammal biologists will train the lookouts in the most effective means to ensure quick and effective communication within the ship's command structure to facilitate implementation of protective measures if they observe marine mammals.

(3) Conduct visual monitoring from the ship's bridge during all daylight hours (30 minutes before sunrise until 30 minutes after sunset). During activities that employ SURTASS LFA sonar in the active mode,

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the SURTASS vessels shall have lookouts to maintain a topside watch with standard binoculars (7x) and with the naked eye.

(b) **Passive Acoustic Mitigation Monitoring:**
(1) Use the low frequency, passive SURTASS sonar system to listen for vocalizing marine mammals.

(c) **Active Acoustic Mitigation Monitoring:**
(1) Use the HF/M3 active sonar to locate and track marine mammals in relation to the SURTASS LFA sonar vessel and the sound field produced by the SURTASS LFA sonar source array, subject to the ramp-up requirements.

2. Mitigation monitoring under Conditions III.1(a), (b), and (c) must:

(a) Commence at least 30 minutes before the first SURTASS LFA sonar transmission (30 minutes before sunrise for visual monitoring);
(a) Continue between sonar transmissions (pings); and
(a) Continue either at least 15 minutes after completion of SURTASS LFA sonar transmissions (30 minutes after sunset for visual monitoring) or if marine mammals are showing abnormal behavioral patterns, for a period of time until behavior patterns return to normal or conditions prevent continued observations.

3. The Navy must:

(a) Cooperate with NMFS and any other federal agency for monitoring the impacts of the activity on marine mammals; and
(b) Designate qualified on-site individuals to conduct the mitigation, monitoring, and reporting activities specified in this NDE.

4. The Navy will conduct all monitoring required under this NDE to increase knowledge of the affected marine mammal species. The Navy must:

(a) Consider recommendations on the different types of monitoring/research that could increase the understanding of the potential effects of SURTASS LFA sonar transmissions on beaked whales and/or harbor porpoises.
(b) Continue to assess data from the Navy Marine Mammal Monitoring (M3) program and work toward making some portion of that data, after appropriate security reviews, available to scientists with appropriate clearances. Any portions of the analyses conducted by these scientists based on these data that are determined to be unclassified after appropriate security reviews should be made publicly available.
(c) Continue to collect ambient noise data and explore the feasibility of declassifying and archiving the ambient noise data for incorporation into appropriate ocean noise research efforts.

IV. REPORTING

1. **Classified and Unclassified Quarterly Reports.** The Navy must submit classified and unclassified quarterly mission reports to the Director, Office of Protected Resources, NMFS no later than 45 days after the end of each quarter, beginning on the date of effectiveness of this NDE. Each quarterly mission report will include summaries of all active-mode sonar missions completed during that quarter. At a minimum, each classified mission report must contain the following information:

(a) Dates, times, and location of each vessel during each mission.
(b) Information on sonar transmissions during each mission and records of any delays or suspensions.
(c) Location of the SURTASS LFA sonar mitigation and buffer zones in relation to the LFA sonar array.

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(d) Marine mammal observations including animal type and/or species, number of animals sighted, date and time of observations, type of detection (visual, passive acoustic, HF/M3 sonar), bearing and range from vessel, abnormal behavior (if any), and remarks/narrative (as necessary).
(e) The report will include the Navy's estimates of the percentages of marine mammal stocks affected (both for the quarter and cumulatively for the year) by SURTASS LFA sonar military readiness activities (both within and outside the LFA sonar mitigation and buffer zones), using predictive modeling based on mission locations, dates/times of operations, system characteristics, LF A sonar transmission durations, oceanographic environmental conditions, and animal demographics.
(f) If no SURTASS LFA sonar missions are completed during a quarter, a report of negative activity will be provided.

2. **Annual Unclassified Report.** The Navy must submit an annual, unclassified report to the Director, Office of Protected Resources, NMFS, no later than 60 days after the annual anniversary of the execution of this NDE. At a minimum, the annual report will contain the following:

(a) An unclassified summary of the year's quarterly reports.
(b) The Navy's estimates of the percentages of marine mammal stocks affected by SURTASS LFA sonar military readiness activities (both within and outside the LFA sonar mitigation and buffer zones), using predictive modeling based on mission locations, dates/times of operations, system characteristics, LFA sonar transmission durations, oceanographic environmental conditions, and animal demographics.
(c) An analysis of the effectiveness of the mitigation measures with recommendations for improvements, where applicable.
(d) An assessment of any long-term effects from SURTASS LFA sonar military readiness activities a.
(e) Any discernible or estimated cumulative impacts from SURTASS LFA sonar military readiness activities.

3. **Status on Marine Mammal Monitoring (M3) Program.** The Navy must provide a status update to NMFS, in proximity to the annual anniversary of the execution of this NDE, on efforts to assess the data collected by the Marine Mammal Monitoring (M3) program and progress toward making some portion of that data, after appropriate security reviews, available to scientists with appropriate clearances. Any portions of the analyses conducted by these scientists based on these data that are determined to be unclassified after appropriate security reviews should be made publicly available. The status update may be submitted with the Navy's annual unclassified report.

4. **Marine Mammal Ship Strike Reporting**. In the event of a ship strike by the SURTASS LFA sonar vessel, at any time or place, the Navy must:

(a) Immediately, or as soon as clearance procedures allow, report to NMFS the species identification (if known), the size and length of the animal, location (lat/long) of the animal (or the strike if the animal has disappeared), whether the animal is alive or dead (or unknown), including an estimate of its injury status if alive (injured but alive, injured and moving, unknown, etc.).
(b) Report the incident to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Dale.Youngkin@noaa.gov.
(c) Report as soon as feasible to the NMFS the vessel's name, class/type, and length, as well as operational status, speed and vessel heading.
(d) Provide NMFS a photo or video of the struck animal, if equipment is available.

5. **Marine Mammal Stranding Reporting.** During SURTASS LFA sonar military readiness activities personnel onboard a SURTASS LFA vessel shall systematically observe for injured or disabled marine mammals and

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Attachment 1

monitor the principal marine mammal stranding networks and other media to correlate analysis of any whale strandings that could potentially be associated with SURTASS LFA sonar activities, the Navy shall:

(a) Ensure that NMFS is notified immediately, or as soon as clearance procedures allow, if an injured, stranded, or dead marine mammal is observed during or shortly after (within 24 hours) and in the vicinity of any SURTASS LFA sonar activities. The Navy will report the incident to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Dale.Youngkin@noaa.gov.

(b) Provide NMFS with species or description of the animal(s), the condition of the animal(s) (including carcass condition if the animal is dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available).

(c) In the event that personnel onboard a SURTASS LFA vessel observe an injured, stranded, or dead marine mammal during transit, or that is not in the vicinity of, or found during or shortly after SURTASS LFA sonar military readiness activities, the Navy will report the same information to NMFS as listed above as soon as operationally feasible and clearance procedures allow.

NAVY APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR SURTASS LFA SONAR; JUNE 2018, TRANSMITTAL LETTER

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

9462
June 4, 2018

From: Director, Undersea Capabilities Branch (OPNAV N2/N6F24)
To: Ms. Donna Wieting
Director, Office of Protected Resources (F/PR)
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, Maryland 20910

Subj: APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR TRAINING AND TESTING ACTIVITIES ASSOCIATED WITH USE OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

Encl: Application for Rulemaking and Letter of Authorization Under the Marine Mammal Protection Act for Activities Associated with Use of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

1. Pursuant to Section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA) of 1972, as amended, the Department of the Navy (hereafter Navy) is submitting an application for regulations and an incidental take authorization for the use of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar during training and testing activities. Marine mammals would be incidentally harassed due to the underwater sound generated by the use of SURTASS LFA sonar systems during training and testing activities in the western and central North Pacific Ocean and eastern Indian Ocean.

2. As a result, the Navy is requesting rulemaking and a LOA under the MMPA for the taking of marine mammals by Level B harassment incidental to the use SURTASS LFA sonar systems within the western and central Pacific and eastern Indian oceans. Currently, the Navy has four surveillance ships with SURTASS LFA sonar systems onboard: United States Naval Ship (USNS) VICTORIOUS (Tactical-Auxiliary General Ocean Surveillance [T-AGOS] 19), USNS ABLE (T-AGOS 20), USNS EFFECTIVE (T-AGOS 21), and USNS IMPECCABLE (T-AGOS 23). The Navy may develop and field additional SURTASS LFA sonar equipped vessels, either to replace

Subj: APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR TRAINING AND TESTING ACTIVITIES ASSOCIATED WITH THE USE OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

or complement, the Navy's current SURTASS LFA sonar capable fleet.

3. The complete application is provided as enclosure (1). This application for rulemaking and an LOA is the fifth such application the Navy has submitted to the National Marine Fisheries Service (NMFS) for use of SURTASS LFA sonar.

4. The basis of this fifth request for rulemaking and an LOA is: (1) the analysis of spatial and temporal distributions of protected marine mammals in areas in which SURTASS LFA sonar would be used, (2) a review of activities that have the potential to affect marine mammals, and (3) a scientific risk assessment to determine the likelihood of impacts from the use of LFA sonar in the western and central North Pacific and eastern Indian oceans.

The Navy has narrowed the geographic scope of its application to reflect only those areas of the world's oceans where the Navy anticipates conducting covered SURTASS LFA sonar activities (i.e., training and testing conducted under the authority of the Secretary of the Navy). The Navy has provided greater detail on the types of covered SURTASS LFA sonar activities in its application. The narrowed scope will allow the Navy to more accurately assess and describe only those impacts associated with covered SURTASSS LFA sonar activities in ocean areas where the Navy expects to conduct these activities.

5. The scientific risk analysis as detailed in the Navy's application applies the 2016 NMFS acoustic thresholds for onset of permanent and temporary threshold shift as detailed in *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing*. The results of the Navy's risk assessment, which included modeling of 15 representative areas of the acoustic regimes and marine mammal species that may be encountered during SURTASS LFA sonar training and testing activities, are that no (0 percent) Level A harassment is estimated for any marine mammal species or stocks, given that the full suite of mitigation measures were implemented. The primary impact anticipated from SURTASS LFA sonar transmission is MMPA Level B harassment of marine mammals. This application assumes that short-term, non-injurious sound exposures may cause temporary threshold shifts (TTS) or temporary behavioral disruptions, which constitute Level B incidental harassment. The results of the Navy's analysis indicate that for most marine mammal species, the maximum annual percent of the stock or

Subj: APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR TRAINING AND TESTING ACTIVITIES ASSOCIATED WITH THE USE OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

population that may experience Level B incidental harassment is less than 15 percent. This means that during one 24-hr period during the year, less than 15 percent of the population may react to SURTASS LFA sonar by changing behavior or moving a small distance or may experience TTS. Of the 139 stocks within the SURTASS LFA sonar study area, ten stocks in years 1 to 4 and thirteen stocks in years 5 and beyond have the potential for MMPA Level B incidental harassment greater than 15 percent. The highest percentage of a population that may experience Level B harassment is the WNP stock and DPS of humpback whales at 233.79% and 313.29% in years 1 to 4 and years 5 and beyond, respectively. This means that each individual in the population may react behaviorally or experience TTS two to three times during one year. The percentage of the WNP stock and DPS of humpback whales that may experience Level B harassment is influenced by the size of the population, which is small (1,328 individuals). The next highest stock is the WNP stock of killer whales, with 85.32% and 117.25% in years 1 to 4 and years 5 and beyond, respectively.

Based on the results of the analyses conducted for SURTASS LFA sonar and more than fifteen years of documented results that are summarized in this application and presented in associated NEPA documentation, use of SURTASS LFA sonar, when used in accordance with the mitigation measures (geographic restrictions and monitoring/reporting), support a negative impact determination.

In summary:

- Potential impacts on marine mammal species and stocks are expected to be limited to Level B harassment. Since the potential Level B harassment would not involve long-term displacement or disruption of foraging, breeding, or migrations of marine mammal species or stocks, the Navy does not estimate that the Level B impacts would affect rates of recruitment or survival of the associated marine mammal species and stocks. Thus, impacts on recruitment or survival are expected to be negligible.
    - Level B harassment of marine mammals would not occur in ocean areas that are biologically important to marine mammals (e.g., foraging, reproductive areas, rookeries, ESA critical habitat) or where small, localized populations occur. Received levels above 180 decibels (root mean squared) would not be transmitted in the four identified areas of importance (offshore biologically important area [OBIAs]) to marine mammals that are within the study area for SURTASS LFA sonar.

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Subj: APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR TRAINING AND TESTING ACTIVITIES ASSOCIATED WITH THE USE OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

- Based on the Navy's impact analysis results, no mortality and no injury (i.e., Level A harassment) of marine mammals may occur as a result of SURTASS LFA sonar use, and the potential to cause strandings of marine mammals is considered negligible.
- The use of SURTASS LFA sonar would entail the addition of sound energy to the oceanic ambient noise environment, which in conjunction with the sound produced by other anthropogenic sources, may increase the overall ambient noise level. Increases in ambient noise levels have the potential to affect marine animals by causing masking. However, broadband, continuous low-frequency ambient noise is more likely to affect marine mammals than narrowband, low duty cycle SURTASS LFA sonar. Moreover, the bandwidth of any SURTASS LFA sonar transmitted signal is limited (approximately 30 Hz), the average maximum pulse length is 60 sec, signals do not remain at a single frequency for more than 10 seconds, and the system is off nominally 90 to 92.5 percent of the time during an at-sea activities. With the nominal duty cycle of 7.5 to 10 percent, masking by LFA sonar would only occur over a very small temporal scale. The cumulative impacts related to the potential for masking are not a reasonably foreseeable significant adverse impact to marine mammals.
- Use of SURTASS LFA sonar would not impact the habitat of marine mammals nor result in loss or modification of marine habitat.
- The availability of marine mammals for subsistence use would not be adversely impacted.
- A comprehensive suite of mitigation measures, including three types of monitoring (passive acoustic, active acoustic, and visual) during LFA sonar transmissions, coastal standoff range (180 decibel sound field restricted to 22 km [12 nmi] from shore), and OBIA restrictions (sound field produced by sonar below 180 decibel received level), would be implemented to reduce the potential for harassment to marine mammals.

6. SURTASS LFA sonar systems would be operated in accordance with the geographic restrictions and monitoring mitigation delineated in the Navy's application.

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Subj: APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR TRAINING AND TESTING ACTIVITIES ASSOCIATED WITH THE USE OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

7. During the period of authorization, the means to increase knowledge of marine mammal species or stocks and determine the level of impacts on marine mammals from potential takes would be determined by the Navy in consultation with NMFS.

8. As the point of contact on this matter, I can be reached at (703) 695-8266.

CDR Patrick Havel

Copy to:
J. Harrison
D. Youngkin
C. Tortorici
K. Petersen
E. MacMillan
D. Kitchen

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NAVY BIOLOGICAL EVALUATION FOR SURTASS LFA SONAR TO INITIATE SECTION 7 CONSULTATION PURSUANT TO THE ENDANGERED SPECIES ACT, JUNE 2018, TRANSMITTAL LETTER

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350

IN REPLY REFER TO

9462
15 June 2018

From: Director, Undersea Capabilities Branch (N2N6F24)
To: Director, Office of Protected Resources
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, Maryland 20910

Subj: BIOLOGICAL EVALUATION FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM (SURTASS) LOW FREQUENCY ACTIVE (LFA) SONAR TO INITIATE SECTION 7 ESA CONSULTATION

Encl: Biological Evaluation for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar; Endangered Species Section 7 Consultation; June 2018

In accordance with Section 7(a)(2) of the Endangered Species Act (ESA) (16 USC 1536(a)(2)), the Department of the Navy (DoN) (hereafter Navy) has prepared the enclosed Biological Evaluation (Enclosure 1) to initiate consultation under the ESA and to request a Biological Opinion (BO) and Incidental Take Statement (ITS) on the training and testing activities of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar in the western and central North Pacific and eastern Indian oceans. SURTASS LFA sonar's transmission of underwater sound has the potential to affect ESA-listed marine mammal, sea turtle, as well as marine and anadromous fish species and their designated critical habitat. To document its consideration of the potential effects on the marine and anadromous species and critical habitat listed or proposed for listing under the ESA that are present in the study area for SURTASS LFA sonar, the Navy has prepared the enclosed Biological Evaluation (BE).

The Navy currently has four ocean surveillance ships that are equipped with SURTASS LFA sonar systems: USNS VICTORIOUS (Tactical-Auxiliary General Ocean Surveillance [T-AGOS] 19); USNS ABLE (T-AGOS 20); USNS EFFECTIVE (T-AGOS 21); and USNS IMPECCABLE (T-AGOS 23). The Navy may develop and field additional SURTASS LFA sonar equipped vessels, either to replace or complement the Navy's current SURTASS LFA sonar-capable

SUBJ: BIOLOGICAL EVALUATION FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM (SURTASS) LOW FREQUENCY ACTIVE (LFA) SONAR

fleet. The Navy proposes to continue using SURTASS LFA sonar systems onboard these vessels within the study area, which includes the western and central North Pacific and eastern Indian oceans. As part of its Proposed Action, the Navy has narrowed the geographic scope to reflect only those areas of the world's oceans where the Navy anticipates conducting covered SURTASS LFA sonar activities in the foreseeable future. The narrowed scope would allow the Navy to more accurately assess and describe only those impacts associated with SURTASSS LFA sonar activities in areas where the Navy expects to conduct these activities.

The Navy proposes to implement procedural and geographic mitigation measures in association with the use of SURTASS LFA sonar. Specifically, the Navy would ensure that received levels of LFA sonar transmissions are below 180 decibels relative to 1 microPascal (root-mean squared) (dB re 1 µPa [rms]) within 12 nautical miles (22 kilometers) of any emergent land and at the boundary of any of the 29 designated offshore biologically important areas (OBIAs) during their effective periods of important biological activity. Of the 29 existing OBIAs, four are located within the study area for SURTASS LFA sonar. Procedural mitigation measures include visual, passive acoustic, and active acoustic (high frequency marine mammal monitoring [HF/M3] sonar) monitoring to minimize effects to marine animals when SURTASS LFA sonar is transmitting by providing the means to detect marine mammals and sea turtles in the 180-dB mitigation zone for SURTASS LFA sonar, and then suspending or delaying LFA sonar transmissions if marine animals are detected. Additionally, the received levels of LFA sonar transmissions would not exceed 145 dB re 1 µPa (rms) within known recreational dive sites.

Pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 USC 1371), the Navy has applied for rulemaking and a Letter of Authorization (LOA) for the continued use of SURTASS LFA sonar during training and testing activities. Marine mammals may be incidentally harassed due to the underwater sound generated by the SURTASS LFA sonar systems during at-sea activities. As a result, the Navy requested rulemaking and a LOA under the MMPA for the taking of marine mammals by Level B harassment incidental to the use of SURTASS LFA sonar systems in the western and central North Pacific and eastern Indian oceans.

The Navy is in the process of preparing a Draft Supplemental Environmental Impact Statement/Supplemental Overseas

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SUBJ: BIOLOGICAL EVALUATION FOR SURVEILLANCE TOWED ARRAY SENSOR SYSTEM (SURTASS) LOW FREQUENCY ACTIVE (LFA) SONAR

Environmental Impact Statement (DSEIS/SOEIS) for SURTASS LFA sonar that is planned to be released to the public in August 2018. This DSEIS/SOEIS would provide detailed supporting information for the BE and MMPA Rule and LOA application.

The Navy formally requests a BO and ITS from the National Marine Fisheries Service (NMFS) for SURTASS LFA sonar activities following review of the information and data presented in the enclosed BE.

As the point of contact on this matter, I can be reached at 703-695-8266 or at <patrick.havel@navy.mil>.

CDR Patrick Havel

Enclosure: 1) Biological Evaluation for SURTASS LFA Sonar

Copy to:
C. Tortorici
K. Petersen
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H. Goldstein
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D. Kitchen
B. Ward

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APPENDIX B: MARINE MAMMAL IMPACT ANALYSIS

APPENDIX B: MARINE MAMMAL IMPACT ANALYSIS

This appendix documents the elements of the acoustic impact analysis for marine mammals presented in Chapter 4 of this SEIS/SOEIS. The acoustic impact analysis represents an evolution that builds upon the analysis, methodology, and impact criteria documented in previous SURTASS LFA sonar NEPA efforts (Department of the Navy [DoN], 2001, 2007, 2012, 2015, 2017), which are incorporated by reference.

The acoustic impact analysis of SURTASS LFA sonar transmissions is a multi-step process based on using the Acoustic Integration Model© (AIM) to integrate the acoustic field created from the underwater transmissions of LFA sonar with the four-dimensional (4D) movement of marine mammals to estimate their potential sonar exposure. AIM is the foundation for the impact analyses presented herein as it has been for all previous analyses of acoustic impacts on marine mammals associated with SURTASS LFA sonar.

Descriptions of the proposed action, including the operating characteristics of LFA sonar, are included in Chapter 2, while Chapter 3 includes information on the distribution and population estimates of the marine mammal species and stocks that occur in the model areas for SURTASS LFA sonar and are assessed in this SEIS/SOEIS.

References to Underwater Sound Levels

- References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (root mean square) (dB re 1 µPa at 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983).
- In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time; the appropriate units for SEL are dB re 1 μPa^2-sec (American National Standards Institute [ANSI], 2006; Southall et al., 2007; Urick, 1983).
- The term “Single Ping Equivalent” (SPE) used herein is an intermediate calculation for input to the behavioral risk continuum used in the acoustic impact analysis for SURTASS LFA sonar. SPE accounts for the energy of all LFA sonar transmissions that a modeled animal (“animat”) receives during a 24-hr period of SURTASS LFA sonar use as well as an approximation of the manner in which the effect of repeated exposures accumulates. As such, the SPE metric incorporates both physics and biology. SPE is a function of SPL, not SEL. SPE levels will be expressed as “dB SPE” in this document, as they have been presented in preceding environmental compliance documentation for SURTASS LFA sonar: FOEIS/FEIS (DoN, 2001); FSEIS (DoN, 2007); FSEIS/SOEIS (DoN, 2012); FSEIS/SOEIS (DoN, 2015); and FSEIS/SOEIS (DoN, 2017).
- Briefly, SPE accounts for the increased potential for behavioral response due to repeated exposures by adding 5 x log10 (number of pings) to each 1-dB RL increment (Kryter, 1985; Richardson, Greene, Malme, & Thomson, 1995; Ward, 1968). This calculation is done for each dB level of RL and then summed across all dB levels to determine the dB SPE for that animal. A more generalized formula is provided in the original FOEIS/FEIS (DoN, 2001).

B-1. Introduction to AIM

AIM is described in detail and has been used in the impact analyses in these preceding environmental compliance documents for SURTASS LFA sonar: FOEIS/FEIS (DoN, 2001), FSEIS (DoN, 2007), FSEIS/SOEIS (DoN, 2012), FSEIS/SOEIS (DoN, 2015), and FSEIS/SOEIS (DoN, 2017). While the information and details on AIM and its use in the analysis of marine mammal acoustic impacts are incorporated by reference, the following summary of AIM is provided for context.

AIM is a Monte Carlo based statistical model in which multiple iterations of realistic predictions of acoustic source use as well as animal distribution and movement patterns are conducted to provide statistical predictions of estimated impacts from exposure to acoustic source transmissions. Each acoustic source and receiver is modeled via the "animat" concept. Animats are computationally simulated animals or objects. When an animat represents an object such as an acoustic source, the speed, direction, and depth are usually specified. When an animat represents an animal, movement is defined by specifying behavioral variables, such as dive parameters, swimming speed, and course/direction changes. This results in a realistic representation of animal movements such as diving patterns that mimic real-world diving patterns of that species. The movement of an animat can also be programmed to respond to environmental factors (e.g., water depth) so that a marine species that normally inhabits a specific environment (e.g., shallow, coastal waters) can be constrained to stay within a specified habitat.

A model run consists of a user-specified number of steps forward in time. During each 30-sec time step, each animat is moved according to the programmed rules describing its behavior and the received sound level at each receiver animat is recorded (in the same units that are used to specify the source level, e.g., dB rms). At the end of each time step, each animat evaluates its environment including its three-dimensional (3D) location. If an environmental variable has exceeded the user-specified boundary value (e.g., the animat has moved into water that is too deep), then the animat will alter its course to respond to the environment. These environmental responses are called "aversions". There are many aversion variables that can be used to specify an animat's reactions and to program realistic behavior, such as bathymetry, geographic boundaries, water temperature, and density of prey species.

B-2 AIM Modeling Inputs

Fifteen representative model areas in the western and central North Pacific and eastern Indian oceans were selected for analysis to represent the acoustic regimes and marine mammal species that may be encountered during LFA sonar training and testing activities (Table B-1). The spatial extent of each model area was defined as the range at which the receive level (RL) from SURTASS LFA sonar transmissions was down at least 100 dB from the array source level (SL) (i.e., transmission loss was at least 100 dB). Seasons as applied herein are defined according to the following monthly breakdown:

- Winter: December, January, and February
- Spring: March, April, and May
- Summer: June, July, and August
- Fall: September, October, and November.

For consistency, the seasonality for marine mammals in all model areas is presented according to this monthly arrangement, even for the model area located in the southern hemisphere (Model Area #14, Northwest of Australia). Winter (encompassing the months of December, January, and February)

Table B-1. Locations of the 15 Representative Model Areas for SURTASS LFA Sonar.

Model Area	*Model Area Name*	*Model Area Center*	*Notes*
1	East of Japan	38°N, 148°E	
2	North Philippine Sea	29°N, 136°E	
3	West Philippine Sea	22°N/124°E	
4	Offshore Guam	11°N, 145°E	Navy Mariana Islands Testing and Training Area
5	Sea of Japan	39°N, 132°E	
6	East China Sea	26°N, 125°E	
7	South China Sea	14°N, 114°E	
8	Offshore Japan 25° to 40°N	30°N, 165°E	
9	Offshore Japan 10° to 25°N	15°N, 165°E	
10	Hawaiʻi North	25°N, 158°W	Navy Hawaiʻi-Southern California Testing and Training Area; Hawaiʻi Range Complex
11	Hawaiʻi South	19.5°N, 158.5°W	Navy Hawaiʻi-Southern California Testing and Training Area; Hawaiʻi Range Complex
12	Offshore Sri Lanka	5°N, 85°E	
13	Andaman Sea	7.5°N, 96°E	
14	Northwest of Australia	18°S, 110°E	
15	Northeast of Japan	52°N, 163°E	

for Model Area #14 is actually austral summer, when for instance, most baleen whales would be expected to be foraging in Antarctic waters.

The marine mammal species potentially occurring in a modeling area were determined, along with any seasonal differences in their occurrence. Modeled species were simulated by creating animats programmed with behavioral values describing their dive behavior, including dive depth, surfacing time, dive duration, swimming speed, and direction change. Animats were randomly distributed over the model simulation area.

The modeled marine mammal animats were set to populate the simulation area with densities of 0.025, 0.05, or 0.1 animats/km^2, densities often higher than those estimated in the marine environment. This "over population" of the modeling environment ensures that the result of the simulation is not unduly influenced by the chance placement of a few simulated marine mammals. To obtain final harassment estimates, the modeled results are normalized by the ratio of the modeled animat density to the real-world marine mammal density estimate. This allows for greater statistical power without overestimating risk.

During AIM modeling, the animats were programmed to "reflect" off the boundaries of the area to remain within the simulation area. This reflection maintains the appropriate density of animats since no animats are allowed to diffuse out of the simulation area. It is also a more protective factor in the modeling results since it keeps animats within the simulation area and available for additional acoustic exposure during the 24-hr simulation period. In reality, an animat that reflects off the simulation boundary would actually leave the simulation area, whereas the animat reflecting into the simulation would actually be a new animal with no acoustic exposure entering the simulation area. Since acoustic exposure accumulates over the 24-hr modeling period, the reflected animat may have a higher exposure than if it were considered as two separate animals.

B-2.1 Acoustic Propagation

B-2.1.1 Sound Source Waypoints

Each model area is defined by geographic coordinates in which the simulated SURTASS LFA sonar vessel travels in a triangular pattern (Figure B-1). For modeling purposes, the center of each model area is the center of the vessel track. For each model area, the ship speed was modeled at 4 kt (7.4 kph), and in all cases, the time on each bearing was 8 hr (480 min). The duration of LFA sonar transmissions was modeled as 24 hr at each model area, with a signal duration of 60 sec and a duty cycle of 10 percent (i.e., the source transmitted for 60 sec every 10 mi for 24 hr for a total of 2.4 LFA sonar transmission hours). These operational parameters represent typical SURTASS LFA sonar transmissions during training and testing activities (Chapter 2).

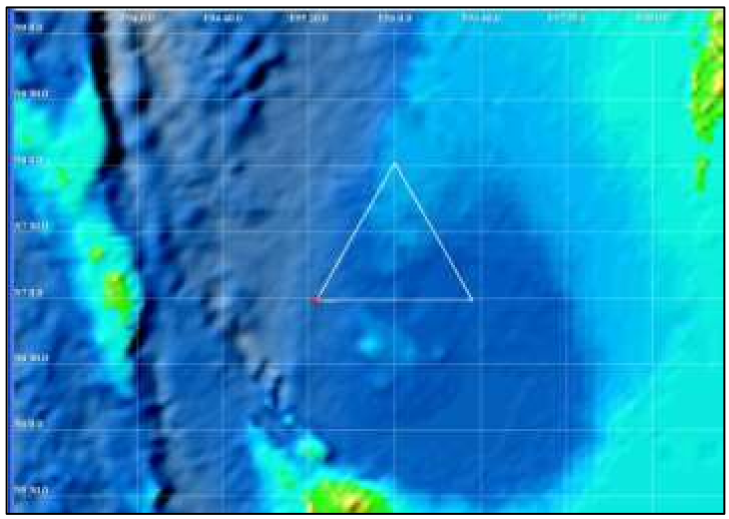


Figure B-1. Modeled Ship Movement Pattern of SURTASS LFA Sonar Vessel during Simulated Use.

B-2.1.2 Transmission Loss and Modeling Area

The LFA sonar source was modeled as a vertical line array using the actual element spacing of the LFA sonar array, with transmissions at a nominal frequency and nominal SL. For this modeling effort, a single frequency of 300 Hz (i.e., the middle of the 100 to 500 Hz band of the system), and an individual element SL of 215 dB re 1 µPa @ 1 m (rms) (SPL) (or an array source level of about 235 dB re 1 µPa @ 1 m (rms) (SPL) in the far-field) were used as these nominal values.

To model the sound fields created by the SURTASS LFA sonar source, the Navy standard parabolic equation (PE) model was used. The bathymetry used was the 2-minute Gridded Global Relief Data set (ETOPO2), with an adjustment to the data that corrects the existing indexing error in the ETOPO2 dataset (NOAA National Geophysical Data Center (NOAA-NGDC), 2006). The sound velocity profiles for each location and season were obtained from the Generalized Digital Environmental Model, Version 3.0 (Carnes, 2009), a standard U.S. Navy OAML database. A wind speed of 15 kt (27.8 kph) was used to calculate surface losses using the Bechmann-Spezzichino formula modified by (Leibiger, 1978). For bottom loss, province 5 and curve 5 from the consolidated bottom loss upgrade (CBLUG) database (Renner and Spofford, 1985) were used for all sites. Four bearings were modeled per location and a nominal vertical half-beam width of 45° was used. Spherical spreading was assumed within 0.054 nmi (0.1 km) of the LFA sonar source.

B-2.2 Parameters that Define Animat Movement in AIM

Animals move through four dimensions: 3D space and time. Several parameters are used in AIM to produce simulated movements that accurately represent expected real animal movement patterns. This section provides short descriptions of the various parameters, with nominal values as examples of how the parameters are implemented in AIM. The actual values used in the impact analysis and the literature from which that information was obtained are detailed later in this appendix.

B-2.2.1 Marine Mammal Diving Patterns

Diving parameters, such as time limits, depth limits, heading variance, and speed, are specified for each animat in the AIM model (Figure B-2). As an example, a dive pattern is presented that consists of a shallow, respiratory sequence (top row of Figure B-2) followed by a deeper, longer dive (bottom row of Figure B-2). The horizontal component of the dive is handled with the "heading variance" term, which allows the animal to change course up to a certain number of degrees at each movement step. For this example, the animal can change course 20° during a shallow dive and 10° during a deep dive (Figure B-2). Using the defined diving parameters, AIM generates realistic dive patterns (Figure B-3).

B-2.2.2 Aversions

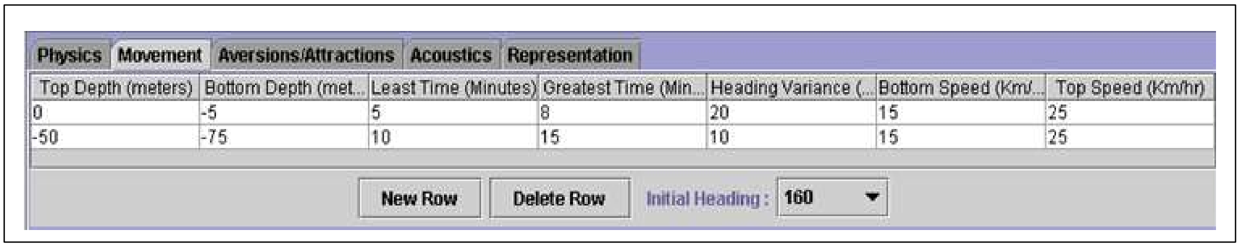
In addition to movement patterns, animats can be programmed to avoid certain environmental characteristics (Figure B-4). For example, aversions can be used to constrain an animal to a particular depth regime. (e.g., an animat can be constrained to waters between 2,000 and 5,000 m deep). An animat will continue to turn until the aversion is satisfied. In this example, animat makes 20° turns in water depths shallower than 6,562 feet (2,000 m) or deeper than 16,404 feet (5,000 m) to remain within that depth range.

B-2.3 Parameters of Marine Mammal Movement Behaviors Used in Impact Analysis

Dive and swim speed information for each marine mammal or marine mammal group is a critical component of accurately and realistically modeling marine mammal movements when assessing potential exposure to underwater acoustic transmissions. Dive and swim parameters used in the AIM modeling of marine mammals potentially occurring in the representative model areas (Table B-1) are summarized (Table B-2). Narrative information, including the literature from which these values were obtained, is included in Chapter B-2.4 or incorporated by reference from the 2017 SEIS/SOEIS as described below. The narrative descriptions include discussion of additional parameters that are not direct inputs into the AIM model (e.g., habitat, group size, residency), but represent information that was used in creating the modeling scenarios to most accurately reflect known distribution patterns.

Some marine mammal species were modeled as representative groups rather than individual species. Beaked whale species are one example, where all potentially occurring beaked whales were divided into two functional modeling groups, the large and small beaked whales (see Table B-2 for the breakdown of species each grouping represents). Additionally, congener species that inhabit the same type of habitat and have similar dive and swim behaviors, such as the *Stenella* group that contains spinner, striped, and spotted dolphins, were modeled as an inclusive generic group rather than by the individual species.

The dive and swim data for many of the marine mammal species modeled for this SEIS/SOEIS (Table B-2) remain unchanged from the data and information presented previously (Appendix B, 2017 SEIS/SOEIS [DoN, 2017]); thus, the narrative information on diving and swimming behavior for some species are incorporated by reference herein and are not repeated in this appendix. Dive and swim data and



Top Depth (meters)	Bottom Depth (met...	Least Time (Minutes)	Greatest Time (Min...	Heading Variance (...	Bottom Speed (Km/...	Top Speed (Km/hr)
0	-5	5	8	20	15	25
-50	-75	10	15	10	15	25

Figure B-2. Example of AIM Marine Mammal Movement Parameters, With the Top Row Showing the Parameters of a Shallow, Respiratory Dive (Diving from Surface to 5 m for 5 to 8 min) and the Bottom Row Showing a Deeper, Longer Dive (Diving Between 50 and 75 m for 10 to 15 min).

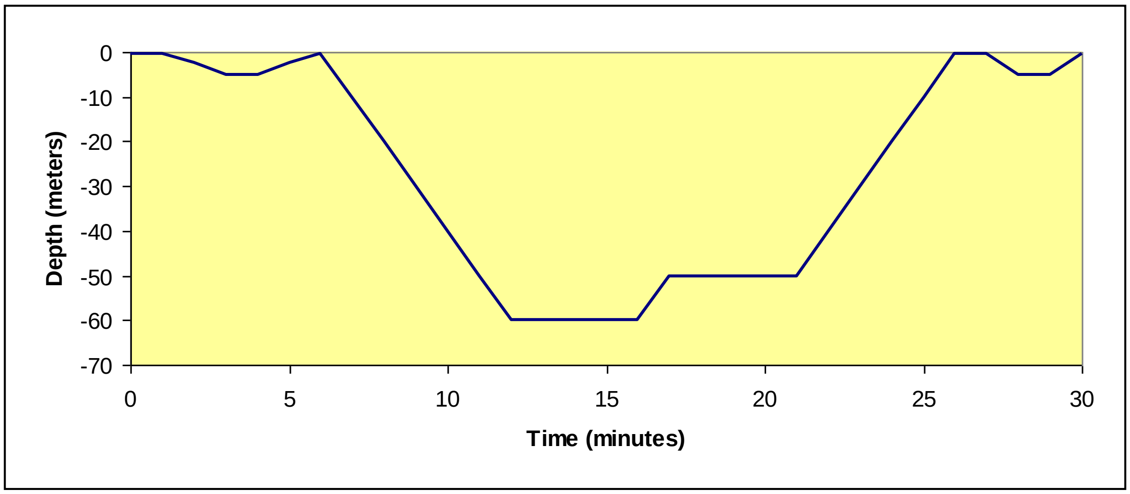
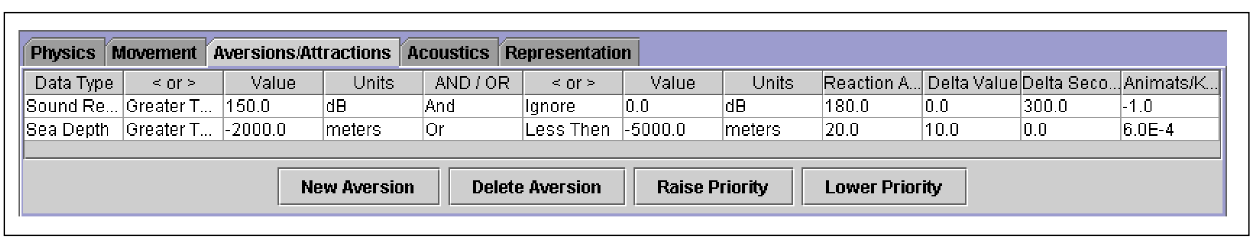


Figure B-3. Marine Mammal Dive Pattern Based on Animat Data in Figure B-2. The Animat Makes a Shallow Dive from the Surface to 16 Feet (5 Meters) for Approximately 6 Minutes, Surfaces, and then Makes a Deep Dive to 197 Feet (60 Meters) for About 5 min, Changes Depth to 164 Feet (50 Meters) for Another 5 Minutes, and then Surfaces.



Data Type	< or >	Value	Units	AND / OR	< or >	Value	Units	Reaction A...	Delta Value	Delta Seco...	Animats/K...
Sound Re...	Greater T...	150.0	dB	And	Ignore	0.0	dB	180.0	0.0	300.0	-1.0
Sea Depth	Greater T...	-2000.0	meters	Or	Less Then	-5000.0	meters	20.0	10.0	0.0	6.0E-4

Figure B-4. Example of Depth Aversion Parameters for Modeling of Marine Mammal Movements.

Table B-2. Dive and Swim Parameters of all the Potentially Occurring Marine Mammal Species Modeled to Assess the Potential Impact of Exposure to SURTASS LFA Sonar Transmissions in 15 Representative Model Areas.

Modeled Species	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle*	*Dive Depth (meters) Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (METERS)/ Reaction Angle*
Antarctic and Common Minke Whale	1/3		20/100	2/6	Surf 45/Dive 20	1/18	Gamma (3.25,2)	10/reflect
Blue Whale (non-foraging) (including pygmy blue whale)	1/4		20/100	2/18	30/300 (50 %) 90/300 (50 %)	3/14	Normal	100/reflect
Blue Whale (foraging) (including pygmy blue whale)	1/4		20/100 (50) 100/300 (50)	2/18 4/18	30/300 90/90	3/14	Normal	100/reflect
Bryde's/Omura's/Sei Whales	1/1	90/75	10/40 (80) 50/267 (20)	2/11	30/300 (50 %) 90/300 (50	1/20	5/1	50/reflect
Fin Whale	1/1		50/250 (45) 50/250 (45) 250/470 (10)	5/8 1/2	20	1/16	Normal	30/reflect
Humpback Whale (migrating)	1/2		10/40 (100)	5/10	10	2/12	Normal	(Min =100)/reflect
Humpback Whale (feeding)	1/2		10/60 (20 percent) 40/100(75 percent)	5/10	45/30	2/10	Normal	(Min =100)/reflect
Humpback Whale (winter grounds, singing)	1/1		15/30 (100)	10/25	10/30	0/1	Normal	>1000/reflect
Humpback Whale (calf)	1/2		5/30 (100)	2/5	45	1/3	Normal	>200/reflect
Humpback Whale (winter adult)	1/1		10/50	5/20	20	1/6	Gamma	1000/reflect
North Pacific Right Whale (feeding)	4/5	75	113/130 (50) 113/130 (50)	11/13 11/13	90/90 30/90	1/4	Normal	
North Pacific Right Whale (migrating)	1/1	75	10/200 (10) 10/35 (90)	1/10 1/7	90/60 30/300	2/5	Normal	
North Pacific Right Whale (breeding)	1/3	75	2/25 (50) 2/25 (50)	1/8 1/8	30/300 90/90	1/3	Normal	

Table B-2. Dive and Swim Parameters of all the Potentially Occurring Marine Mammal Species Modeled to Assess the Potential Impact of Exposure to SURTASS LFA Sonar Transmissions in 15 Representative Model Areas.

Modeled Species	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle*	*Dive Depth (meters) Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (METERS)/ Reaction Angle*
Western North Pacific Gray Whale (migrating)	1/2		10/40	3/12	10/300	2/9	Normal	10/reflect
Western North Pacific Gray Whale (summering)	1/2		10 / bottom	1/7	90/90	1/5	Normal	
Western North Pacific Gray Whale (mating)	1/2		10/40	1/7	90/90	1/5	Normal	
Beaked Whales—Small (Blainville's, Cuvier's, Longman's, Hubbs', Ginkgo-toothed, Deraniyagala's, Spade-toothed, Stejneger's beaked whales)	1/7		2000/3000 (5) 1000/2000 (25) 200/500 (70)	100/140 48/74 12/30	30/300 (50) 90/300 (50)	2/7	Normal	253/ reflect
Beaked Whales—Large (Baird's beaked whales and southern bottlenose whales)	1/7		500/1453 (50) 50/200 (50)	48/70 12/70	30/300 (50) 90/300 (50)	3/6	Normal	253/reflect
Kogia spp. (dwarf and pygmy Sperm Whales)	1/2		200/1000	5/12	30	1/11	Normal	117/reflect
Blackfish (false killer whale, melon-headed whale, pygmy killer whale)	1/1		5/50 (80) 50/300 (20)	1/3 4/8	30/300 (50) 90/90 (50)	2/22.4	Gamma	200/reflect
Common and Indo-Pacific Bottlenose Dolphins (Coastal)	1/1		15/98	1/3	90/300 (50) 90/90 (50)	2/16	Normal	10/reflect
Common and Indo-Pacific Bottlenose Dolphins (Pelagic)	1/1		6/50 (80) 50/100 (5) 100/250 (5) 250/500 (10)	1/2 2/3 3/4 5/6	30/300 (45) 90/90 (45) 90/90(10)	2/16	Normal	101/1226 reflect

Table B-2. Dive and Swim Parameters of all the Potentially Occurring Marine Mammal Species Modeled to Assess the Potential Impact of Exposure to SURTASS LFA Sonar Transmissions in 15 Representative Model Areas.

Modeled Species	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle*	*Dive Depth (meters) Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (METERS)/ Reaction Angle*
Common Dolphins	1/1		50, /200	1/5	30	2/9	Normal	100-1000/reflect
Dall's Porpoise	1/1		5/94	1/2	30	6/16	Normal	>100 m
Fraser's Dolphin	1/1		50/700	1/6	30/300 (50) 90/300 (50)	2/15	Normal	100/reflect
Harbor Porpoise	1/1	17/31	1/10 (35) 10/40 (45) 40/100 (15) 100/230 (5)	1/4	30/150	2/8	Normal	100-1000/reflect
Killer Whale	1/1		10/180	1/10	30/300 (50)	3/12	Normal	25/ reflect
Northern Right Whale Dolphin	1/1			1/6	30	2/30	Gamma	
Pacific White-sided Dolphin	1/1		25/125	1/3	30/300 (50) 90/90 (50)	2/9	Normal	
Stenella spp. (pantropical spotted, spinner, and striped dolphins)	1/1		Day: 5/25 (50) Night: 10/400 (10) Night: 10/100 (40)	1/4	30	2/15	Normal	10/ reflect
Risso's Dolphin	1/3		150/1000	2/12	30/300 (50) 90/300 (50)	2/12	Normal	150/ reflect
Rough-toothed Dolphin	1/3		50/600	1/7	30/300 (50) 90/300 (50)	5/16	Normal	194/ reflect
Short-finned Pilot Whale	1/1		5/100 (80) 50/1000 (20)	1/10 5/21	30	2/12	Normal	200/ reflect
Sperm Whale	8/11	90/75	600/1400 (90) 200/600 (10)	40/65 18/40	20	1/10	Normal	200/reflect

Table B-2. Dive and Swim Parameters of all the Potentially Occurring Marine Mammal Species Modeled to Assess the Potential Impact of Exposure to SURTASS LFA Sonar Transmissions in 15 Representative Model Areas.

Modeled Species	*Min/Max Surface Time (Min)*	*Surface/ Dive Angle*	*Dive Depth (meters) Min/Max (Percentage)*	*Min/Max Dive Time (Min)*	*Heading Variance (Angle/Time)*	*Min/ Max Speed (kph)*	*Speed Distribution*	*Depth Limit (METERS)/ Reaction Angle*
Hawaiian Monk Seal (NW Hawaiian Islands)	1/2		10/60 (45) 10/60 (45) 50/500 (10)	2/8 2/8 8/12	30/300 90/300 90/300	2/9	Normal	
Hawaiian Monk Seal (Main Hawaiian Islands)	1/2		20/50 (90) 50/100 (10)	4/9 8/12	90/300 90/300	2/9	Normal	
Northern Fur Seal (on shelf)	0.5/2 1/2 1/2		0/5 (57) 100/150 (26) -1/5 (17)	1/4 3/7 1/4		4.0/6.5 4.0/6.5 0/1		>200/reflect
Northern Fur Seal (off shelf)	0.5/2 1/2 1/2		0/5 (57) 30/75 (26) -1/5 (17)	1/4 1/4 1/4		4.0/6.5 4.0/6.5 0/1		<1000/reflect
Pagophilic *Phoca* spp. (spotted and ribbon seals)	1/2 0.4/2.3		-1/5(30) 5/50(49)	1/4 1/5.4		0/1 1.1/3.6		
Steller Sea Lion (winter)	3/8		4/10 (54) 10/50 (37) 50/250 (10)	0/2 2/4 4/8		3/10		
Steller Sea Lion (summer)	3/8		4/10 (35) 10/50 (61) 50/250 (3)	0/1 1/4 4/8		3/10		

Descriptions for the following marine mammal species are included by reference from the 2017 SEIS/SOEIS:

- Humpback Whale (Winter Grounds: Singer)
- Humpback Whale (Calf)
- Right Whales: North Pacific Right Whale
- Gray Whales: Western North Pacific Gray Whale
- Common and Indo-Pacific Bottlenose Dolphins
- Common Dolphin
- Dall's Porpoise
- *Kogia* spp. (Dwarf and Pygmy Sperm Whales)
- Fraser's Dolphin
- Harbor Porpoise
- Killer Whale
- Right Whale Dolphins: Northern Right Whale Dolphin
- *Lagenorhynchus* spp.: Pacific White-Sided Dolphin
- Risso's Dolphin
- Rough-toothed Dolphin
- *Stenella* spp.: Pantropical Spotted, Spinner, and Striped Dolphins
- Phagophilic *Phoca* spp. Seals (Spotted and Ribbon Seals)
- Steller Sea Lion

Updated details follow on diving for the remainder of marine mammal species that occur in the potential model areas for SURTASS LFA sonar.

B-2.4 Marine Mammal Diving Descriptions

B-2.4.1 Antarctic and Common Minke Whale

Surface Time

A mean surface time of 1.72 min, with a range of 0.63 to 2.35 min, was reported by Stern (1992).

Dive Depth

Inferred from other species, however reduced in depth, since minke whales are likely to be pelagic feeders, feeding on species found near the surface (Olsen and Holst, 2001). Four tagged minkes had a maximum dive depth of 150 m, and rarely dove deeper than 120 m (Kvadsheim et al., 2017). Their dives were grouped into three categories: long and deep (14 percent of all baseline dives), intermediate (29 percent of all baseline dives) and short and shallow (57 percent of all baseline dives).

Minke whales' dive depth is inferred from other species; however, reduced in depth, since minke whales are likely to be pelagic feeders, feeding on species found near the surface (Olsen and Holst, 2001).

Dive Time

The mean dive time was 4.43 (+/- 2.7) min was reported by (Stern, 1992). Dive times measured off Norway range from approximately 1 to 6 min (Joyce et al., 1989). Dive times also show small diel and seasonal variability (Stockin et al., 2001), but the variability is small enough to be considered not significant for AIM modeling. Dive times were non-normal (Figure B-5) (Øien et al., 1990). Minke whales in the St. Lawrence River performed both 'short' and 'long' dives. Short dives lasted between 2 and 3 min, while long dives ranged from 4-6 min (Christiansen et al., 2015).

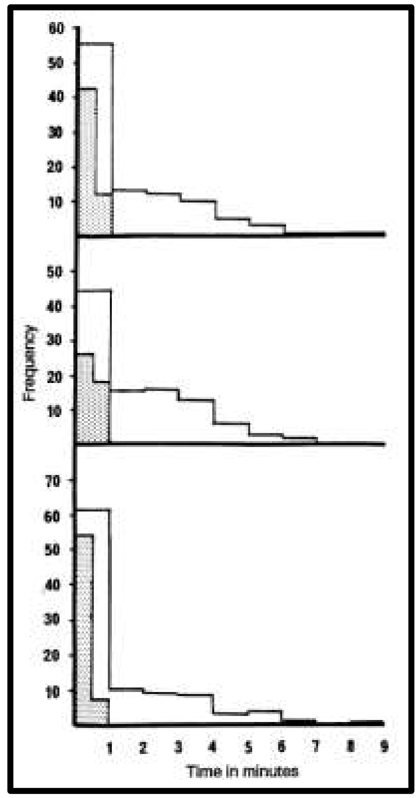


Figure B-5. Minke Whale Dive Durations (Øien et al., 1990).

Speed

The mean speed value for minke whales in Monterey Bay was 8.3 +/- 6.4 kph (4.5 +/- 3.45 knots) (Stern, 1992). Satellite tagging studies have shown movement of up to 79 km/day (3.3 kph). Minke whales being pursued by killer whales were able to swim at 15 to 30 kph (Ford et al., 2005).

A gamma function was fit to the available speed data (Figure B-6). The modal speed of this function is 4.5 kph, matching the Stern (1992) data, and has a maximum of 18 kph, somewhat less than the maximum speed achievable (30 kph), observed during predation. "Cruising" minke whales have been reported at 3.25 m/s (Blix and Folkow, 1995).

Habitat

Minke whales in Monterey Bay were reported to be at a median depth of 48.6 m (Stern, 1992). They are known to move into very shallow water as well as deep oceanic basins. The 10-m limit and reflection aversion are intended to let minke whales roam freely, but to keep them in the water.

Group Size

Minke whales in the Gulf of California were seen in group sizes of 1 to 50, with a mean group size of 5.7 (Silber et al., 1994). Mean group sizes in the Antarctic was 1.6 (Blix and Folkow, 1995).

Residency

Foraging minke whales have been shown to exhibit small scale site fidelity (Morris and Tscherter, 2006). Therefore, foraging minke whales should have their course change parameters set to be variable to allow for small net movements. Long-duration ARGOS tracks of minke whales show that their behavior can be broken into Transiting, intermediate and foraging periods (Area Restricted search) based upon Multi-Scale Straightness Index (Lee et al., 2017).

B-2.4.2 Bryde's/ Omura's/Sei Whales

There is a paucity of data for these species. Since they are similar in size, data for both species have been pooled to derive model parameters for these species.

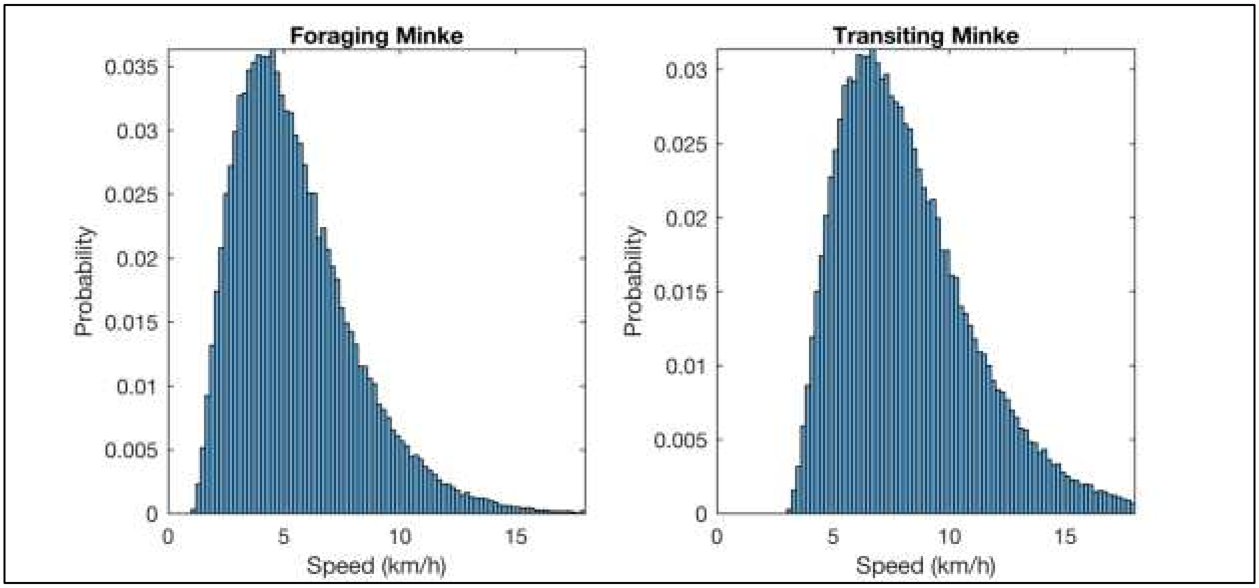


Figure B-6. Speed Distributions used for Foraging and Transiting Minke Whales.

Surface Time

No direct data were available so fin whale values were used.

Dive Depth

A limited number of Bryde's whales have been tagged with TDRs (Alves et al., 2010). Shallow dives, less than 40 m were recorded 85 percent of the time, while deep dives occurred 15 percent of the time. The maximum dive depth reported was 876 ft (267 m). Two distinct dive types were noted for Bryde's whales. Both performed a long series of shallow dives of less than 131 ft (40 m) until 1.5 before sunset. The animals then made the deepest dives. During the night, sequential deep dives took place. Foraging lunges were recorded during about half of these nighttime dives.

Vocalizing sei whales were most often acoustically located at depths of 49 to 131 ft (15 to 40 m), with occasional calls at 70 m (Newhall et al., 2012).

Dive Time

Sei whale dive times ranged between 0.75 and 11 min, with a mean duration of 1.5 min (Schilling et al., 1992). Most of the dives were short in duration, presumably because they were associated with surface or near-surface foraging. The same paper reported surface times that ranged between 2 sec and 15 min. The maximum dive time reported for two Bryde's whales was 9.4 min (Alves et al., 2010), with mean durations of 4 to 6 min.

Heading Variance

Observations of foraging sei whales found that they had a very high reorientation rate, frequently resulting in minimal net movement (Schilling, et al., 1992). Acoustically active Bryde's whales tracked off of Kaua'i, HI. The majority (16/17) had directivity indices greater than 0.95, with a single individual that had a value of 0.14 (Helble et al., 2016).

Speed

Brown (1977) reported an overall speed of advance from tagged sei whales as 4.6 kph. The highest speed reported for a Bryde's whale was 20 kph (Cummings, 1985). A Bryde's whale being attacked by killer whales traveled approximately 9 km in 94 min, with most of the travel occurring in the first 50 min, producing an estimated speed of 10.8 kph (Silber et al., 1990). The maximum speed of sei whales reported from a satellite tracking study was 7.6 m/sec, although the distribution of speeds was highly skewed toward lower values (Olsen et al., 2009). The speed parameters used in AIM are 1 to 20 kph, using a gamma distribution with alpha and beta parameters of 5 and 1 (Figure B-7), which covers the reported range of speed reported by Brown (1977). A satellite tagging study with eight sei whales reported a migration speed of 7.4 kph (SD = 0.4) and an 'off-migration' speed of 6.2 kph (SD=0.8) (Prieto, Silva, Waring, and Gonçalves, 2014). Bryde's Whales tracked off of Kaua'i, HI had speeds that ranged from 0.15 to 16 kph, with and overall mean of 6 kph (Helble, et al., 2016).

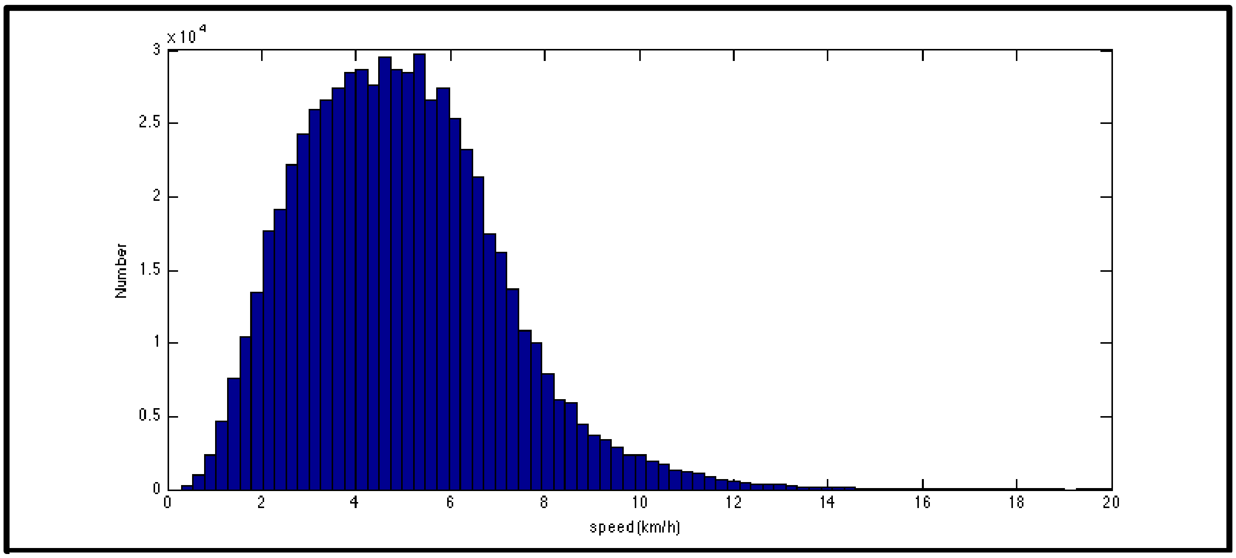


Figure B-7. Bryde's Whale Speed Distribution.

Habitat

Sei whales are known to feed on shallow banks, such as Stellwagen Bank (Kenney and Winn, 1986). Therefore, sei and Bryde's whales are allowed to move into shallow water.

Group Size

Sei whales in the Gulf of Maine were seen in groups of 1-6 animals with a mean group size of 1.8 whales (Schilling et al., 1992). Bryde's whales in the Gulf of California were seen in groups of 1 to 2 animals, with a mean size of 1.2 whales (Silber et al., 1994).

B-2.4.3 Blue Whale

Surface Time

Of four satellite tagged blue whales, one reported surface intervals of 7 to 90 sec, with a mean of 48 sec. The other three did not report intervals > 60 sec, indicating that the surface time was short (Lagerquist et al., 2000). Blue whales off Sri Lanka had a mean surfacing time of 167 (+/-68) sec, with a range of 29 to 421 sec (de Vos et al., 2013). DeRuiter et al. (2016) identified three behavioral states in blue whales off Southern California. The surfacing times for those three states are shown in Table B-3. Based on these two reports, the AIM surfacing interval will range from 1 to 3 min.

Dive Depth

(Croll et al., 2001) reported a mean dive depth of 140 m (+/- 46.01) for non-foraging animals, while foraging whales had a mean dive depth of 67.6 m (+/- 51.46). Satellite tagged whales off California had a maximum dive depth of 192 m (Lagerquist et al., 2000). The distribution of dive depths was bimodal, as typified by the plot below (note that this is from one animal). A series of blue whales had Crittercam attached to them off California and Mexico. The maximum dive depth reported was 293 m (Calambokidis et al., 2008). Many of these animals had deep feeding dives, with lunges occurring between 200 and 260 m. Notably, one animal transitioned from deep feeding dives of decreasing depth as the sun set, transitioning into shallow non-feeding dives. This does indicate that there may be a diurnal character to some blue whale behavior. Migrating pygmy blue whales had dives consistently to ~ 13 m, the minimum depth predicted to avoid surface drag effects (Owen et al., 2016).

Heading Variance

DeRuiter et al. (2016) identified three behavioral states in blue whales off Southern California. Heading change angle (per dive) and heading variance for those three states are shown in Table B-3. The value of heading change selected was the one with the mean probability of occurrence (from 0° to 180°). The time basis was taken as the mean dive time, as the angles were measured from the midpoint of one dive to the next. Thus, a single dive was the unit of analysis.

The transition probability matrix for these three behavioral states was estimated, and produced stationary probabilities for the occurrence of each behavioral state of 43, 20, and 37 percent, respectively.

Residency

A pygmy blue whale has been observed across 27 years, with resightings occurring less than 10 km away (de Vos, 2016).

Group Size

Blue whales in the Eastern Tropical Pacific had a modal group size of one, although pods of two were somewhat common (Reilly and Thayer, 1990). The mean group size of blue whales off Australia (*B. m. brevicauda*) was 1.55 (Gill, 2002).

B-2.4.4 Fin Whale

Surface Time

Remarkably good data for surface times exist for fin whales. A log survivorship analysis of all inter-blow intervals was used to determine an inflection point of 28 and 31 sec between surface and dive activity for feeding and non-feeding animals, respectively (Kopelman and Sadove, 1995). The mean surface duration for fin whales, without boats present, off Maine was 54.63 sec (SD = 59.61) while dive times were 200.84 sec (SD = 192.91) (Stone, Katona, Mainwaring, Allen, and Corbett, 1992). Surface time of four fin whales off Kodiak Alaska was 3 min (+/- 0.8) (Witteveen, De Robertis, Guo, and Wynne, 2015).

Dive Depth

Foraging fin whales had mean dive depths of 97.9 +/- 32.59 m, while traveling fin whales had mean dive depths of 59.3 +/- 29.67 m (Croll et al., 2001). Migrating fin whales were determined to have a maximal dive depth of 364 m (Charif et al., 2002). Fin whales in the Mediterranean Sea typically dove to about 100 m, and occasionally dove to 470 m, or more (Panigada et al., 1999), however these are

Table B-3. Reproduced from Deruiter et al. (2016). These are the Parameters Describing the Probability Distributions for Different Dive Components. Dive Duration, Surface Duration, Maximum Depth, and Step Length are Modeled with a Gamma Distribution (Parameters here are Mean and S.D.), but the Number of Lunges Is Modeled with a Poisson Distribution. Turning Angle uses a Von Mises (Circular Normal) Distribution, while Heading Variance is Modeled upon a Beta Distribution.

Variable	State 1	State 2	State 3
Duration (gamma)	$\mu = 135.4, \sigma = 75.3$	$\mu = 350.5, \sigma = 216.1$	$\mu = 508.2, \sigma = 135.8$
Surf. Duration (gamma)	$\mu = 70.5, \sigma = 68.4$	$\mu = 86.4, \sigma = 53.9$	$\mu = 148.3, \sigma = 69.1$
Max. Depth (gamma)	$\mu = 30.5, \sigma = 21.8$	$\mu = 71.3, \sigma = 67.2$	$\mu = 166.7, \sigma = 62.0$
No. Lunges (Poisson)	$\lambda = 0.60$	$\lambda = 0.01$	$\lambda = 3.30$
Step Length (gamma)	$\mu = 193.8, \sigma = 139.1$	$\mu = 710.7, \sigma = 294.4$	$\mu = 401.3, \sigma = 281.2$
Turn. Angle (von Mises)	$\mu == 0, \kappa = 1.04$	$\mu == 0, \kappa = 3.11$	$\mu == 0, \kappa = 0.83$
Head. Variance (beta)	$a = 0.88, b = 2.05$	$a = 0.52, b = 6.16$	$a = 1.68, b = 1.59$

unusually deep dives. The animats here model the more typical dive pattern 90 percent of the time. Foraging fin whales off California had a mean maximum dive depth of 248 m (Goldbogen et al., 2006). Fin whales foraging off Kodiak Alaska had mean dive depths between 103 and 144 m (Witteveen, et al., 2015).

Dive Time

Foraging fin whales had mean dive times of 6.3 +/- 1.53 min, while traveling fin whales had mean dive time of 4.2 +/- 1.67 min (Croll et al., 2001). The maximum dive time observed was 16.9 min. Fin whales off the east coast of the U.S. were observed to have mean dive times of 2.9 min. Ranges for feeding animals ranged from 29 to 1001 sec, while non-feeding animals had longer dives between 32 and 1212 sec (Kopelman and Sadove, 1995). Panigada et al. (1999) found that shallow (<100meters) dives had a mean dive time of 7.1 min, while deeper dives had dive times of 11.7 and 12.6 min. Fin whales foraging on Jeffrey's Ledge in the Gulf of Maine had mean dive times of 5.83-5.89 min (Ramirez, Schulte, and Kennedy, 2006). Fin whales foraging off California had a mean dive time of 7 +/- 1 (S.D.) min (Goldbogen et al., 2006). Fin whales foraging off Kodiak had a mean dive time of 6 min (Witteveen et al., 2015).

Heading Variance

The meander parameter is defined as the ratio of the total distance along the smoothed path to the net distance traveled; a value of 1 would indicate a straight path. Acoustically tracked fin whales off Washington state had a mean meander value of 1.8, with a standard deviation of 2.1 (Soule and Wilcock, 2013). The mean percentage of transiting tracks (speeds > 4 kph and meander < 1.25) was 37 percent with a range of 17-60 percent.

Satellite tagged fin whales in the Mediterranean Sea spent an average of 9.6 percent in transit mode (high linearity values), 62.6 percent in Area Restricted Search (low linearity values) and 27.9 percent in an intermediate "uncertain" behavioral state (Panigada et al., 2017).

Speed

Watkins (1981) reported a mean speed of 10 kph, ranging from 1 to 16 kph, with bursts of 20 kph reported. Mean descent speeds of 3.2 m/s (SD = 1.82) and ascent speeds of 2.1 m/s (SD=0.82) have been reported from fin whales in the Mediterranean (Panigada et al., 1999). Acoustically tracked fin whales had mean speeds of 4.3 kph (S.D.= 2.1) with a range of 1-12 kph (Soule and Wilcock, 2013).

Habitat

Fin whales are found feeding on shallow banks and in bays (Woodley and Gaskin, 1996) as well as in the abyssal plains of the ocean (Watkins, 1981). Thus, fin whales are allowed to move into shallow water in AIM, with a 30-meter inshore limit to keep them out of the very shallow waters. Off Vancouver Island, fin whales were primarily found offshore of the shelf break, in waters deeper than 450 m (Nichol, Wright, O'Hara, and Ford, 2017). This suggests that AIM parameters for fin whales should be reviewed prior to project creation, to reflect the habitat limitation of the relevant population of fin whales.

Group Size

In the Gulf of Mexico, fin whales had a mean group size of 5.7, with a range in group sizes form 1-50 (Silber et al., 1994). In the Mediterranean Sea the mean group size over a number of years was 1.75 animals (Panigada et al., 2005).

B-2.4.5 Humpback Whale (Migrating)

Surface Time

Approximately 65 percent of all surfacings observed in Alaska were two min in length or less (Dolphin, 1987). Surface times in Hawai'i are similar, with the exception of surface-active groups (SAGs) (Bauer, Mobley, Frankel, Helweg, and Herman, 1995).

Dive Depth

Humpback whale dive depths have been measured on the feeding grounds. 75 percent of their dives were to 40 m or less (Dolphin, 1988). It is likely that migrating animals would also predominantly dive to these shallow depths. Humpbacks foraging off California had a mean maximum dive depth of 156 m (Goldbogen et al., 2008).

Dive Time

Surface times range between 1 and 2 min while dive times range between 5 and 10 min (Gabriele, Straley, Herman, and Coleman, 1996). Foraging humpbacks off California had mean dive times of 7.8 +/- 2.0 min (Goldbogen et al., 2008).

Heading Variance

Set very low for migrating animals. Most non-competitive, group breeding animals also have linear travel. Migrating humpbacks swam very close to magnetic north from Hawai'i with very little deviation (Mate, Gisiner, and Mobley, 1998). Migrating animals have very linear travel, although statistics were not provided by (Cerchio et al., 2016).

Speed

Mean speeds for humpbacks are near 4.5 kph. The measured range is 2 to 11.4 kph (excluding stationary pods) (Gabriele et al., 1996). Satellite tracked migrating humpback whales moved at a minimum of 150 km/day (6.25 kph) for a mother and calf pod, while another two whales moved 110 km/day (4.5 kph).

Humpbacks off Australia were estimated to migrate at a mean speed of 8 kph, with a range between 4.8-14.2 kph (Chittleborough, 1953). A mean northern migration speed of 5.47 kph was measured for Australian humpbacks, while the southern migration speed had a mean of 5.02 kph for non-calf pods, while calf pods had mean speeds of 5.03 and 4.25 kph respectively (Chaudry, 2006). Migrating humpbacks in the northwest Atlantic mad a mean estimated migratory speed of 4.3 (SD = 1.2) kph (Kennedy et al., 2014). Migrating mom and calf pods (behavioral mode 1) had speeds of 81 km/d (3.4 kph), while speed dropped to 32 km/d (1.3 kph) in area restricted movement mode 2. The intermediate behavior (mode 3) had intermediate speeds of 41.1 km/d (1.7 kph) (Guzman and Félix, 2017).

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the abyssal plains. Humpbacks swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for this species has been set at 100m. Non-calf pods migrating off Australian had a mean offshore distance of 3177m during the northern migration and 2560 m during the southern migration. Calf pods migrated “significantly” closer inshore (Chaudry, 2006).

B-2.4.6 Humpback Whale (Feeding)

Surface Time

Approximately 65 percent of all surfacings observed in Alaska were two min in length or less (Dolphin, 1987). Burrows et al. (2016) reported surface times that ranged from 1.8 to 3.3 min, with a mean of 2.5 min.

Dive Depth

Humpback whale dive depths have been measured on the feeding grounds. Seventy-five percent of their dives were to 40 m or less with a maximum depth of 150 m (Dolphin, 1988). Dive depth appears to be determined by prey distribution. Whales in this study were primarily foraging upon euphausids. There is also a strong correlation of dive depth and dive time and is described by the following equation (Dolphin, 1987).

Time (s) = 0.52 * depth (meters) +3.95, $r^2 = 0.93$

Feeding humpbacks off Kodiak Alaska had a mean maximum depth of 106.2m, with 62 percent of the dives occurring between 92 and 120 m, with a maximum of ~ 160 m (Witteveen et al., 2008) (Figure B-8). The distribution of their depths is shown below. The humpbacks appeared to be feeding largely on capelin and pollock. There are strong differences in the data between these two studies. This difference may reflect the distribution of prey rather than behavioral abilities of the whales.

Dive Time

The maximum of the continuous portion of the distribution of dive times was 15 min (Dolphin, 1987). The distribution was skewed toward shorter dives. Several dive steps can be programmed in AIM to capture this variability. (Burrows et al., 2016) reported dive times that ranged from 7.5 to 9.6 min, with a mean of 6.0 min.

Heading Variance

Satellite tracking of feeding humpback whales in the Southern Ocean showed very erratic travel, and animals frequently remained in a specific area for up to a week at a time. There were periodic movements between feeding areas (Dalla Rosa et al., 2008). Therefore, the heading variance for feeding

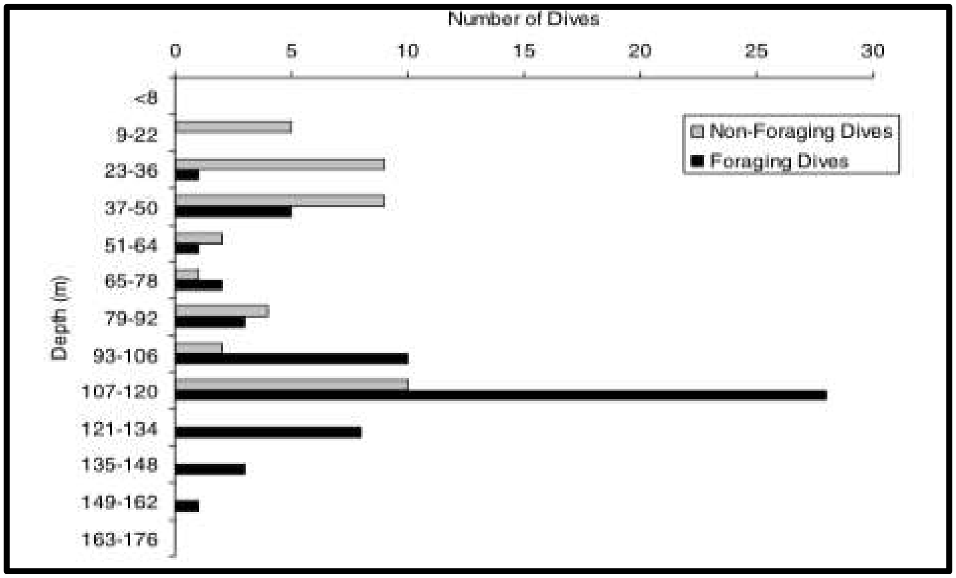


Figure B-8. Frequency Distribution of Feeding Humpback Whale Mean Maximum Dive Depths in 14 m (1 SD of Mean Maximum Dive Depth) Depth Bins for Dives Recorded from Tagged Humpback Whales (Witteveen et al. 2008).

humpbacks will be set relatively high, for 80 percent of the time. Twenty percent of the time will be set to low heading variance, to simulate movement between feeding areas.

Argos data for humpbacks feeding in the Aleutian Islands found that the animals spent 13 percent of their time in travel mode, 62 percent in 'area-restricted search' (presumed to be foraging) and 25 percent in 'unclassified' behavior (Kennedy, Zerbini, Rone, and Clapham, 2014).

Speed

Mean speeds for humpbacks are near 4.5 kph. The measured range is 2 to 11.4 kph (excluding stationary pods) (Gabriele et al., 1996). Feeding humpbacks in the Southern Ocean had mean measured speeds between 2.26 and 4.03 kph (Dalla Rosa et al., 2008). These values were derived from short segments of satellite tracking data; therefor they are likely underestimates of speed. Ascent rates during dive range from 1.5 to 2.5 m/s, while descent rates range between 1.25 and 2 m/s (Dolphin, 1987). The mean speed for all pod types in Glacier Bay was 3.31 kph (Baker and Herman, 1989).

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the oceanic abyssal plains. Humpbacks that swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for this species has been set at 100 m.

Group Size

Ninety-six percent of 27,252 pods in the Gulf of Maine were composed of 1 to 3 animals, with a modal size of one adult (Clapham, 1993).

B-2.4.7 Humpback Whale (Winter Adult)

Surface Time

Approximately 65 percent of all surfacings observed in Alaska were 2 min in length or less (Dolphin, 1987). Surface times in Hawaiʻi are similar, with the exception of surface active groups (Bauer et al., 1995).

Dive Depth

The maximum dive depth reported for a humpback on the Hawaiian winter grounds was 176 m (Baird, Ligon, and Hooker, 2000). The distribution of dive depths was strongly skewed toward shallower dives (Table B-4).

Table B-4. Humpback Whale Dive Distributions.

Depth Category (m)	*Mean Time In Depth Category (percent)*	*Standard Deviation*	*Cumulative Time (percent)*
1-10	39.55	20.57	39.55
11-20	26.51	13.29	66.06
21-30	11.65	11.84	77.71
31-40	4.25	2.77	81.96
41-50	3.04	2.28	85.00
51-60	2.47	2.28	87.47
61-70	2.14	1.73	89.61
71-80	1.66	1.54	91.27
81-90	1.97	1.91	93.24
91-100	1.55	2.36	94.79
101-110	1.39	2.17	96.18
111-120	1.31	2.33	97.49
121-130	0.92	1.75	98.41
131-140	0.72	1.73	99.13
141-150	0.30	0.56	99.43
151-160	0.23	0.40	99.66
161-170	0.15	0.26	99.81
171-180	0.09	0.22	99.90

Dive Time

Surface times range between 1 and 2 min, while dive times range between 5 and 10 min (Gabriele et al., 1996).

Heading Variance

Most non-competitive group breeding animals also have largely linear travel.

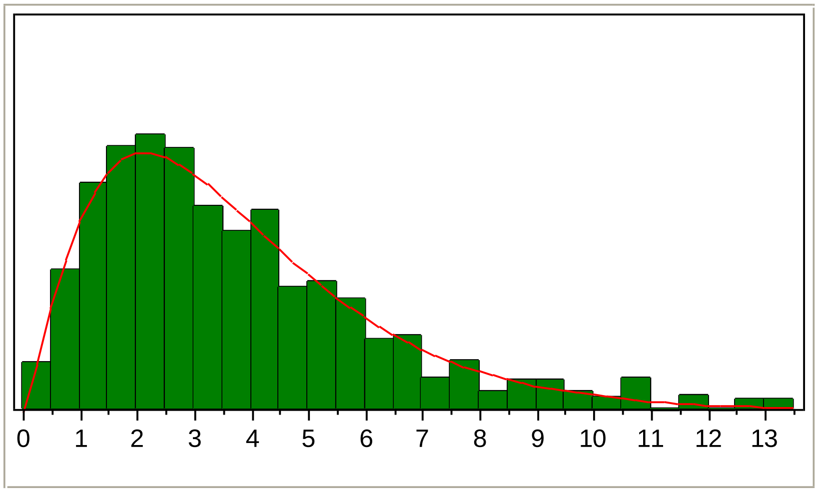


Figure B-9. Histogram of Speeds for all Humpback Whale Pods Tracked in Hawai'i.

Speed

The estimated speed on the breeding grounds from satellite tagged whales was 1.7 (SD = 0.8) kph (Kennedy et al., 2014). Mean speeds for humpbacks are near 4.5 kph while the measured range is 2 to 11.4 kph (excluding stationary pods) min (Gabriele et al., 1996). Migrating and resident humpback off Madagascar had speeds between 1.3 and 4.6 kph, with a mean of 3.0 kph (Cerchio et al., 2016). Fitted Gamma curve parameters (Table B-5) and humpback whale speed distribution measured in Hawai'i (Figure B-9) are shown below.

Table B-5. Gamma Curve Parameters for Figure B-9.

Type	*Parameter*	*Estimate*	*Lower 95 Percent*	*Upper 95 Percent*
Shape	Alpha	2.326775	2.255537	2.398012
Scale	Sigma	1.617174	1.561936	1.672412
Threshold	Theta	0.000000	1.570127	

Group Size

The modal group size in Hawai'i was two adults (Mobley and Herman, 1985).

B-2.4.8 Beaked Whales

Data on the behavior of beaked whales is sparse. Therefore, all beaked whale species have been pooled into two animats, large and small beaked whales. A taxonomic approach (Dalebout et al., 2004) would suggest divisions by the genus *Berardius*, *Hyperoodon*/*Tasmacetus*, and *Mesoplodon*. *Ziphius*, a genus with a single species, seems to be behaviorally related most closely to *Mesoplodon*. At this point, available behavioral data are sufficient to support splitting beaked whales into large (*Berardius, Hyperoodon,* and *Tasmacetus*) and smaller whales (*Mesoplodon, Ziphius,* and *Indopacetus*) (Table B-5). The behavior of *Indopacetus* has not been documented, but it is grouped with *Mesoplodon* because it was initially classified as a *Mesoplodon* and is most closely related taxonomically to smaller beaked whales.

Small Beaked Whales

Surface Time

Sowerby's beaked whales had surface times of 1-2 min, during which they would blow 6-8 times (Hooker and Baird, 1999b). Cuvier's beaked whales have surfacing bouts of 23-26 intervals that are 3-15 sec apart, with a mean of 7 sec (SD = 2.1) (Baird et al., 2006). Blainville's beaked whale surfacings are composed of an average of 18 (SD = 11.3) surfacing intervals, each with a mean duration of 10.9 (SD = 5.51) sec. Cuvier's beaked whales off Southern California had surface times between 3 and 6 min in the absence of mid-frequency sonar (Falcone et al., 2017). Surfacing times tended to increase in the presence of MF sonar.

Dive Depth

Ziphius tagged off the Canary Islands had foraging dives between 824 and 1267 m, while Blainville's beaked whales dove to depths between 655 and 975 m (Johnson, Madsen, Zimmer, Aguilar de Soto, and Tyack, 2004). Blainville's beaked whales in Hawai'i performed dives to mid-water depth (100 to 600 m) approximately 6 times more frequently than at night. Dives deeper than 800 m had no diurnal difference (Baird, Webster, Schorr, McSweeney, and Barlow, 2008). Cuvier's beaked whales tagged off southern California had mean deep dive depths of 1401 (SD = 137.8) m and a duration of 67.4 (S.D. = 6.9) min (Schorr, Falcone, Moretti, and Andrews, 2014). This study also reported a maximum dive depth of 2,992 m that lasted 137.5 min.

Acoustically tracked Cuvier's beaked whales in the northwest Atlantic had mean dive depths of 1158 +/- 287 m and 870 +/- 151 for *Mesoplodon* whales (DeAngelis, Valtierra, Van Parijs, and Cholewiak, 2017).

Blainville's beaked whales in the Caribbean performed non-foraging dives to ~ 350 m, while foraging dives ranged between 600 and 1900 m. Cuvier's beaked whales in the Caribbean performed non-foraging dives to ~ 500 m, while foraging dives ranged between 700 and 1900 m (Joyce et al., 2017).

Dive Time

The minimum and maximum dive time measured was 16 and 70.5 min respectively (Hooker and Baird, 1999a). Sowerby's beaked whales had dives between 12 and (at least) 28 min in the Gully in Canada (Hooker and Baird, 1999b). Arnoux's beaked whale had modal dive times between 35-65 min (mean = 46.4 min, SD = 13.1), with a maximum dive time of at least 70 min (Hobson and Martin, 1996). Tagging results with *Ziphius* had one animal diving for 50 min (Johnson, et al., 2004). *Mesoplodon stejnegeri* were observed to dive for "10-15 min" in Alaska (Loughlin, 1982).

Cuvier's beaked whales in Hawai'i performed a regular pattern of one very long (>59 min) and deep dive (>1000meters), followed by 1-4 shallow (~ 292 to 568 m) and shorter (~ 20 min) dives (Baird et al., 2006). This pattern has been seen in many other studies as well.

Blainville's beaked whales in Hawai'i appeared to have two general dive types. The first are shallow dives that range from < 50 m to a bit deeper. Deep dives (> 800 m) were reported to occur once every 2 hours with a maximum depth of 1408 m (Baird et al., 2006). Despite similar maximum dive depths, Blainville's beaked whales spent more time in the upper portion of the water column (Baird et al., 2006).

Cuvier's beaked whales in southern California waters had shallow dive times of ~ 20 min and deep dive times of ~ 60 min (Falcone et al., 2017). Dive depth and duration were very strongly positively correlated.

Blainville's beaked whales in the Caribbean performed non-foraging dives that lasted to ~ 40 min, while foraging dives ranged between 30 and 70 min (Joyce et al., 2017). Dive times and depths were related with the equation:

$$\text{Depth in meters} = 0.434 * \text{time (in min)} - 163.342$$

Cuvier's beaked whales in the Caribbean performed non-foraging dives that lasted to ~ 40 min, while foraging dives ranged between 30 and 100 min (Joyce et al., 2017). Dive times and depths were related with the equation:

$$\text{Depth in meters} = 0.304 * \text{time (in min)} - 107.523.$$

Heading Variance

Sowerby's beaked whales surfacing in the Gully were reported to have no apparent orientation, and would change orientation up to 180 ° between surfacings (Hooker and Baird, 1999b). The opposite pattern was seen in open-ocean Blainville's beaked whales, which showed travel that was very directed for long distances before beginning a different pattern with more turns (Baird et al., 2011).

The distributions of changes in headings were presented for a Blainville's beaked whale before and after presentation of a killer whale playback (Figure B-10) (Allen et al., 2014). The pre-test data are taken as a good estimate of the normal variance in heading data for this species.

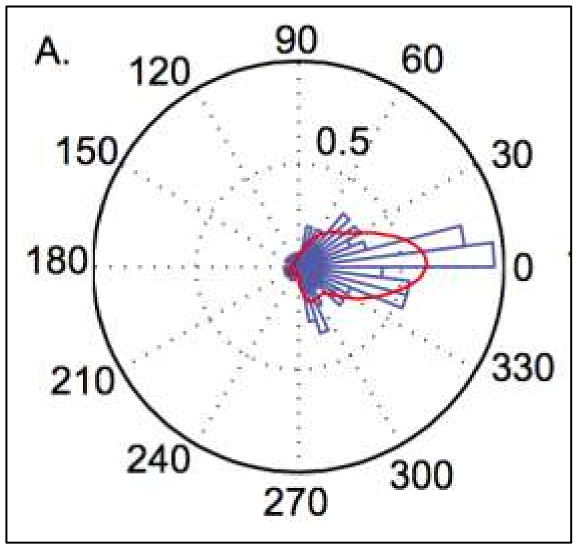


Figure B-10. Distributions of Changes in Course are Shown for Blainville's Beaked Whales Before the Presentation of Killer Whale Recordings (Allen et al., 2014).

Residency

Mesoplodon whales off Kaua'i were observed in all months of the year with no obvious seasonality (Henderson, Martin, Manzano-Roth, and Matsuyama, 2016).

Speed

Dive rates averaged 1 m/s or 3.6 kph (Hooker and Baird, 1999a). A mean surface speed of 5 kph was reported by (Kastelein and Gerrits, 1991).

Habitat

The minimum sea depth in which beaked whales were found in the Gulf of Mexico was 253 m (Davis et al., 1998). In the Gully in Canada, Sowerby's beaked whales were found in water ranging from 550 to 1500 m in depth (Hooker and Baird, 1999b). Blainville's beaked whales (*M. densirostris*) were found in water depths of 136 to 1319 m in the Bahamas, and were found most often in areas with a high bathymetric slope (MacLeod and Zuur, 2005). *Mesoplodon* species were found in waters from 700m to > 1800m off Scotland and the Faroe Islands (Weir, 2000) and between 680 and 1933 m in the Gulf of Mexico (Davis et al., 1998).

Table B-6. Model Groupings of the Beaked Whale Species Encountered in Model Areas for SURTASS LFA Sonar.

Common Name	*AIM Grouping*
Baird's beaked whale	Large
Southern bottlenose whale	Large
Blainville's beaked whale	Small
Cuvier's beaked whale	Small
Deraniyagala's beaked whale	Small
Ginkgo-toothed beaked whale	Small
Hubbs' beaked whale	Small
Longman's beaked whale	Small
Spade-toothed whale	Small
Stejneger's beaked whale	Small
Strap-toothed beaked whale	Small

Baird et al. (2006) reported that Blainville's beaked whales off Hawai'i were found in waters from 633 to 2050 m deep (mean = 1119) while Cuvier's beaked whales were found in waters from 1381 to 3655 m deep (mean = 2131). *Mesoplodon* whales off Kaua'i were most often observed in water between 2,000 and 3,000 m in depth, with areas of high bathymetric slope (Henderson et al., 2016).

Group Size

Mesoplodon stejnegeri in Alaska had pod sizes between 5 and 15 animals (Loughlin, 1982). Sowerby's beaked whale in the Gully in Canada had group sizes between 3 and 10 (Hooker and Baird, 1999b). Dense-beaked whales off the Canary Islands had group sizes ranging between 2 and 9 with a mean size of 3.44 whales (Ritter and Brederlau, 1999). Sightings of Longman's beaked whale in the western Indian Ocean found group sizes between 1 and 40, with a mean size of 7.2 whales (Anderson et al., 2006). Blainville's beaked whales off Hawai'i had a mean group size of 2.6 (SD=3.0) with a range of 1-9, while Cuvier's beaked whales groups were smaller, with a mean size of 2.6 (SD = 1.3) and a range of 1-5 animals (Baird et al., 2006).

Large Beaked Whales

Surface Time

Surface times in Arnoux's beaked whales ranged from 1.2-6.8 min (Hobson and Martin, 1996). Sowerby's beaked whales had surface times of 1-2 min, during which they would blow 6-8 times (Hooker and Baird, 1999b).

Dive Depth

The minimum and maximum dive depth measured for a northern bottlenose whale was 120 and 1453 m respectively (Hooker and Baird, 1999a). Northern Bottlenose whales performed shallow dives with a range of 41-332 m (n=33), while deep dives ranged from 493-1453 m (n=23). Dive depth and dive duration were strongly correlated (Hooker and Baird, 1999a). Based on the depth distribution of the most commonly consumed prey, Baird's beaked whales off Honshu, Japan probably feed at depths of 800-1,200 m (Walker, Mead, and Brownell, 2002).

Dive Time

The minimum and maximum dive time measured was 16 and 70.5 min respectively (Hooker and Baird, 1999a). Sowerby's beaked whales had dives between 12 and (at least) 28 min in the Gully in Canada (Hooker and Baird, 1999b). Arnoux's beaked whale had modal dive times between 35-65 min (mean = 46.4, S.D. = 13.1), with a maximum dive time of at least 70 min (Hobson and Martin, 1996). Tagging results with *Ziphius* had one animal diving for 50 min (Johnson, et al., 2004). *Mesoplodon stejnegeri* were observed to dive for "10-15 min" in Alaska (Loughlin, 1982).

Heading Variance

Sowerby's beaked whales surfacing in the Gully were reported to have no apparent orientation, and would change orientation up to 180° between surfacings (Hooker and Baird, 1999b)

Speed

Northern bottlenose whale dive rates averaged 1 m/s or 3.6 kph (Hooker and Baird, 1999a). A mean surface speed of 5 kph was reported by (Kastelein and Gerrits, 1991) for Northern bottlenose whales.

Habitat

The minimum sea depth in which beaked whales were found in the Gulf of Mexico was 253 m (Davis et al., 1998). The distribution of Baird's beaked whale is restricted to the cool, deep waters of the northern North Pacific Ocean and contiguous seas (R. R. Reeves and Mitchell, 1993). Northern bottlenose whales are known for inhabiting deep-water nearshore canyons (Wimmer and Whitehead, 2004).

Group Size

Baird's beaked whales have been seen in groups of up to 30, but groups of four to ten whales are more common (Reeves and Mitchell, 1993).

B-2.4.9 Blackfish: False Killer Whale, Pygmy Killer Whale, and Melon-Headed Whale

Studies describing the movements and diving patterns of these species are rare and sparse. Therefore, they have been combined into a single "blackfish" category. As more data become available, these species will be split into separate animats.

Surface Time

No direct measurements of surface time are available, so the default value of one min was used.

Dive Depth

The maximum dive depth of a single false killer whale off the Madeira was 72 m. Most of the time was spent at depths deeper than 20 m, and the dives were V-shaped (Alves, Freitas, and Dinis, 2006). Three false killer whales in Hawai'i had shallow dives as well, with maximum depths of 22, 52 and 53 m (Ligon and Baird, 2001). It should be noted that these animals were feeding on fish. False killer whales offshore of Japan had mean dive depths of 17 m (SD = 5) for shallow dives and 170 m (SD = 185) for deep dives (Minamikawa, Watanabe, and Iwasaki, 2013). Shallow dives were approximately five times more common than deep dives.

Mooney et al. (2012) reported in preliminary research findings that a tagged melon-headed whale in Hawaiian waters dove deeply to near the seafloor, >984 feet (300 m), at night but they stayed near the sea surface during the day, with no dives >67 feet (20 m).

Melon-headed whales in the Caribbean Sea appeared to have two modes of foraging diving; a small percentage of less than 100 m and most dives between 150 and 500 m (distributed nearly normally) (Joyce et al., 2017)

Dive Time

In the western North Pacific Ocean, shallow dives of false killer whales were reported with a mean duration of 103 sec, while deep dives had a mean duration of 269 sec (S.D. = 189) (Minamikawa et al., 2013). Melon-headed whales in the Caribbean appeared to forage primarily at night, with dives lasting to about 18 min (Joyce et al., 2017). Dive time and depth were related by the equation:

Log(depth in meters) = 1.557 * log(time in min) – 1.742.

Speed

Maximum speed recorded for false killer whales was 8.0 m/s (28.8 kph) (Rohr et al., 2002), although the typical cruising speed is typically 20 to 24 percent less than the maximum speed (Fish and Rohr, 1999). This "typical" maximum of 6.24 m/s (22 kph) was used as the maximum speed for AIM.

Group Size

False Killer whales in the Gulf of Mexico had group sizes between 20 and 35 (mean = 27.5, SE = 7.5, n=2) (Mullin and Fulling, 2004). False killer whales off of Costa Rica had a mean group size of 36.16 (+/- 52.38) (May-Collado et al., 2005)

B-2.4.10 Pilot Whales: Short-finned Pilot Whales

There are insufficient data available to have separate animats for the two pilot whale species. Therefore, they are combined into a single pilot whale animat. In the SURTASS LFA sonar study area, only the short-finned pilot whale is expected to occur.

Surface Time

A rehabilitated long-finned pilot whale in the North Atlantic was equipped with a satellite tag and a time-depth recorder (TDR). The log survivorship plot of dive time from this animal had an inflection point at about 40 sec (Mate et al., 2005). The authors did not feel that this qualified as a breakpoint to separate surface and dive behavior. However, it does suggest that most surface intervals are less than one min.

Dive Depth

Long-finned pilot whales in the Mediterranean were observed to display considerable diurnal variation in their dive depths. They never dove to more than 16 m during the day. However, at night, they dove to maximum depths of 360 and 648 m with mean depth of 308 and 416 m (Baird et al., 2002). Rehabilitated long-finned pilot whales dove to 312 m on Georges Bank, which has a depth of 360 m, so these values should not be taken as the maximum. The distribution of dive depths was also skewed toward lower values (Nawojchik, et al., 2003). Long-finned pilot whales in Norway had maximum dive depths of 444 m (+/- 85) (Aoki et al., 2017)

Short-finned pilot whales off Madeira Island in the Atlantic Ocean spent most (~75 percent) of their time in the top 10 m of the water column during the day, with a very few deep dives, including one to a maximum depth of 130-988 m (Alves et al., 2013). Short-finned pilot whales off the Canary Islands had maximum depth of 1019 m (Aguilar Soto et al., 2008). The majority of these were to depths of less than 100 m, while the remainders of depths were approximately evenly distributed between 100 and 1000 m (Figure B-11). Shortfin pilot whales in the Caribbean had foraging dives to maximum depth of 900 m, but in a near exponential distribution, with most dives being shallow (Joyce, et al., 2017).

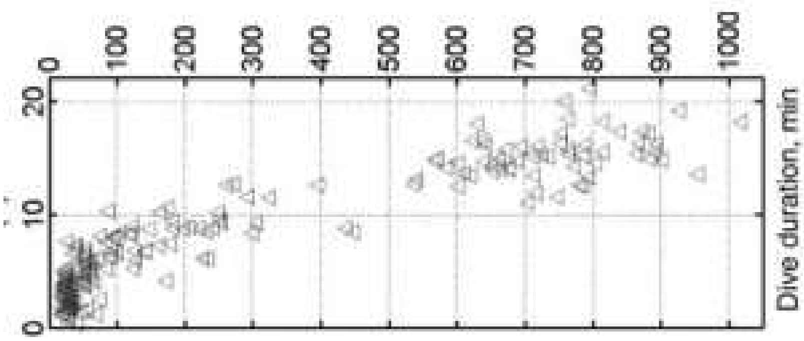


Figure B-11. Relationship of Dive Depth and Dive Time for Short-Finned Pilot Whales of the Canary Islands (Aguilar Soto et al., 2008).

Dive Time

Baird et al. (2002) reported on dives of two individual long-finned pilot whales, and dive times varied between 2.14 and 12.7 min during the night. Animals spent all of their time in the top 16 m during the day.

A rehabilitated long-finned pilot whale in the North Atlantic had dive times between 1 and 6 min (Mate et al., 2005). Other rehabilitated long-finned whales were reported to dive to at least 25 min, although the distribution is skewed toward shorter dives, with most lasting about two min (Nawojchik et al., 2003; Figure B-12). Long-finned pilot whales off the Faroe Islands never dove longer than 18 min (Heide-Jørgensen et al., 2002). Long-finned pilot whales in Norway had relative short dives (8.9 +/-1.5 min) (Aoki et al., 2017).

Short-finned pilot whales off the Canary Islands had maximum foraging dive times of 21 min (Aguilar Soto et al., 2008). They demonstrated a near-linear relationship between dive depth and dive duration. Short-finned pilot whales off Madeira Island performed only a few deep dives during the day. The mean duration for these was about 15 min (Alves et al., 2013). Therefore, shallow dives had times ranging between 1 and 10 min, while deep dives were set to have times between 5 and 21 min.

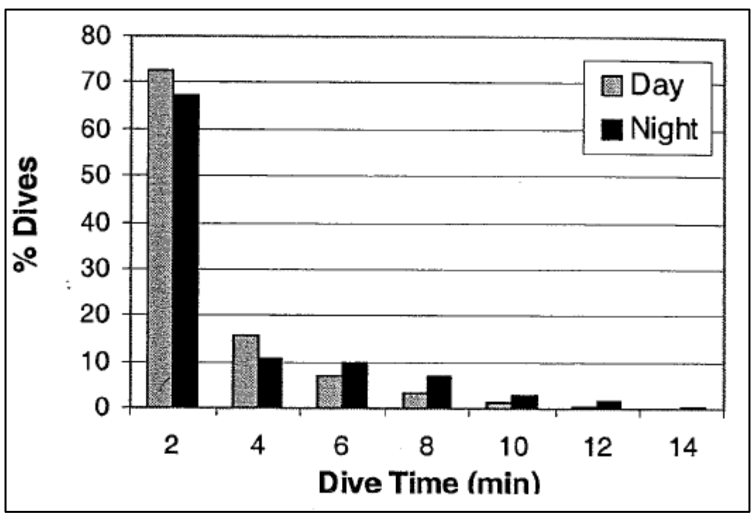


Figure B-12. Dive Times for Long-Finned Pilot Whales (Nawojchik, St Aubin, & Johnson, 2003).

Speed

Shane (1995) reported a minimum speed of 2 kph and a maximum of 12 kph for pilot whales. During the day in the Mediterranean, animals slowly swam, with mean values for two animals of 0.76 and 0.89 m/sec (2.85 and 3.18 kph), while at night, they swam faster at 1.90 m/sec (6.83 kph) and 1.52 m/sec (5.48 kph) (Baird et al., 2002). A single satellite tracked long fined pilot whale had a minimum speed of 1.4 kph (Mate et al., 2005). The speeds of traveling pilot whales (*G. scammoni*) was estimated at 4 to 5 kt (Norris and Prescott, 1961) (cited in Mate, 2005). Vertical dive speeds of three TDR tagged long-finned pilot whales ranged from 0.79 to 3.38 m/s, with a mean of 1.99 m/s (Heide-Jørgensen et al., 2002). A long-finned pilot whale had speeds of ~ 0.8 to 2.2 m/s before playback of acoustic stimuli (Miller et al., 2012).

Residency

Short-finned pilot whales in the Northwest Atlantic showed a strong affinity for continental shelf breaks and canyons. These individuals showed high level of area-restricted search behavior, indicating low linearity indices and high residency values. Other individuals followed meanders in the Gulf Stream (Thorne et al., 2017). These individuals would show a corresponding low residency value.

Habitat

The minimum water depth that pilot whales were seen in the Gulf of Mexico was 246 m (Davis, et al., 1998) while off of Spain they preferred water deeper than 600 m (Cañadas et al., 2002). Short-finned pilot whales in the Northwest Atlantic showed a strong affinity for continental shelf breaks and canyons. Other individuals followed meanders in the Gulf Stream, indicating that distribution of these whales is non-random (Thorne et al., 2017).

Group Size

Short-finned pilot whales in the Gulf of Mexico ranged in group size between 5 and 50 (mean = 20.4, SE=3.6, n=11) (Mullin et al., 2004). Off the Pacific coast of Costa Rica the mean group size of Pilot whales was 14.22 (SD=12.06) (May-Collado et al., 2005).

B-2.4.11 Sperm Whale

Surface Time

Male sperm whales in New Zealand had a mean duration on the surface of 9.1 min, with a range of 2 to 19 min (Jaquet et al., 2000). The distribution of surface times was non-normal, with 68 percent of the surface times falling in between 8 and 11 min.

Surfacing and Dive Angles

Surfacing angles of 90° and diving angles between 60° and 90° have been reported (Miller et al., 2004).

Dive Depth

The maximum, accurately measured, sperm whale dive depth was 1,330 m (Watkins et al., 2002). Foraging dives typically begin at depths of 300 m (Papastavrou et al., 1989). D-tag data from the Gulf of Mexico show that most foraging dives were between the depths of 400 to 800 m, with occasional dives between 900 and 1000 m (Jochens et al., 2008). Sperm whale diving is not uniform. As an example, data from a paper on sperm whale diving reported different dive types (Amano and Yoshioka, 2003). AIM can now accommodate these different dive types, at different frequencies of use (Table B-7). Dive depths have also been shown to have diel variation in some areas while others do not show this variation (Aoki et al., 2007). These differences have been attributed to the behavior of the prey species. Off California, tagged whales changed their dive patterns in response to changes in the depth of tagged squid (Davis et al., 2007). Male sperm whales foraging in high latitude waters dove to a maximum depth of 1860 m, but the median dive depth was only 175 m (Teloni, Mark, Patrick, and Peter, 2008). In the Atlantic Ocean, maximum dive depths ranged from 639 to 934 m (Table B-7) (Palka and Johnson, 2007).

Table B-7. Sperm Whale Dive Parameters (Amano and Yoshioka, 2003).

Type of Dive	*N*	*Depth (m)*		*Time (min)*	
		Min	*Max*	*Min*	*Max*
Dives w/ active bottom period	65	606	1082	33.17	41.63
Dives w/o active bottom period	4	417	567	31.29	33.71
V shaped dives	3	213	353	12.77	20.83
Total	74				

Note: The dive data in this table represent only the sperm whales in the Amano and Yoshioka study. These data do not equate to the values used in AIM. For example, the table shows minimum and maximum dive times as 12.77 and 41.63 min respectively, while the values used in AIM runs are 18.2 and 65.3 min respectively, as stated below under dive time.

Dive Time

Sperm whale dive times average 44.4 min in duration and range from 18.2-65.3 min (Watkins, et al., 2002). In the Gulf of Mexico, the modal dive time is about 55 min (Jochens et al., 2008). Dive times in the Atlantic averaged 40-45 min (Palka and Johnson, 2007).In Japan, sperm whales showed diel variability off Ogasawara. Whales dove deeper during the day (mean = 853 +/- 130 m) than at night (mean = 469 +/- 122 m) (Aoki et al., 2007). However, off of Kumano Coast, there was not a strong difference in depths (561 m vice 646 m).

Sperm whales off Kaikoura foraged at depths between 294 and 1433 m (Guerra et al., 2017). These whales also engaged a substantial portion of demersal foraging, within 50 m of the sea floor.

Sperm whales in the Caribbean performed non-foraging dives to 500 m, while foraging dives ranged between 550 and 1300 m (Joyce et al., 2017).

Heading Variance

Whales in the Gulf of Mexico tend to follow bathymetric contours (Figure B-13) (Jochens et al., 2008). Sperm whales in the Pacific had mean 'zigzag' scores (ratio of distance swum in 12 hours/straight-line distance) reported as 1.71 (S.D> = 0.80) with a range of 1.12 to 3.7 (Jaquet and Whitehead, 1999).

Examination of group behavior found the turns occurred at a rate of 0.1/hr, with a mean change of direction of 70˚ (median 56˚) for sudden turns and 84˚ (median 75˚) for gradual turns (Hal Whitehead, 2016). The time needed for gradual turns was 1.3 hours (median 0.8h), producing a turn rate of 63˚/hr (median 92˚/hr). Irvine et al. (2017) reported diving characteristics for sperm whales tagged in the Gulf of California (Table B-8).

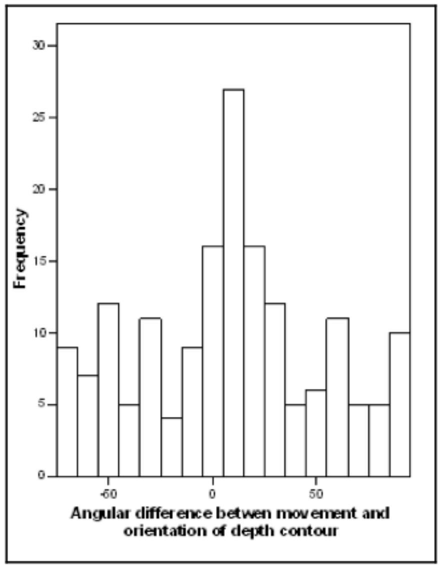


Figure B-13. Histogram of Angular Difference between Between Two Fluke up Movement Positions and the Orientation of the Depth Contours at the Midpoint of the Dive for Movement Intervals of Less than 70 Mins. Relative Angles Between Direction of Movements and Direction of Contours have Been Calculated and Transformed so that 0 Shows Alignment with the Orientation of the Contour, -90 Would be Moving Directly Offshore, and +90 Would Indicate a Movement Directly Inshore (Jochens et al., 2008).

Speed

Sperm whales are typically slow or motionless on the surface. Mean surface speeds of 1.25 kph were reported by (Jaquet et al., 2000) and 3.42 kph (Whitehead, Smith, and Papastavrou, 1989). Their mean dive rate ranges from 5.22 kph to 10.08 kph with a mean of 7.32 kph (Lockyer, 1997). In Norway, horizontal swimming speeds varied between 0.2 and 2.6 m/s (0.72 and 9.36 kph) (Wahlberg, 2002). Sperm whales in the Atlantic Ocean swam at speeds between 2.6 and 3.5 kph (Watkins et al., 1999), (need to reference (Nathalie Jaquet and Whitehead, 1999). Mean speeds in the Gulf of Mexico were 3.3 kph (Jochens et al., 2008). Based on these data, a minimum speed of 1 kph, and a maximum speed of 8 kph was set for sperm whales, specified with a normal distribution, so that mean speeds will be about 4 kph. Off Ogasawara Japan, sperm whales swam faster during the day (mean = 2.0 m/s, SD = 0.3) than during the night (mean = 1.5 m/s, SD = 0.3)

Habitat

Sperm whales are found almost everywhere, but they are usually in water deeper than 480 m (Davis et al., 1998). However, there have been sightings of animals in shallow water (40 to 100 m) (Scott and Sadove, 1997; Whitehead, Brennan, and Grover, 1992). In the Gulf of California, there was no relationship between depth or bathymetric slope and abundance, and animals were seen in water as shallow as 100m (Jaquet and Gendron, 2002). Based on these reports, a compromise value of 200 m will be used as the shallow water limit for sperm whales.

Table B-8. Sperm whale dive parameters for Gulf of California whales.

Dive Type	Dive Duration (min)	Max Dive Depth (m)	Mean Bottom Depth (m)	SD Bottom Depth	Ascent Rate (m/s)	Descent Rate (m/s)
Mid- water	30.3 (5.8–61.2)	340.0 (119.2–581.2)	310.2 (74.2–549.1)	19.4 (0.7–165.9)	0.8 (0.1–1.9)	0.7 (0.0–1.8)
Short, shallow	2.3 (1.0–24.1)	16.0 (10.4–310.8)	15.0 (10.2–305.8)	0.0 (0.0–15.3)	0.1 (0.0–2.2)	0.1 (0.0–1.4)
V- shaped	21.4 (1.3–48.1)	290.0 (42.6–832.0)	281.5 (15.4–832.0)	5.9 (0.0–101.9)	0.6 (0.1–3.2)	0.5 (0.1–2.2)
Benthic	45.8 (27.3–77.3)	456.5 (203.0–978.2)	442.0 (198.7–973.0)	6.9 (0.8–128.4)	1.0 (0.6–1.7)	1.0 (0.3–1.8)
Variable	33.1 (12.1–61.6)	635.0 (267.2–1501.0)	512.6 (154.0–1425.5)	60.3 (0.0–311.3)	1.0 (0.1–2.3)	0.9 (0.3–2.6)
Long, shallow	11.0 (1.3–44.9)	21.4 (10.6–206.2)	17.0 (10.1–122.1)	1.8 (0.1–66.9)	0.1 (0.0–1.1)	0.1 (0.0–0.5)

Dive Type	Bottom Duration (min)	Post-Dive Interval (min)	BottDur/ TotalDur	Dist to Bottom (m)	Speed (km/hr)	Turning Angle (deg)
Mid- water	16.0 (1.0–49.9)	8.4 (1.1–124.4)	0.5 (0.1–0.9)	388.9 (0.0–1406.8)	3.8 (0.1–8.7)	22.9 (0.0–178.9)
Short, shallow	0.0 (0.0–10.2)	3.9 (0.0–92.0)	0.0 (0.0–0.8)	547.1 (115.0–1195.6)	3.2 (0.3–10.7)	0.0 (0.0–125.9)
V- shaped	4.2 (0.0–18.3)	7.5 (0.1–49.3)	0.2 (0.0–0.9)	458.3 (0.0–1195.0)	3.5 (0.1–9.1)	17.5 (0.0–177.8)
Benthic	31.0 (9.5–64.9)	7.8 (2.8–17.9)	0.7 (0.2–0.8)	0.0 (0.0–129.0)	3.2 (0.3–8.2)	30.0 (0.0–178.6)
Variable	14.2 (0.0–37.9)	8.0 (4.0–49.3)	0.5 (0.0–0.8)	80.1 (0.0–943.0)	3.6 (0.2–10.9)	25.3 (0.0–179.7)
Long, shallow	8.0 (0.7–39.9)	6.0 (0.2–81.5)	0.7 (0.2–1.0)	434.8 (127.2–1113.0)	3.0 (0.3–9.2)	8.0 (0.0–173.1)

Group Size

Social, female-centered groups of sperm whales in the Pacific have 'typical' group sizes of 25-30 animals, based on the more precise measurements in Coakes and Whitehead (2004), although less precise estimates are as high as 53 whales in a group.

B-2.4.12 Hawaiian Monk Seal

Activity Budget

The mean proportion of time ashore ranges from 0.13 to 0.43, with a mean of 0.27 (DeLong, Kooyman, Gilmartin, and Loughlin, 1984). On average, monk seals spent 49 percent of their time diving, 19 percent on the surface and 32 percent hauled out on land (Kenady Wilson, Littnan, and Read, 2017).

Surface Time

Mean surface time was 0.8 sec (Kiraç, Savas, Güçlüsoy, and Veryeri, 2002).

Dive Depth

Monk seals were observed to dive between 50 and 500 m (Parrish, Abernathy, Marshall, and Buhleier, 2002). The overwhelming majority of the foraging dives recorded with a Crittercam were to 50-60 m in depth (Parrish, Craig, Ragen, Marshall, and Buhleier, 2000). In the main Hawaiian Islands, monk seals dove to between 20 and 50 m (Wilson et al., 2017). The distribution of dive depths was skewed toward shallower dives. Maximum dive depth can be approximated with gamma distribution parameters of a=1.70625 and b = 11.8725, with bounds of 0 and 103 m.

Dive Time

Maximum dive times of 12 min were observed (Neves, 1998). Mean dive times of 6.4 min have been observed (Kiraç et al., 2002). The mean proportion of time ashore ranges from 0.13 to 0.43, with a mean of 0.27 (DeLong et al., 1984). The distribution of foraging dives was fairly normally distributed between zero and 1,000 sec with a mean of 355 sec (SD = 151) (Wilson, Littnan, Halpin, and Read, 2017)

Speed

No swim speeds have been reported for Hawaiian monk seals. Therefore, the 4.6 knot (9 kph) value for harbor seals was used (Lesage, Hammill, and Kovacs, 1999).

Heading Variance

Yaw rates were calculated, but not reported by (Wilson, et al., 2017).

Residency

Monk Seals in the main Hawaiian Islands (MHI) had relatively small home ranges, most less than 2,000 sq. km (Wilson et al., 2017).

Habitat

Hawaiian monk seals are found primarily on the leeward Hawaiian Islands north of Kaua'i. They haul out on the shores and return to the water to feed. This atoll habitat makes deep water available close to shore, and they are known to dive to the bottom in at least 500 m of water. They have recently been increasing in numbers throughout the Main Hawaiian Islands (MHI) and numbers there are increasing while decreasing in the Leeward Islands (Wilson et al., 2017). The boundary between nearshore Northwest Hawaiian Island and Main Hawaiian Island monk seals is taken to be 161˚ W.

Group Size

Hawaiian monk seals are solitary, except for mothers and calves (Reeves, Stewart, Clapham Phillip, and Powell, 2002).

B-2.4.13 Northern Fur Seal

Surface Time

The activity budget during feeding trips of 7 lactating females consisted of diving 26 percent of the time while at sea and either resting (17 percent) or swimming (57 percent) at the surface (Gentry, Kooyman, and Goebel, 1986). Between deep dives, the surface time was calculated as 0.8 min, whereas between shallow dives, the surface time was 0.5 min (Goebel, Bengston, DeLong, Gentry, and Loughlin, 1991).

Dive Depth

Three types of diving patterns: deep dives, shallow dives, and mixed dives. Deep dives (to depths > 125 m) occur throughout the day and night and represent foraging dives over the continental shelf (< 200 m water depth) to the sea floor. Shallow dives (to depths < 75 m) occur primarily at night in areas with deep water depths (Ponganis, Gentry, Ponganis, and Ponganis, 1992). Gentry et al. (1986) measured modal dive depths of 50-60 m for shallow dives and 175 m for deep dives. Goebel et al. (1991) calculated average dive depths of 36 ± 23 m for shallow dives and 86 ± 26 m for deep dives.

Dive Time

Goebel et al. (1991) calculated average dive durations of 4.1 ± 0.2 min for shallow dives and 7.3 ± 0.5 min for deep dives. This is similar to other measured modal durations of less than 2 min for shallow dives and between 3 and 5 min for deep dives (Ponganis et al., 1992).

Speed

Three females tagged during the winter migration exhibited average traveling speeds of 1.1-1.7 kph (Baba, Boltnev, and Stus, 2000). Summer foraging trips, mean swim velocities on shallow dives were 1.5 and 1.2 m/s; deep dives 1.8 and 1.5 m/s (Ponganis et al., 1992). During the winter migration, an overall swim speed of 48 ± 12.4 cm/s was measured (Ream, Sterling, and Loughlin, 2005). Fur seals from Bering Sea islands had a mean speed of 5 kph while travelling (Battaile, Nordstrom, Liebsch, and Trites, 2015).

Habitat

The majority of the population of northern fur seals breeds on the Pribilof Islands of Alaska (74 percent) or the Commander Islands of Russia (17 percent) (Gentry, 2002). From November to March, foraging north of about 35° N; March and April, animals move to continental shelf breaks and begin to migrate north. Pups mainly born in July, weaned in October or November, and begin southbound migration with rest of population (Gentry, 2002). Animals that breed at San Miguel Island and adult males of all breeding colonies are non-migratory.

B-3 RESULTS OF AIM MODELING

B-3.1 Animat Exposure Histories

AIM simulates realistic animal movement through the calculated acoustic field where the received level (SPL) is recorded at each time step into the animat's exposure history. Thus, the output of AIM is the time history of exposure for each animat. For this modeling effort, the exposure history provides the received level for each modeled animat every 30 seconds for 24 hours. This history was sampled to reflect the 10 percent duty cycle of SURTASS LFA sonar; that is, 60 seconds of LFA sonar transmission every 10 minutes, which corresponds to 2.4 transmission hours over the 24-hr modeling duration.

Since AIM records the exposure history for each individual animat, the potential impact is determined on an individual animal basis. The sound energy received by each individual animat over the 24-hr modeled period was calculated as SEL and the potential for that animal to experience PTS and then TTS was considered using the NMFS (2018) acoustic guidance thresholds. If an animal was not predicted to experience PTS or TTS, then the sound energy received over the 24-hr modeled period was calculated as dB SPE and used as input to the risk continuum function to assess the potential risk of biologically significant behavioral reaction.

A step-wise process is undertaken to ensure that each individual is considered for only one potential impact (i.e., there is no double counting). The potential for PTS is considered first, as it represents the highest threshold. If an individual does not exceed the PTS threshold, then the potential for TTS is considered. If an animal does not exceed the TTS threshold, then the potential for a behavioral response is considered. Thus, individuals are only considered for one acoustic impact during a 24-hr exposure scenario.

B-3.2 Behavioral Risk Function for SURTASS LFA Sonar

The potential for a biologically significant behavioral response is estimated using the SURTASS LFA risk continuum function. This function has been described in detail in the Navy's 2001, 2007, 2012, 2015, and 2017 SEISs for SURTASS LFA sonar (DoN, 2001, 2007, 2012, 2015, and 2017), which as previously noted are incorporated by reference. For the convenience of the reader, parts of Chapters 4.2.3 through 4.2.5 of the FOEIS/FEIS (2001) have been included here, with updates as appropriate for current best practices, to provide the foundation upon which the analysis methodology is based.

B-3.2.1 Development of the Risk Continuum Approach [Reiteration from the 2001 FOEIS/FEIS for SURTASS LFA Sonar]

Before the biological risk standards could be applied to realistic SURTASS LFA sonar scenarios, two factors had to be considered, which resulted in the development of the risk continuum approach. In assessing the potential risk of significant change in a biologically important behavior, two questions must be resolved:

- How does risk vary with repeated exposure?
- How does risk vary with RL?

These questions have been addressed by the use of a function that translates the history of repeated exposures (as calculated in the Acoustic Integration Model) into an equivalent RL for a single exposure with a comparable risk. This approach is similar to those adopted by previous studies of risk to human hearing (Crocker, 1997; W. J. Richardson, et al., 1995).

B-3.2.1.1 Effects of Repeated Exposure

The human model provides the most extensive data and is presently the best objective foundation for an assessment of repeated exposure. Long term hearing loss in humans is accelerated by chronic daily 8-hour workplace exposure (over time scales on the order of tens of years) to sounds at levels of 85 dB(A) re 20 µPa (A-weighted; i.e., in air) or greater (American Academy of Ophthalmology and Otolaryngology, 1969; Ward, 1997). The sound power reference unit dB(A) is the accepted convention for frequency-weighted measure of hearing in humans. In young healthy humans, 0 dB(A) is the nominal threshold of best hearing, and measured free-field thresholds for the frequencies of best binaural hearing (400 to 8,000 Hz) vary between –10 to + 10 dB re 20 µPa (Beranek, 1954; Harris, 1998), depending on measurement objective and technique used.

It is intuitive to assume that the effects of exposure to multiple LF sounds would be greater than the effects of exposure to a single sound. A formula is needed to address the potential for accumulation of effects over a 7 to 20-day period (estimated maximum SURTASS LFA sonar mission period), allowing for varying RLs and a duty cycle of 20 percent or less. There are no published data on marine mammals regarding responses to repeated exposure to LF sound. Two lines of evidence from human studies were used to devise a plausible formula.

Richardson et al. (1995), citing Kryter et al. (1966), discusses workplace damage risk criteria relative to exposure to continuous narrowband (one-third octave) noise. To relate to workplace data, note that during an 8-hour exposure during normal SURTASS LFA sonar use, the pings would add up to a total of 48 to 96 min of LF sound transmission. The workplace damage risk criteria change from 88 dB to 82 dB to 80 dB re 20 µPa SPL, as the duration of exposure changes from 8 to 2 hours to 30 min. These changes indicate that the effects of increased exposure are not constant across this range of durations. When continuous exposure increases from 30 min to 2 hr per day, the effect scales with 10 log10(T). When continuous exposure increases from 2 to 8 hr per day, the effect scales with 3.3 log10(T). These values do not account for the probable reduction of effect due to the long intervals between SURTASS LFA sonar pings.

The second line of evidence comes from repeated exposure to impulsive sounds. Richardson et al. (1995b), citing Kryter (1985) and Ward (1968), discussed the relationship between repeated exposures of the human ear to impulsive sound and a TTS in the subject's hearing. The risk threshold is lowered by 5 dB per ten-fold increase in the number of pulses per exposure if the number of pulses per exposure is less than 100. These findings are consistent with qualitative statements by Crocker (1997). Following this logic, if a ping of level L (in dB SPL) is repeated N times, the SPE level is defined as L + 5 log10(N) in dB SPE. For example, using this formula, 100 pings at RL 170 dB re 1 µPa (rms) (SPL) are equivalent to one ping at 180 dB SPE.

The following provides some mathematical details of how the 5 log10(N) factor was implemented for repeated exposure to varying levels:

- For each animal in the AIM simulation, the RL of each ping was calculated as the animal moved in relation to the sound source;
- These RLs were converted into raw acoustic intensities (proportional to the intensity of the signal, or the variance of the waveform);
- To correctly summarize the intensities, their values were squared and summed together; and
- This sum was converted back to an equivalent dB value by taking the base 10 logarithm of the sum, and multiplying it by 5.

In this process, an SPE RL is larger than the maximum SPL RL of any single ping in a sequence (see text box below). Also, the SPE for a sequence consisting of a single loud ping and a long series of much softer pings is almost the same as the level of the single loud ping.

B-3.2.1.2 Determination of Risk Function

Prior to the research and analyses documented in the FOEIS/EIS (DoN, 2001), the definition of biological risk to marine mammals had generally been based on a received sound level threshold for individual species. For example, 120 dB re 1 µPa (rms) (SPL) has been used as a threshold for behavioral modification (National Research Council (NRC), 1994). However, this approach set a discrete threshold below which any RL value was considered risk-free, and any value above it had been considered certain to cause responses by marine mammals.

Nonetheless, it was unreasonable to assume that in a large animal stock a one decibel RL increase (say, from 119 to 120 dB re 1 µPa (rms) (SPL)) would cause a change from no behavioral response to all animals in the stock responding. Additionally, the use of an SPE metric for this basement value is more protective because it is adding the potential impact of many signals, not just the loudest received.

Sample Single Ping Equivalent (SPE) and Risk Examples

A generic example to illustrate the calculations used for translating the number of pings into an SPE (Figure B-14). This illustration assumes a marine mammal is exposed to a total of ten SURTASS LFA sonar transmissions, or pings, at received levels (RL) between 150 to 159 dB re 1 µPa (rms) (SPL). The pings are delineated by individual bins of one dB each. The example illustration shows that the animal was exposed to two pings at RL 150 dB re 1 µPa (rms) (SPL), none at RL 151 dB re 1 µPa (rms) (SPL), three pings at RL 152 dB re 1 µPa (rms) (SPL), etc. To arrive at a total SPE for the entire exposure, the intensity level for each ping is first calculated (i.e., 1 x 10^{15} µPa for each of the two 150 dB RL exposures, 1.58^{15} x 10 µPa for each of three 152 dB RL exposures, etc.). These intensity values are then squared and added together. Taking 5 log10 of this sum of the squared intensities (1.24 x 10^{32}) results in a total of 160.47 dB SPE.

An example of the effect of increased RL can be seen in Figure B-15, which displays the probability function for a single ping. At an RL of 150 dB SPE, the risk of significant change in a biologically important behavior is 2.5 percent. The RL corresponding to 50 percent risk on this curve is 165 dB SPE. At 180 dB SPE, the risk of significant change in a biologically important behavior is 95 percent. For the above SPE example, the risk function would predict a 24.48 percent probability of significant change in a biologically important behavior.

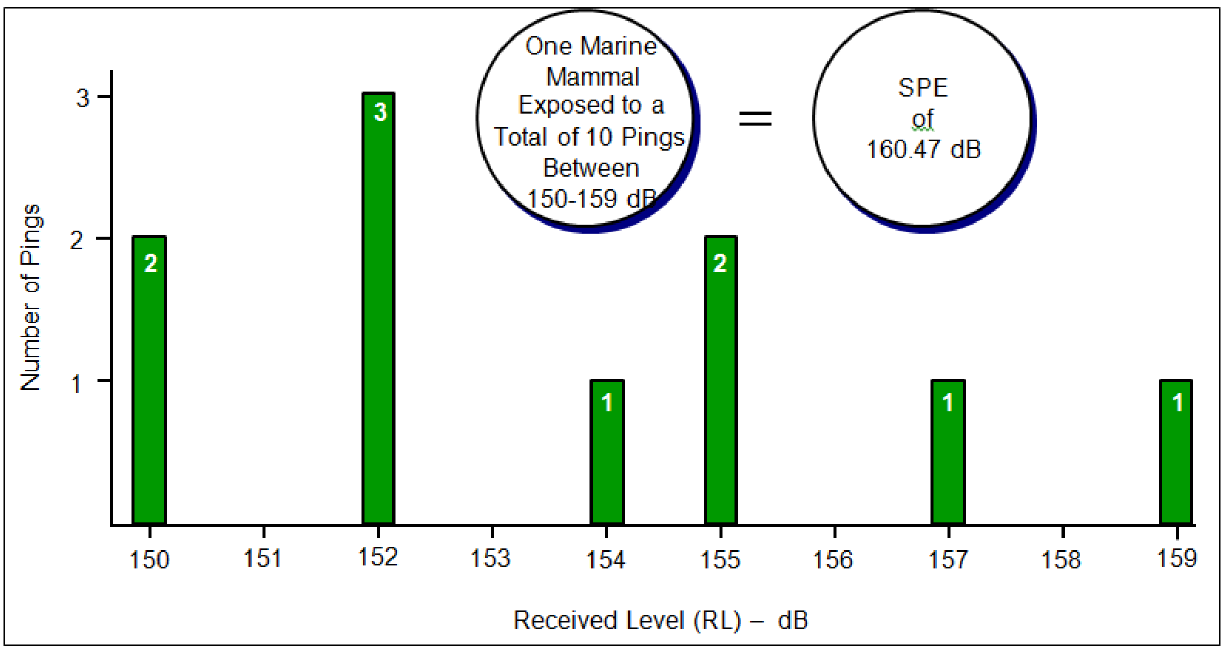


Figure B-14. Sample Single Ping Equivalent (SPE) Calculation.

The widely adopted approach used in the 2001 FOEIS/EIS (DoN, 2001) for SURTASS LFA sonar to assess biological risk was a smooth, continuous function that mapped RL to risk (Figure B-15). Scientifically, this acknowledges that individuals may vary in responsiveness. Mathematically, this eliminated the possibility for dramatic changes in estimated impact as a result of small changes in parameter values.

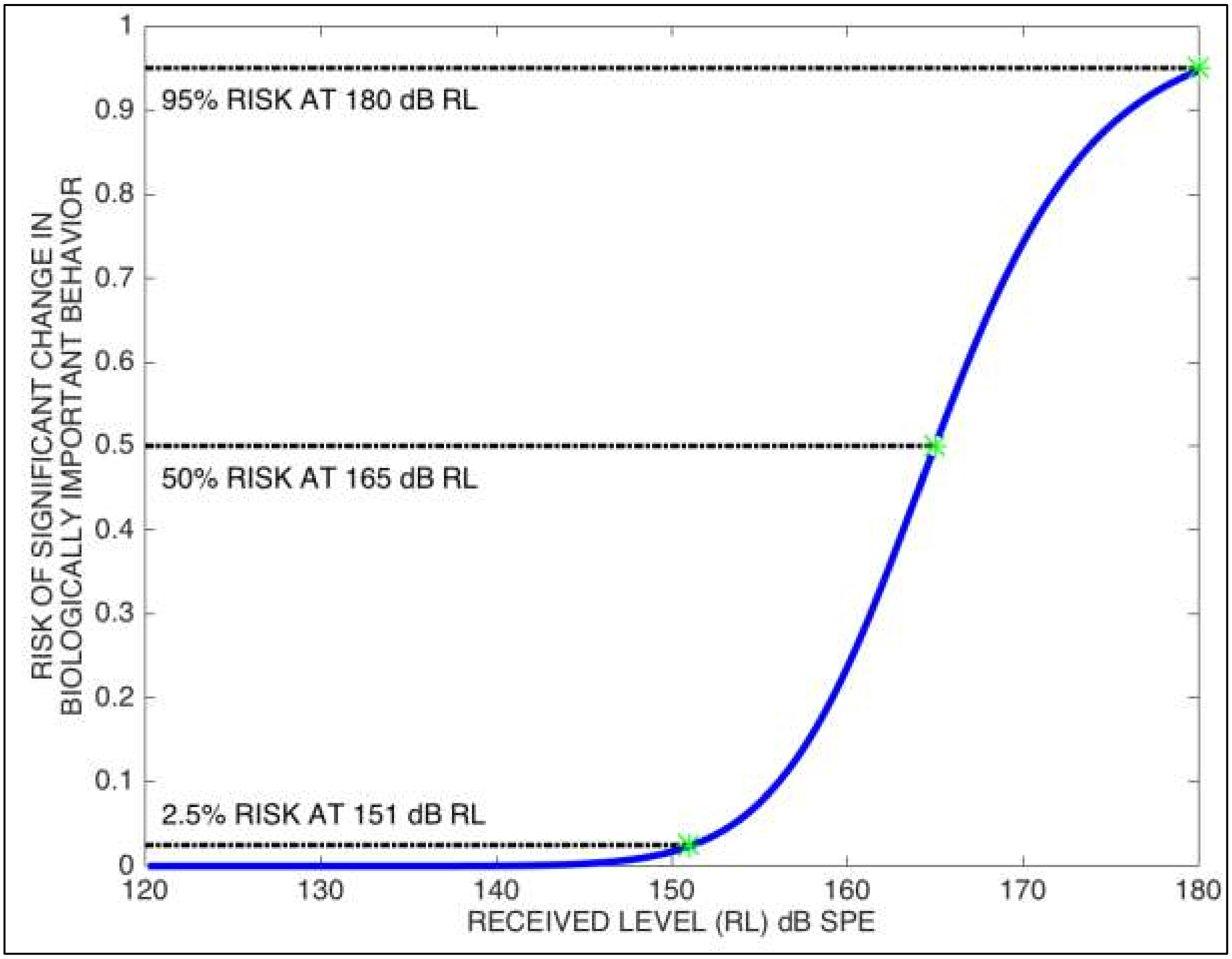


Figure B-15. Risk Continuum Function for SURTASS LFA Sonar Analysis that Relates the Risk of Significant Change in Biologically Important Behavior to Received Levels in Decibels Single Ping Equivalent (SPE).

As a result, the potential for misleading results was greatly reduced. These were the reasons for developing the risk continuum.

To represent a probability of risk of a biologically significant behavioral response (hereafter, risk), the function should have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfied this criterion was cumulative probability distributions, or cumulative distribution functions. In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on regions of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

The function used here is adapted from the solution in (Feller, 1968) and the parameter values are provided as determined through the Low Frequency Sound Scientific Research Program (LFS SRP):

$$R = \frac{1 - \left(\frac{L - B}{K}\right)^{-A}}{1 - \left(\frac{L - B}{K}\right)^{-2A}}$$

Where:

R = risk of biologically significant behavior (values=0-1.0)
L = RL in dB
B = basement RL in dB, below which risk is negligible (value=120 dB)
K = RL increment above basement at which there is 50 percent risk (value=45 dB)
A = risk transition sharpness parameter (value=10).

To use this function, the values of the three parameters (B, K, and A) need to be established. The values used in the FOEIS/EIS (DoN, 2001) analysis were based on the results of the 1997 to 1998 LFS SRP. Prior to the LFS SRP, a 50 percent probability of avoidance might have been associated with a RL of 120 dB re 1 µPa (rms) (SPL) (Malme, Miles, Clark, Tyack, and Bird, 1983, 1984). It was also hypothesized, prior to the LFS SRP, that marine mammals exposed to RLs near 140 dB re 1 µPa (rms) (SPL) would depart the area (e.g., Richardson et al., 1995b). It was critical, therefore, to examine the logic that motivated the selection of experiments for the LFS SRP, how those results related to earlier data, and how the LFS SRP results related to the development of the risk continuum.

B-3.2.2 Low Frequency Sound Scientific Research Program (LFS SRP) [Reiteration from the 2001 FOEIS/FEIS for SURTASS LFA Sonar]

In 1997, there was a widespread consensus that cetacean response to LF sound signals needed to be better defined using controlled experiments. In response, the Navy worked with scientists to develop the LFS SRP. The LFS SRP was designed to supplement the data from previous studies. Also, the Navy made the SURTASS LFA sonar vessel (R/V *Cory Chouest*) available to the LFS SRP, which enabled greater control over RL due to the dynamic range of the ship's transmission system and the quality of its environmental acoustic modeling capabilities. Logistical constraints limited the experimental use of the SURTASS LFA sonar to the North Pacific.

B-3.2.2.1 Previous Studies

Prior to the LFS SRP, the best information regarding whale responses to continuous, LF, anthropogenic noise was summarized by Richardson et al. (1995b):

"Some marine mammals tolerate, at least for a few hours, continuous sound at received levels above 120 dB re 1 µPa (rms). However, others exhibit avoidance when the noise level reaches ~120 dB (re 1 µPa [rms] [SPL]). It is doubtful that many marine mammals would remain for long in areas where received levels of continuous underwater noise are 140+ dB (re 1 µPa [rms] [SPL]) at frequencies to which the animals are most sensitive."

There have been several studies that have demonstrated responses of marine mammals to exposure levels ranging from detection threshold to 120 dB re 1 µPa (rms) (SPL):

- One study examined responses of gray whales migrating along the California coast to various sound sources located in their migration corridor (Malme et al., 1983, 1984). Gray whales showed statistically significant responses to four different underwater playbacks of continuous sound at RLs of approximately 120 dB re 1 µPa (rms) (SPL). The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform. This study was replicated in Phase II of the LFS SRP using SURTASS LFA sonar stimuli. However, the Phase II research demonstrated that it may be invalid to apply the inshore (2 km [1.1 nmi] from shore) response model (when 50 percent of the whales avoided SURTASS LFA sonar stimuli at RL of 141 +3 dB re 1 µPa [rms] [SPL]) to sources that were offshore (4 km [2.2 nmi] from shore) of migrating whales where the whales did not avoid offshore sources at RLs of 140 dB re 1 µPa (rms) (SPL).

- Two other studies concern Arctic animals. Belugas (white whales) and narwhals showed behavioral responses to noise from an icebreaker at 50 km (27 nmi). At this range, the RL of the noise is near the detection threshold. Richardson et al. (1995b) point out that the strong reactions to icebreaker noise are unique in the marine mammal disturbance literature. These reactions appeared similar to the responses of each species to their most significant predator, the killer whale (Finley, Miller, Davis, and Greene, 1990). It is not known why these animals were so sensitive to icebreaker noise and responded as if it were a predator. But, if these animals are responding to ice breakers as if to predators, it was understandable why these animals would show strong responses at detection threshold. This response has not been noted for other sound stimuli, only playback of killer whale calls. The sensitive responses of the Arctic species may relate to the fact that these animals are hunted using motorized boats. Other factors specific to the Arctic that may contribute to this sensitivity are sounds of ice breaking that may mimic a potentially dangerous movement of ice, scarcity of ships in the high Arctic, and low background noise and good underwater sound propagation in Arctic waters.
- Controlled playback experiments and observations around actual industrial sources show bowhead whales avoid drill ship noise at estimated RLs of 110 to 115 dB re 1 µPa (rms) (SPL) and seismic sources at estimated RLs of 110 to 132 dB re 1 µPa (rms) (SPL) (W. J. Richardson, 1997, 1998; W. John Richardson, Finley, Miller, Davis, and Koski, 1995).

B-3.2.2.2 Selection of Species and Study Sites

The selection of species and study sites for the LFS SRP emerged from an extensive review in several workshops by a broad group of interested parties: academic scientists, federal regulators, and representatives of environmental and animal welfare groups. The outcome of this group's decisions was that baleen whales became the focus of all three projects, since they were thought most likely among all marine species to have sensitive hearing in the SURTASS LFA sonar frequency band, because of their protected status and because of prior evidence of avoidance responses to LF sounds. Study sites were selected that offered the best opportunities for detailed observations combined with previous research that documented undisturbed patterns of behavior and distribution, or avoidance reactions to anthropogenic sound at low RLs.

This focus on the most sensitive species and the best sites for detecting a response was intended to produce a model of response that could be applied to other species for which data were lacking. This was a critical element of the logic of the LFS SRP. Extrapolation was unavoidable. By selecting marine mammal species that probably have the most sensitive LF hearing, the LFS SRP results produced a model of response that is likely to overestimate the responses of other species.

The species and settings chosen for the three phases of the LF sound playback experiments were:

- Blue and fin whales feeding in the Southern California Bight (Phase I) (September-October 1997);

- Gray whales migrating past the central California coast (Phase II) (January 1998); and
- Humpback whales off Hawaiʻi (February-March 1998) (Phase III).

These studies included three important behavioral contexts for baleen whales: feeding, migrating, and breeding. The first phase also involved some studies of northern elephant seals tagged with acoustic data loggers. Elephant seals are considered among the most sensitive pinnipeds to LF sound and are deep divers (Le Boeuf, 1994). The third phase was designed to include playbacks with sperm whales, but no animals were encountered during the offshore portions of the cruise schedule. Sperm whales are listed by the U.S. as endangered under the ESA, and they were suspected to be the toothed whale most sensitive to LF sound (Ketten, 1997). There have also been reports of sperm whales being sensitive to anthropogenic transient noise (Bowles, Smultea, Würsig, DeMaster, and Palka, 1994; B.R. Mate and Stafford, 1994; Watkins, Moore, and Tyack, 1985; Watkins and Schevill, 1975).

B-3.2.2.3 Research Program

The 1997-98 LFS SRP was designed to ensure that no marine mammal was exposed to RLs exceeding 160 dB re 1 µPa (rms) (SPL). The LFS SRP produced new information about responses to the SURTASS LFA sonar sounds at RLs from 120 to 155 dB re 1 µPa (rms) (SPL). The LFS SRP team explicitly focused on situations that promoted high RLs (maximum 160 dB re 1 µPa [rms] [SPL]), but were seldom able to achieve RLs in the high region of this exposure range due to the natural movements of the whales and maneuvering constraints of the LF source vessel.

During the first phase of LFS SRP research, the source ship transmitted routinely with the full source array (18 source projectors) at source levels similar to those that would be used normally by the Navy (Clark and Fristrup, 2001). The ship also approached whales while transmitting from two of the projectors at full power levels. Over the 19-day period, there were no immediately obvious responses from either blue or fin whales as noted during observations made from any of the research vessels during playback of LFA sounds (Donald A Croll, Clark, Calambokidis, Ellison, and Tershy, 2001).

In the second phase of LFS SRP research, migrating gray whales showed responses similar to those observed in earlier research (Malme et al., 1983, 1984) when the source was moored in the migration corridor (2 km [1.1 nmi] from shore). The study extended those results with confirmation that a louder SL elicited a larger scale avoidance response. However, when the source was placed offshore (2.2 nmi [4 km] from shore) of the migration corridor, the avoidance response was not evident. This implies that the inshore avoidance model—in which 50 percent of the whales avoid exposure to levels of 141 +3 dB re 1 µPa (rms) (SPL)—may not be valid for whales in proximity to an offshore source (Buck and Tyack, 2000).

The third phase of LFS SRP research examined potential effects of SURTASS LFA sonar transmissions on singing humpback whales. These whales showed some apparent avoidance responses and cessation of song during specific LFA sound transmissions at RLs ranging from 120 to 150 dB re 1 µPa (rms) (SPL). However, an equal number of singing whales exposed to the same levels showed no cessation of song during the same LFA sound transmissions. Of the whales that did stop singing, there was little response to subsequent LFA sound transmissions; most joined with other whales or resumed singing within less than an hour of the possible response. Those that did not stop singing, sang longer songs during the period of LFA transmissions, and returned to baseline after transmissions stopped (Clark and Fristrup, 2001; Fristrup et al., 2003; Miller et al., 2000). Further analysis is required to establish how often male humpbacks stop singing in the absence of the SURTASS LFA sonar transmissions, and to evaluate the significance of the song cessation observed during playbacks.

This kind of brief interruption, followed by resumption of normal interactions, was similar to that seen when whales interrupt one another or when small vessels approach whales (Miller et al., 2000). If whales are in a breeding habitat where vessel interactions are frequent, then the aggregate impact of all disruptive stimuli could become significant. However, because the SURTASS LFA sonar system would be located well offshore of these humpback breeding areas, it is likely that the cumulative impact of numerous inshore vessels would be significantly greater on these animals than that caused by an occasional offshore series of SURTASS LFA sonar transmissions.

In summary, the scientific objective of the LFS SRP was to conduct independent field research in the form of controlled experimental tests of how baleen whales responded to SURTASS LFA sonar signals. Taken together, the three phases of the LFS SRP do not support the hypothesis that most baleen whales exposed to RLs near 140 dB re 1 µPa (rms) (SPL) would exhibit disturbance of behavior and avoid the area. These experiments, which exposed baleen whales to RLs ranging from 120 to about 155 dB re 1 µPa (rms) (SPL), detected only minor, short-term behavioral responses. Short-term behavioral responses do not necessarily constitute significant changes in biologically important behaviors. The fact that none of the LFS SRP observations revealed a significant change in a biologically important behavior helped determine an upper bound for risk. The LFS SRP results cannot, however, be used to prove that there is zero risk at these levels. Accordingly, the risk continuum presented below assumes that risk is small, but not zero, at the RLs achieved during the LFS SRP. The risk continuum modeled a smooth increase in risk that culminates in a 95 percent level of risk of significant change in a biologically important behavior at 180 dB SPE. In this region, the risk continuum is unsupported by observations. However, the AIM simulation results indicate that a small fraction of any marine mammal stock would be exposed to sound levels exceeding 155 dB re 1 µPa (rms) (SPL).

B-3.2.3 Risk Continuum Parameters [Reiteration from the 2001 FOEIS/FEIS for SURTASS LFA Sonar]

To utilize the risk function (Section B-3.2.1), the values of B, A, and K (discussed in detail below) need to be specified. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment. In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on a stock.

B-3.2.3.1 Basement Value for Risk—The B Parameter

The B parameter defines the basement value for risk of biologically significant behavioral response, below which the risk is so low that calculations are impractical. This 120-dB SPE level is taken as the estimate of RL (SPE) below which the risk of significant change in a biologically important behavior approaches zero for the SURTASS LFA sonar risk assessment. This level is the value at which avoidance reactions have been noted in bowhead, beluga, and gray whales. The Navy recognizes that for the actual risk of changes in biologically significant behavior to be zero, the signal-to-noise ratio at the animal must also be zero. However, the present convention of ending the risk calculation at 120 dB SPE has a negligible impact on subsequent calculations, because the risk function does not attain appreciable values until RLs (SPEs) exceed 130 dB SPE (Figure B-15).

B-3.2.3.2 Risk Transition—The A Parameter

The A parameter controls how rapidly risk transitions from low to high values with increasing RL (SPE). As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response. The value used here (A=10) (Figure B-15) produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies (Malme et al., 1984). The choice of a more gradual slope than the empirical data would indicate was consistent with all other decisions to make assumptions that are more protective when extrapolating from other data sets.

B-3.2.3.3 The K Parameter

The K parameter is the RL (SPE) increment above basement at which there is a 50 percent risk of a biologically significant behavioral reaction. Given the lack of consistent and sustained behavioral responses in all three LFS SRP phases, the RL (SPE) at which a 50 percent potential for risk may occur is above 150 dB SPE. Thus, the LFS SRP data cannot be used to specify the value of K directly. Instead, this analysis set the value of K (in conjunction with A) such that the risk for an SPE exposure of 150 dB SPE was 2.5 percent and the risk at 180 dB SPE was 95 percent. Thus, K equals 45 dB, leading to an estimated 50 percent risk at an SPE of 165 dB (i.e., 120 dB + 45 dB). The 2.5 percent risk estimate at 150 dB SPE reflects the fact that tens of experimental trials at RLs (SPEs) up to 155 dB failed to reveal any response that could be construed as affecting survival or reproduction. The 95 percent risk value at 180 dB SPE reflects the assumption that most individuals may be at risk but that a small fraction (5 percent) of the population would not be at risk.

B-3.3 Current TTS and PTS Thresholds

According to the NMFS acoustic guidance (NMFS, 2018), quantitative assessment of TTS and PTS consists of two parts: 1) an acoustic threshold level and 2) an associated auditory weighting function. To account for the fact that different species groups use and hear sound differently, acoustic thresholds and auditory weighting functions were defined for five broad functional hearing groups: low-, mid-, and high-frequency cetaceans as well as phocid and otariid pinnipeds in water. NMFS (2018) defined these functional hearing groups by combining behavioral and electrophysiological audiograms with comparative anatomy, modeling, and response measured in ear tissues:

- Low-frequency Cetaceans—this group consists of the mysticetes (baleen whales) with a collective a generalized hearing range of 7 Hz to 35 kHz.
- Mid-frequency Cetaceans—this group includes most of the dolphins, all the toothed whales except for the Family Kogiidae, and all the beaked and bottlenose whales with a generalized hearing range of approximately 150 Hz to 160 kHz.
- High-frequency Cetaceans—this group incorporates all the true porpoises, the river dolphins, plus the Franciscana, *Kogia* spp., all of the genus *Cephalorhynchus*, and two species of *Lagenorhynchus* (Peale's and hourglass dolphins) with a generalized hearing range estimated from 275 Hz to 160 kHz.
- Phocids in Water—this group consists of 23 species and subspecies of true seals with a generalized underwater hearing range from 50 Hz to 86 kHz.
- Otariids in Water—this group includes 16 species and subspecies of sea lions and fur seals with a generalized underwater hearing range from 60 Hz to 39 kHz.

The NMFS guidance (NMFS, 2018) details the science underlying the development of the acoustic threshold levels and the associated auditory weighting functions. Quantitative assessment of the received levels, or acoustic thresholds, above which individuals are predicted to experience changes in their hearing sensitivity for acute, incidental exposure to underwater sound is based upon marine mammal composite audiograms, equal latency, and data on susceptibility to noise-induced hearing loss. Acoustic thresholds and auditory weighting functions are defined for each functional hearing group.

The overall shape of the weighting functions is based on a generic band-pass filter described as:

$$W(f) = C + 10log_{10}\left(\frac{\left(\frac{f}{f_1}\right)^{2a}}{[1+(\frac{f}{f_1})^2]^a[\,1+(\frac{f}{f_2})^2]^b}\right)$$

where W(f) is the weighting function amplitude in dB at a particular frequency (f) in kHz. The function shape is determined by the following weighting function parameters (Table B-9; Figure B-16).

The weighting function is based on parameters that define a generic band-pass filter:

Low-frequency exponent (a): This parameter determines the rate at which the weighting function amplitude declines with frequency at the lower frequencies. As the frequency decreases, the change in amplitude becomes linear with the logarithm of frequency, with a slope of “a” times 20 dB/decade (e.g., if “a” equals 1, the slope is 20 dB/decade).

Table B-9. Parameters of the Weighting Functions Utilized in AIM Modeling of PTS and TTS Potential Impacts Associated with Exposure to SURTASS LFA Sonar Transmissions.

Functional Hearing Group	***a***	***b***	***f_1 (kHz)***	***f_2 (kHz)***	***C (dB)***
Low-frequency (LF) cetaceans	1.0	2	0.2	19	0.13
Mid-frequency (MF) cetaceans	1.6	2	8.8	110	1.20
High-frequency (HF) cetaceans	1.8	2	12	140	1.36
Phocid pinnipeds (underwater)	1.0	2	1.9	30	0.75
Otariid pinnipeds (underwater)	2.0	2	0.94	25	0.64

High-frequency exponent (b): Rate at which the weighting function amplitude declines with frequency at the upper frequencies. As the frequency increases, the change in amplitude becomes linear with the logarithm of frequency, with a slope of “b” times 20 dB/decade. Low-frequency cutoff (f_1): This parameter defines the lower limit of the band-pass filter (i.e., the lower frequency where weighting function amplitude begins to roll off or decline from the flat, central portion of the function). This parameter is directly dependent on the value of the low-frequency exponent (a). High-frequency cutoff (f_2): This parameter defines the upper limit of the band-pass filter (i.e., the upper frequency where weighting function amplitude begins to roll off or decline from the flat, central portion of the function). This parameter is directly dependent on the value of the high-frequency exponent (b). Weighting function gain (C): This parameter determines the vertical position of the function and is adjusted to set the maximum amplitude of the weighting function to 0 dB.

These weighting function parameters have been used in AIM modeling of potential noise-induced hearing loss to marine mammals (Table B-10). The calculated SEL exposure for each individual animat is

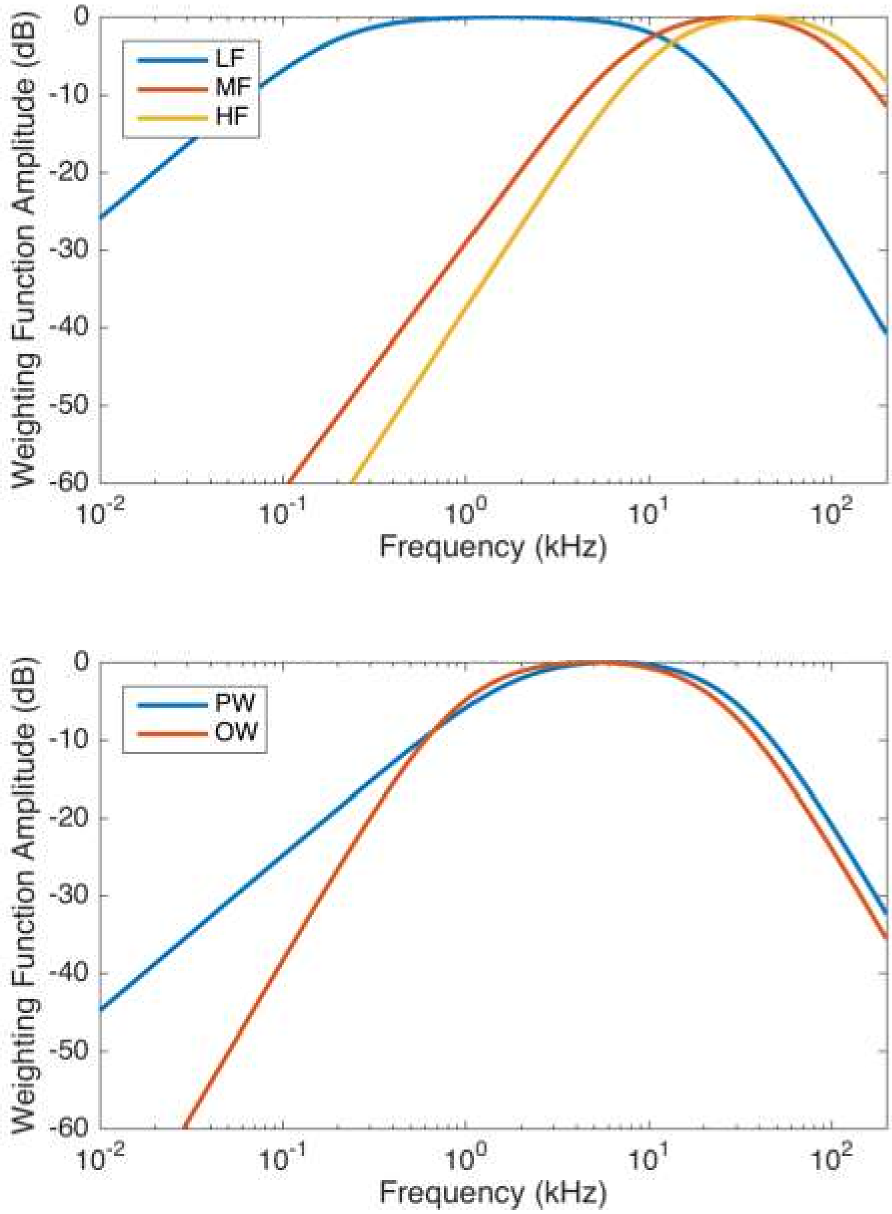


Figure B-16. Auditory Weighting Functions for Cetaceans (Top Panel: LF, MF, and HF Species) and Pinnipeds (Bottom Panel: PW, OW) (NMFS, 2018).

weighted by the appropriate auditory weighting function, which is then compared to the acoustic thresholds described in the next section.

B-3.4 Application of PTS and TTS Acoustic Thresholds

In the assessment of the potential for noise-induced hearing loss to marine mammals from exposure to SURTASS LFA sonar transmissions, the final step is to compare the weighted SEL values to the appropriate weighted SELcum threshold to determine if the threshold is exceeded and noise-induced hearing loss is predicted to occur (Table B-10). Since TTS is recoverable and is considered to result from

Table B-10. Acoustic Criteria and Thresholds Used to Predict Physiological Impacts on Marine Mammals Associated with Exposure to SURTASS LFA Sonar Transmissions (NMFS, 2018).

Functional Hearing Group	***Weighted TTS onset acoustic threshold level (SEL_{cum}) (dB)***	***Weighted PTS onset acoustic threshold level (SEL_{cum}) (dB)***
Low-frequency (LF) Cetaceans	179	199
Mid-frequency (MF) Cetaceans	178	198
High-frequency (HF) Cetaceans	153	173
Phocid Pinnipeds (PW underwater)	181	201
Otariid Pinnipeds (OW underwater)	199	219

Note: LF cetaceans include all mysticetes (baleen whales) while MF cetaceans include dolphins, beaked whales, and medium to large toothed whales

the temporary, non-injurious fatigue of hearing-related tissues, it represents the upper bound of the potential for MMPA Level B impacts. PTS, however, is non-recoverable and results from irreversible impacts on auditory sensory cells, supporting tissues, or neural structures within the auditory system. PTS is an injury and is thus considered within the potential for MMPA Level A harassment impacts.

The potential for PTS (MMPA Level A incidental harassment) is further considered within the context of the mitigation and monitoring efforts that will occur when SURTASS LFA sonar is transmitting. The NMFS (2018) acoustic guidance for estimating the potential for PTS defines weighted thresholds as sound exposure levels (SELs) (Table B-10). The length of a nominal LFA transmission is 60 sec, which lowers the thresholds by approximately 18 dB SEL (10 x $\log_{10}$ [60 sec] =17.8) if the assumption is made that all RLs are at the same RL. However, if transmissions at 300 Hz are considered for this example, as it is in the middle of the frequency range of LFA sonar transmissions (100 to 500 Hz), the thresholds must be appropriately weighted to account for each functional hearing group's sensitivity. This results in an increase in the thresholds of approximately 1.5, 56, 56, 15, and 20 dB, respectively, for LF, MF, HF, PW, and OW groups when considering a signal at 300 Hz. Based on simple spherical spreading (i.e., a transmission loss [TL] based on 20 × $\log_{10}$ [range in meters]), all functional hearing groups except LF cetaceans would need to be within 22 feet (7 m) for an entire LFA transmission (60 sec) to potentially experience PTS. An LF cetacean would need to be within 135 feet (41 m) for an entire LFA transmission to potentially experience PTS. Thus, when mitigation is applied in the modeling-analysis environment, estimations of PTS impacts were 0 for all marine mammal species in all model areas. This result along with the greater than required (i.e., more protective) isopleth of 180 dB (rms) used as the extent of the LFA mitigation zone around the transmitting sonar results in the Navy requesting no Level A incidental harassment takes.

B-4 IMPACT ANALYSIS

B-4.1 24-hr Impact Analysis

Modeling was conducted for one 24-hr period in each of the four seasons in each model area. Since AIM records the exposure history for each individual animat, the potential impact was determined on an individual animal basis. When determining the potential physiological impact, the exposure history was weighted to reflect the hearing abilities of the species according to the weighting function described in

Section B-3.3 (NMFS, 2018). The sound energy received by each individual animat over the 24-hr modeled period was calculated as SEL and the potential for that animal to experience PTS and then TTS was considered using the NMFS (2018) acoustic guidance (Table B-10). If an animal was not predicted to experience PTS or TTS, then the sound energy received over the 24-hr modeled period was calculated as dB SPE and used as input to the risk continuum function to assess the potential risk of biologically significant behavioral reaction. The dB SPE input to the risk continuum function is an unweighted level.

To ensure that each individual is considered for only one potential impact (i.e., there is no double counting), the potential for PTS is considered first, as it represents the highest threshold. If an individual does not exceed the PTS threshold, then the potential for TTS is considered. If an animal does not exceed the TTS threshold, then the potential for a behavioral response is considered. Thus, individuals are not considered for more than one acoustic impact during a 24-hr exposure scenario.

To estimate the potential impacts for each marine mammal stock on an annual basis, several calculation steps are required. The first step is to calculate the potential impact for one LFA sonar transmission hour. The 24-hr modeling results for each season are for 2.4 transmission hours (i.e., the SURTASS LFA sonar was simulated to transmit at a 10 percent duty cycle, so 24 hours of LFA sonar use equate to 2.4 sonar transmission hours; Table B-11). Therefore, the impact estimates from 24 hours of LFA sonar use (2.4 transmission hours) were divided by 2.4 to transform the results into potential impacts on a per transmission hour basis. Then, because the use of SURTASS LFA sonar is not driven by any seasonal factors, and LFA sonar activities are most likely to occur with equal frequency in any of the four seasons, the per transmission hour impact estimates for each season were averaged to provide a single annual per transmission hour impact estimate. At this point, the average impact of an hour of SURTASS LFA transmission during any time of the year has been calculated for every species or stock.

B-4.2 Alternatives Impact Analysis

The second step for calculating the potential impacts from all SURTASS LFA transmissions within a year is to determine the number of LFA sonar transmission hours that might occur in each model area, for each activity. To develop the total annual LFA sonar transmission hours, the Navy determined the training and testing activities that occur each year, the number of transmission hours conducted during each activity for each action alternative, and the model areas in which each activity is expected to occur (Tables B-12 and B-13), as not all proposed activities would occur in all modeled areas. To calculate the potential impact in each model area for each activity, the number of annual LFA sonar transmissions hours for each activity was evenly distributed across the model areas in which that activity might occur. The hours for each activity were evenly distributed across the model areas in which that activity might occur because there is an equal chance of activities happening in each model area identified for an activity; the Navy is not aware of any planning factors that would influence the distribution of activity hours among model areas. For example, the execution of vessel and equipment maintenance is estimated to require a total of 64 transmission hours, which are planned to occur only in either Model Area #2 or Model Area #3. Therefore, the 64 transmission hours were equally distributed to Model Areas #2 and #3, or 32 hours in each model area, for vessel and equipment maintenance activities.

The third step was to determine the number of model areas in which each stock may occur for each activity. The fourth step was to select the maximum per hour impact for each stock that may occur in the model areas for that activity. For instance, for maintenance activities that occur in model areas #2 and #3, if a stock occurs in both model areas, whichever per hour impact estimate for that stock was higher between the two modeling areas was selected for all subsequent calculations for estimating the impacts from maintenance activities.

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Mission Area 1: East of Japan									
Blue whale	9,250	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	20,501	1.16	1	2	0	0.01%	0.00%	0.01%	0.00%
Common minke whale	25,049	4.82	5	10	0	0.02%	0.02%	0.04%	0.00%
Fin whale	9,250	0.12	0	0	0	0.00%	0.00%	0.00%	0.00%
Humpback whale	1,328	0.06	0	0	0	0.00%	0.00%	0.00%	0.00%
North Pacific right whale	922	0.01	0	0	0	0.00%	0.0%	0.00%	0.00%
Sei whale	7,000	0.56	1	2	0	0.01%	0.01%	0.03%	0.00%
Baird's beaked whale	5,688	6.1	0	6	0	0.11%	0.00%	0.11%	0.00%
Common bottlenose dolphin	100,281	40.84	0	41	0	0.04%	0.00%	0.04%	0.00%
Common dolphin	3,286,163	247.09	0	247	0	0.01%	0.00%	0.01%	0.00%
Cuvier's beaked whale	90,725	11.44	0	11	0	0.01%	0.00%	0.01%	0.00%
Dall's porpoise (*truei*)	178,157	51.39	0	51	0	0.03%	0.00%	0.03%	0.00%
False killer whale	16,668	10.64	0	11	0	0.06%	0.00%	0.07%	0.00%
Ginkgo-toothed beaked whale	22,799	1.84	0	2	0	0.01%	0.00%	0.01%	0.00%
Harbor porpoise	31,046	25.73	0	26	0	0.08%	0.00%	0.08%	0.00%
Hubbs' beaked whale	22,799	1.84	0	2	0	0.01%	0.00%	0.01%	0.00%
Killer whale	12,256	0.38	0	0	0	0.00%	0.00%	0.00%	0.00%
Kogia spp.	350,553	11.1	0	11	0	0.00%	0.00%	0.00%	0.00%
Pacific white-sided dolphin	931,000	16.4	0	16	0	0.00%	0.00%	0.00%	0.00%
Pantropical spotted dolphin	130,002	12.45	0	12	0	0.01%	0.00%	0.01%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	Stock Abundance	24 Hour Takes and Percentages of Stock Affected							
		Takes				Percentage (%) of Stock Affected			
		Behavioral Risk	TTS	Total Level B Harassment	Level A Harassment	Behavioral Risk (%)	TTS (%)	Total Level B Harassment (%)	Level A Harassment (%)
Pygmy killer whale	30,214	6.21	0	6	0	0.02%	0.00%	0.02%	0.00%
Risso's dolphin	143,374	32.69	0	33	0	0.02%	0.00%	0.02%	0.00%
Rough-toothed dolphin	5,002	7.58	0	8	0	0.15%	0.00%	0.16%	0.00%
Short-finned pilot whale	20,884	36.88	0	37	0	0.18%	0.00%	0.18%	0.00%
Sperm whale	102,112	3.53	0	4	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	0.4	0	0	0	0.00%	0.00%	0.00%	0.00%
Stejneger's beaked whale	8,000	1.84	0	2	0	0.02%	0.00%	0.03%	0.00%
Striped dolphin	497,725	18.77	0	19	0	0.00%	0.00%	0.00%	0.00%
Northern fur seal	503,609	220.92	0	221	0	0.04%	0.00%	0.04%	0.00%
Mission Area 2: North Philippine Sea									
Blue whale	9,250	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	20,501	1.21	1	2	0	0.01%	0.00%	0.01%	0.00%
Common minke whale	25,049	8.59	9	18	0	0.03%	0.04%	0.07%	0.00%
Fin whale	9,250	0.19	1	1	0	0.00%	0.01%	0.01%	0.00%
Humpback whale	1,328	1.16	7	8	0	0.09%	0.53%	0.60%	0.00%
North Pacific right whale	922	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	1,800	0.08	0	0	0	0.00%	0.00%	0.00%	0.00%
Blainville's beaked whale	8,032	1.62	0	2	0	0.02%	0.00%	0.02%	0.00%
Common bottlenose dolphin	3,516	38.52	0	39	0	1.10%	0.00%	1.11%	0.00%
Common dolphin	3,286,163	154.33	0	154	0	0.00%	0.00%	0.00%	0.00%
Cuvier's beaked whale	90,725	17.54	0	18	0	0.02%	0.00%	0.02%	0.00%
False killer whale	16,668	8.13	0	8	0	0.05%	0.00%	0.05%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Fraser's dolphin	220,789	19.5	0	20	0	0.01%	0.00%	0.01%	0.00%
Ginkgo-toothed beaked whale	22,799	1.62	0	2	0	0.01%	0.00%	0.01%	0.00%
Killer whale	12,256	0.27	0	0	0	0.00%	0.00%	0.00%	0.00%
Kogia spp.	350,553	10.54	0	11	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	0.78	0	1	0	0.01%	0.00%	0.01%	0.00%
Melon-headed whale	56,213	12	0	12	0	0.02%	0.00%	0.02%	0.00%
Pacific white-sided dolphin	931,000	15.56	0	16	0	0.00%	0.00%	0.00%	0.00%
Pantropical spotted dolphin	130,002	32.02	0	32	0	0.02%	0.00%	0.02%	0.00%
Pygmy killer whale	30,214	5.89	0	6	0	0.02%	0.00%	0.02%	0.00%
Risso's dolphin	143,374	35.44	0	35	0	0.02%	0.00%	0.02%	0.00%
Rough-toothed dolphin	5,002	7.61	0	8	0	0.15%	0.00%	0.16%	0.00%
Short-finned pilot whale	31,396	46.5	0	47	0	0.15%	0.00%	0.15%	0.00%
Sperm whale	102,112	3.38	0	3	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	1.94	0	2	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	19,631	76.89	0	77	0	0.39%	0.00%	0.39%	0.00%
Mission Area 3: West Philippine Sea									
Blue whale	9,250	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	20,501	1.28	1	2	0	0.01%	0.00%	0.01%	0.00%
Common minke whale	25,049	6.75	9	16	0	0.03%	0.04%	0.06%	0.00%
Fin whale	9,250	0.21	0	0	0	0.00%	0.00%	0.00%	0.00%
Humpback whale	1,328	1.45	2	3	0	0.11%	0.15%	0.23%	0.00%
Omura's whale	1,800	0.09	0	0	0	0.00%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Blainville's beaked whale	8,032	1.27	0	1	0	0.02%	0.00%	0.01%	0.00%
Common bottlenose dolphin	40,769	42.15	0	42	0	0.10%	0.00%	0.10%	0.00%
Common dolphin	3,286,163	151.86	0	152	0	0.00%	0.00%	0.00%	0.00%
Cuvier's beaked whale	90,725	0.77	0	1	0	0.00%	0.00%	0.00%	0.00%
Deraniyagala's beaked whale	22,799	1.27	0	1	0	0.01%	0.00%	0.00%	0.00%
False killer whale	16,668	8.67	0	9	0	0.05%	0.00%	0.05%	0.00%
Fraser's dolphin	220,789	19.55	0	20	0	0.01%	0.00%	0.01%	0.00%
Ginkgo-toothed beaked whale	22,799	1.27	0	1	0	0.01%	0.00%	0.00%	0.00%
Killer whale	12,256	0.28	0	0	0	0.00%	0.00%	0.00%	0.00%
Kogia spp.	350,553	5.56	0	6	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	0.08	0	0	0	0.00%	0.00%	0.00%	0.00%
Melon-headed whale	56,213	12.8	0	13	0	0.02%	0.00%	0.02%	0.00%
Pantropical spotted dolphin	130,002	34.95	0	35	0	0.03%	0.00%	0.03%	0.00%
Pygmy killer whale	30,214	6.28	0	6	0	0.02%	0.00%	0.02%	0.00%
Risso's dolphin	143,374	33.95	0	34	0	0.02%	0.00%	0.02%	0.00%
Rough-toothed dolphin	5,002	6.82	0	7	0	0.14%	0.00%	0.14%	0.00%
Short-finned pilot whale	31,396	22.96	0	23	0	0.07%	0.00%	0.07%	0.00%
Sperm whale	102,112	3.04	0	3	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	2.12	0	2	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	52,682	41.84	0	42	0	0.08%	0.00%	0.08%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Mission Area 4: Offshore Guam									
Blue whale	9,250	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	20,501	0.23	0	0	0	0.00%	0.00%	0.00%	0.00%
Common minke whale	25,049	0.08	0	0	0	0.00%	0.00%	0.00%	0.00%
Fin whale	9,250	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Humpback whale	1,328	0.19	0	0	0	0.01%	0.00%	0.00%	0.00%
Omura's whale	1,800	0.03	0	0	0	0.00%	0.00%	0.00%	0.00%
Sei whale	7,000	0.12	0	0	0	0.00%	0.00%	0.00%	0.00%
Blainville's beaked whale	8,032	2.25	0	2	0	0.03%	0.00%	0.02%	0.00%
Common bottlenose dolphin	40,769	9.07	0	9	0	0.02%	0.00%	0.02%	0.00%
Cuvier's beaked whale	90,725	0.78	0	1	0	0.00%	0.00%	0.00%	0.00%
Deraniyagala's beaked whale	22,799	2.44	0	2	0	0.01%	0.00%	0.01%	0.00%
Dwarf sperm whale	350,553	13.35	0	13	0	0.00%	0.00%	0.00%	0.00%
False killer whale	16,668	1.15	0	1	0	0.01%	0.00%	0.01%	0.00%
Fraser's dolphin	16,992	26.16	0	26	0	0.15%	0.00%	0.15%	0.00%
Ginkgo-toothed beaked whale	22,799	2.44	0	2	0	0.01%	0.00%	0.01%	0.00%
Killer whale	12,256	0.06	0	0	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	5.55	0	6	0	0.07%	0.00%	0.08%	0.00%
Melon-headed whale	56,213	4.43	0	4	0	0.01%	0.00%	0.01%	0.00%
Pantropical spotted dolphin	130,002	12.66	0	13	0	0.01%	0.00%	0.01%	0.00%
Pygmy killer whale	30,214	0.15	0	0	0	0.00%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Pygmy sperm whale	350,553	5.45	0	5	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	143,374	9.35	0	9	0	0.01%	0.00%	0.01%	0.00%
Rough-toothed dolphin	5,002	3.3	0	3	0	0.07%	0.00%	0.06%	0.00%
Short-finned pilot whale	31,396	10.27	0	10	0	0.03%	0.00%	0.03%	0.00%
Sperm whale	102,112	2.42	0	2	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	0.46	0	0	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	52,682	3.45	0	3	0	0.01%	0.00%	0.01%	0.00%
Mission Area 5: Sea of Japan									
Bryde's whale	20,501	0.31	0	0	0	0.00%	0.00%	0.00%	0.00%
Common minke whale	2,611	0.47	0	0	0	0.02%	0.00%	0.00%	0.00%
Fin whale	9,250	2.76	9	12	0	0.03%	0.10%	0.13%	0.00%
North Pacific right whale	922	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	1,800	0.12	0	0	0	0.01%	0.00%	0.00%	0.00%
Western North Pacific gray whale	140	0.01	0	0	0	0.01%	0.00%	0.00%	0.00%
Baird's beaked whale	5,688	1.73	0	2	0	0.03%	0.00%	0.04%	0.00%
Common bottlenose dolphin	105,138	2.83	0	3	0	0.00%	0.00%	0.00%	0.00%
Common dolphin	279,182	501.97	0	502	0	0.18%	0.00%	0.18%	0.00%
Cuvier's beaked whale	90,725	18.73	0	19	0	0.02%	0.00%	0.02%	0.00%
Dall's porpoise	173,638	64.8	0	65	0	0.04%	0.00%	0.04%	0.00%
False killer whale	9,777	11.16	0	11	0	0.11%	0.00%	0.11%	0.00%
Harbor porpoise	31,046	18.99	0	19	0	0.06%	0.00%	0.06%	0.00%
Killer whale	12,256	0.39	0	0	0	0.00%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Kogia spp.	350,553	9.53	0	10	0	0.00%	0.00%	0.00%	0.00%
Pacific white-sided dolphin	931,000	4.01	0	4	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	143,374	41.14	0	41	0	0.03%	0.00%	0.03%	0.00%
Rough-toothed dolphin	5,002	12.18	0	12	0	0.24%	0.00%	0.24%	0.00%
Sperm whale	102,112	9.86	0	10	0	0.01%	0.00%	0.01%	0.00%
Spinner dolphin	1,015,059	0.6	0	1	0	0.00%	0.00%	0.00%	0.00%
Stejneger's beaked whale	8,000	3.02	0	3	0	0.04%	0.00%	0.04%	0.00%
Spotted seal	3,500	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Northern fur seal	503,609	223.46	0	223	0	0.04%	0.00%	0.04%	0.00%
Mission Area 6: East China Sea									
Bryde's whale	137	0.48	2	2	0	0.35%	1.46%	1.46%	0.00%
Common minke whale	4,492	2.39	9	11	0	0.05%	0.20%	0.24%	0.00%
Fin whale	500	0.27	1	1	0	0.05%	0.20%	0.20%	0.00%
North Pacific right whale	922	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	1,800	0.06	0	0	0	0.00%	0.00%	0.00%	0.00%
Western North Pacific gray whale	140	0.01	0	0	0	0.01%	0.00%	0.00%	0.00%
Blainville's beaked whale	8,032	1.71	0	2	0	0.02%	0.00%	0.02%	0.00%
Common bottlenose dolphin	105,138	4.49	0	4	0	0.00%	0.00%	0.00%	0.00%
Common dolphin	279,182	344.59	0	345	0	0.12%	0.00%	0.12%	0.00%
Cuvier's beaked whale	90,725	1.03	0	1	0	0.00%	0.00%	0.00%	0.00%
False killer whale	9,777	3.54	0	4	0	0.04%	0.00%	0.04%	0.00%
Fraser's dolphin	220,789	25.44	0	25	0	0.01%	0.00%	0.01%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Ginkgo-toothed beaked whale	22,799	1.71	0	2	0	0.01%	0.00%	0.01%	0.00%
Killer whale	12,256	0.29	0	0	0	0.00%	0.00%	0.00%	0.00%
Kogia spp.	350,553	5.77	0	6	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	0.8	0	1	0	0.01%	0.00%	0.01%	0.00%
Melon-headed whale	56,213	13.63	0	14	0	0.02%	0.00%	0.02%	0.00%
Pacific white-sided dolphin	931,000	3.76	0	4	0	0.00%	0.00%	0.00%	0.00%
Pantropical spotted dolphin	130,002	36.49	0	36	0	0.03%	0.00%	0.03%	0.00%
Pygmy killer whale	30,214	0.45	0	0	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	143,374	39.01	0	39	0	0.03%	0.00%	0.03%	0.00%
Rough-toothed dolphin	5,002	7.96	0	8	0	0.16%	0.00%	0.16%	0.00%
Sperm whale	102,112	3.3	0	3	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	2.21	0	2	0	0.00%	0.00%	0.00%	0.00%
Spotted seal	1,000	0.03	0	0	0	0.00%	0.00%	0.00%	0.00%
Mission Area 7: South China Sea									
Bryde's whale	20,501	0.78	0	1	0	0.00%	0.00%	0.00%	0.00%
Common minke whale	4,492	2.58	1	4	0	0.06%	0.02%	0.09%	0.00%
Fin whale	9,250	0.14	0	0	0	0.00%	0.00%	0.00%	0.00%
Humpback whale	1,328	0.17	0	0	0	0.01%	0.00%	0.00%	0.00%
North Pacific right whale	922	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	1,800	0.05	0	0	0	0.00%	0.00%	0.00%	0.00%
Western North Pacific gray whale	140	0.01	0	0	0	0.01%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Blainville's beaked whale	8,032	1.07	0	1	0	0.01%	0.00%	0.01%	0.00%
Common bottlenose dolphin	105,138	1.25	0	1	0	0.00%	0.00%	0.00%	0.00%
Common dolphin	279,182	236.26	0	236	0	0.08%	0.00%	0.08%	0.00%
Cuvier's beaked whale	90,725	0.64	0	1	0	0.00%	0.00%	0.00%	0.00%
Deraniyagala's beaked whale	22,799	1.07	0	1	0	0.00%	0.00%	0.00%	0.00%
False killer whale	9,777	2.06	0	2	0	0.02%	0.00%	0.02%	0.00%
Fraser's dolphin	220,789	14.22	0	14	0	0.01%	0.00%	0.01%	0.00%
Ginkgo-toothed beaked whale	22,799	1.07	0	1	0	0.00%	0.00%	0.00%	0.00%
Killer whale	12,256	0.21	0	0	0	0.00%	0.00%	0.00%	0.00%
Kogia spp.	350,553	4.31	0	4	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	0.76	0	1	0	0.01%	0.00%	0.01%	0.00%
Melon-headed whale	56,213	7.96	0	8	0	0.01%	0.00%	0.01%	0.00%
Pantropical spotted dolphin	130,002	13.96	0	14	0	0.01%	0.00%	0.01%	0.00%
Pygmy killer whale	30,214	0.26	0	0	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	143,374	25.18	0	25	0	0.02%	0.00%	0.02%	0.00%
Rough-toothed dolphin	5,002	5.39	0	5	0	0.11%	0.00%	0.10%	0.00%
Short-finned pilot whale	31,396	2.71	0	3	0	0.01%	0.00%	0.01%	0.00%
Sperm whale	102,112	2.27	0	2	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	0.84	0	1	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	52,682	5.93	0	6	0	0.01%	0.00%	0.01%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Mission Area 8: Offshore Japan 25° to 40°N									
Blue whale	9,250	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	20,501	0.96	2	3	0	0.00%	0.01%	0.01%	0.00%
Common minke whale	25,049	1.02	1	2	0	0.00%	0.00%	0.01%	0.00%
Fin whale	9,250	0.15	0	0	0	0.00%	0.00%	0.00%	0.00%
Humpback whale	1,328	0.41	0	0	0	0.03%	0.00%	0.00%	0.00%
Sei whale	7,000	0.55	1	2	0	0.01%	0.01%	0.03%	0.00%
Baird's beaked whale	5,688	0.39	0	0	0	0.01%	0.00%	0.00%	0.00%
Blainville's beaked whale	8,032	2.04	0	2	0	0.03%	0.00%	0.02%	0.00%
Common bottlenose dolphin	100,281	2.89	0	3	0	0.00%	0.00%	0.00%	0.00%
Common dolphin	3,286,163	343.57	0	344	0	0.01%	0.00%	0.01%	0.00%
Cuvier's beaked whale	90,725	10.91	0	11	0	0.01%	0.00%	0.01%	0.00%
Dall's porpoise (*dalli*)	162,000	97.83	0	98	0	0.06%	0.00%	0.06%	0.00%
Dwarf sperm whale	350,553	18.62	0	19	0	0.01%	0.00%	0.01%	0.00%
False killer whale	16,668	15.38	0	15	0	0.09%	0.00%	0.09%	0.00%
Hubbs' beaked whale	22,799	1.46	0	1	0	0.01%	0.00%	0.00%	0.00%
Killer whale	12,256	0.39	0	0	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	0.97	0	1	0	0.01%	0.00%	0.01%	0.00%
Melon-headed whale	56,213	11.54	0	12	0	0.02%	0.00%	0.02%	0.00%
Mesoplodon spp.	22,799	1.46	0	1	0	0.01%	0.00%	0.00%	0.00%
Northern right whale dolphin	68,000	0.03	0	0	0	0.00%	0.00%	0.00%	0.00%
Pacific white-sided dolphin	931,000	22.26	0	22	0	0.00%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Pantropical spotted dolphin	130,002	36.31	0	36	0	0.03%	0.00%	0.03%	0.00%
Pygmy killer whale	30,214	0.43	0	0	0	0.00%	0.00%	0.00%	0.00%
Pygmy sperm whale	350,553	7.79	0	8	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	143,374	1.98	0	2	0	0.00%	0.00%	0.00%	0.00%
Rough-toothed dolphin	5,002	6.59	0	7	0	0.13%	0.00%	0.14%	0.00%
Short-finned pilot whale	20,884	9.28	0	9	0	0.04%	0.00%	0.04%	0.00%
Sperm whale	102,112	5.41	0	5	0	0.01%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	6.11	0	6	0	0.00%	0.00%	0.00%	0.00%
Stejneger's beaked whale	8,000	1.46	0	1	0	0.02%	0.00%	0.01%	0.00%
Striped dolphin	497,725	18.63	0	19	0	0.00%	0.00%	0.00%	0.00%
Hawaiian monk seal	1,427	0.38	0	0	0	0.03%	0.00%	0.00%	0.00%
Northern fur seal	503,609	9.11	0	9	0	0.00%	0.00%	0.00%	0.00%
Mission Area 9: Offshore Japan 10° to 25°N									
Blue whale	9,250	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	20,501	0.67	1	2	0	0.00%	0.00%	0.01%	0.00%
Fin whale	9,250	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Humpback whale	1,328	0.52	1	2	0	0.04%	0.08%	0.15%	0.00%
Omura's whale	1,800	0.09	0	0	0	0.00%	0.00%	0.00%	0.00%
Sei whale	7,000	0.31	1	1	0	0.00%	0.00%	0.00%	0.00%
Blainville's beaked whale	8,032	1.43	0	1	0	0.02%	0.00%	0.01%	0.00%
Common bottlenose dolphin	40,769	2.17	0	2	0	0.01%	0.00%	0.00%	0.00%
Cuvier's beaked whale	90,725	7.62	0	8	0	0.01%	0.00%	0.01%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Deraniyagala's beaked whale	22,799	1.9	0	2	0	0.01%	0.00%	0.01%	0.00%
Dwarf sperm whale	350,553	12.3	0	12	0	0.00%	0.00%	0.00%	0.00%
False killer whale	16,668	1.76	0	2	0	0.01%	0.00%	0.01%	0.00%
Fraser's dolphin	16,992	7.43	0	7	0	0.04%	0.00%	0.04%	0.00%
Ginkgo-toothed beaked whale	22,799	1.9	0	2	0	0.01%	0.00%	0.01%	0.00%
Killer whale	12,256	0.28	0	0	0	0.00%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	0.68	0	1	0	0.01%	0.00%	0.01%	0.00%
Melon-headed whale	56,213	8.23	0	8	0	0.01%	0.00%	0.01%	0.00%
Pantropical spotted dolphin	130,002	32.94	0	33	0	0.03%	0.00%	0.03%	0.00%
Pygmy killer whale	30,214	0.19	0	0	0	0.00%	0.00%	0.00%	0.00%
Pygmy sperm whale	350,553	5.03	0	5	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	143,374	1.29	0	1	0	0.00%	0.00%	0.00%	0.00%
Rough-toothed dolphin	5,002	5.19	0	5	0	0.10%	0.00%	0.10%	0.00%
Short-finned pilot whale	31,396	6.05	0	6	0	0.02%	0.00%	0.02%	0.00%
Sperm whale	102,112	4.76	0	5	0	0.00%	0.00%	0.00%	0.00%
Spinner dolphin	1,015,059	5.44	0	5	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	52,682	17	0	17	0	0.03%	0.00%	0.03%	0.00%
Mission Area 10: Hawaii North									
Blue whale	133	0.08	0	0	0	0.06%	0.00%	0.00%	0.00%
Bryde's whale	1,751	0.2	0	0	0	0.01%	0.00%	0.00%	0.00%
Common minke whale	25,049	7.56	7	15	0	0.03%	0.03%	0.06%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Fin whale	154	0.1	0	0	0	0.06%	0.00%	0.00%	0.00%
Humpback whale	10,103	6.26	11	17	0	0.06%	0.11%	0.17%	0.00%
Sei whale	391	0.26	0	0	0	0.07%	0.00%	0.00%	0.00%
Blainville's beaked whale	2,105	2.28	0	2	0	0.11%	0.00%	0.10%	0.00%
Common bottlenose dolphin	21,815	3.45	0	3	0	0.02%	0.00%	0.01%	0.00%
	184	0	0	0	0	0.00%	0.00%	0.00%	0.00%
	191	0.01	0	0	0	0.01%	0.00%	0.00%	0.00%
	743	0.08	0	0	0	0.01%	0.00%	0.00%	0.00%
	128	0.01	0	0	0	0.01%	0.00%	0.00%	0.00%
Cuvier's beaked whale	723	0.8	0	1	0	0.11%	0.00%	0.14%	0.00%
Dwarf sperm whale	17,519	23.78	0	24	0	0.14%	0.00%	0.14%	0.00%
False killer whale	1,540	1.98	0	2	0	0.13%	0.00%	0.13%	0.00%
	167	0	0	0	0	0.00%	0.00%	0.00%	0.00%
	617	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Fraser's dolphin	51,491	70.56	0	71	0	0.14%	0.00%	0.14%	0.00%
Killer whale	146	0.23	0	0	0	0.16%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	11.91	0	12	0	0.16%	0.00%	0.16%	0.00%
Melon-headed whale	8,666	6.56	0	7	0	0.08%	0.00%	0.08%	0.00%
	447	0.34	0	0	0	0.08%	0.00%	0.08%	0.00%
Pantropical spotted dolphin	55,795	9.37	0	9	0	0.02%	0.00%	0.02%	0.00%
	220	0.03	0	0	0	0.01%	0.00%	0.00%	0.00%
	220	0.03	0	0	0	0.01%	0.00%	0.00%	0.00%
Pantropical spotted dolphin (continued)	220	0.03	0	0	0	0.01%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Pygmy killer whale	10,640	14.28	0	14	0	0.13%	0.00%	0.13%	0.00%
Pygmy sperm whale	7,138	9.66	0	10	0	0.14%	0.00%	0.14%	0.00%
Risso's dolphin	11,613	15.03	0	15	0	0.13%	0.00%	0.13%	0.00%
Rough-toothed dolphin	72,528	7.73	0	8	0	0.01%	0.00%	0.01%	0.00%
Short-finned pilot whale	19,503	14.37	0	14	0	0.07%	0.00%	0.07%	0.00%
Sperm whale	4,559	3.84	0	4	0	0.08%	0.00%	0.09%	0.00%
Spinner dolphin	3,351	4.02	0	4	0	0.12%	0.00%	0.12%	0.00%
	601	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
	631	0.03	0	0	0	0.00%	0.00%	0.00%	0.00%
	355	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
	260	0	0	0	0	0.00%	0.00%	0.00%	0.00%
	300	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	61,201	9.76	0	10	0	0.02%	0.00%	0.02%	0.00%
Hawaiian monk seal	1,427	0.11	0	0	0	0.01%	0.00%	0.00%	0.00%
Mission Area 11: Hawaii South									
Blue whale	133	0.06	0	0	0	0.05%	0.00%	0.00%	0.00%
Bryde's whale	798	0.17	0	0	0	0.02%	0.00%	0.00%	0.00%
Common minke whale	25,049	5.36	8	13	0	0.02%	0.03%	0.05%	0.00%
Fin whale	154	0.07	0	0	0	0.05%	0.00%	0.00%	0.00%
Humpback whale	10,103	6.42	11	17	0	0.06%	0.11%	0.17%	0.00%
Sei whale	391	0.18	0	0	0	0.05%	0.00%	0.00%	0.00%
Blainville's beaked whale	2,105	1.84	0	2	0	0.09%	0.00%	0.10%	0.00%
Common bottlenose dolphin	21,815	2.8	0	3	0	0.01%	0.00%	0.01%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Common bottlenose dolphin (Continued)	184	0.48	0	0	0	0.26%	0.00%	0.00%	0.00%
	191	0.17	0	0	0	0.09%	0.00%	0.00%	0.00%
	743	1.39	0	1	0	0.19%	0.00%	0.13%	0.00%
	128	0.02	0	0	0	0.02%	0.00%	0.00%	0.00%
Cuvier's beaked whale	723	0.64	0	1	0	0.09%	0.00%	0.14%	0.00%
Deraniyagala beaked whale	22,799	1.99	0	2	0	0.01%	0.00%	0.01%	0.00%
Dwarf sperm whale	17,519	18.25	0	18	0	0.10%	0.00%	0.10%	0.00%
False killer whale	1,540	2.09	0	2	0	0.14%	0.00%	0.13%	0.00%
	167	0.03	0	0	0	0.02%	0.00%	0.00%	0.00%
Fraser's dolphin	51,491	52.66	0	53	0	0.10%	0.00%	0.10%	0.00%
Killer whale	146	0.18	0	0	0	0.12%	0.00%	0.00%	0.00%
Longman's beaked whale	7,619	26.83	0	27	0	0.35%	0.00%	0.35%	0.00%
Melon-headed whale	8,666	4.88	0	5	0	0.06%	0.00%	0.06%	0.00%
	447	0.07	0	0	0	0.02%	0.00%	0.00%	0.00%
Pantropical spotted dolphin	55,795	10.8	0	11	0	0.02%	0.00%	0.02%	0.00%
	220	0.82	0	1	0	0.37%	0.00%	0.45%	0.00%
	220	0.84	0	1	0	0.38%	0.00%	0.45%	0.00%
	220	1.15	0	1	0	0.52%	0.00%	0.45%	0.00%
Pygmy killer whale	10,640	10.62	0	11	0	0.10%	0.00%	0.10%	0.00%
Pygmy sperm whale	7,138	7.41	0	7	0	0.10%	0.00%	0.10%	0.00%
Risso's dolphin	11,613	11.25	0	11	0	0.10%	0.00%	0.09%	0.00%
Rough-toothed dolphin	72,528	6.18	0	6	0	0.01%	0.00%	0.01%	0.00%
Short-finned pilot whale	19,503	12.72	0	13	0	0.07%	0.00%	0.07%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Sperm whale	4,559	2.51	0	3	0	0.06%	0.00%	0.07%	0.00%
Spinner dolphin	3,351	6.95	0	7	0	0.21%	0.00%	0.21%	0.00%
	601	3.02	0	3	0	0.50%	0.00%	0.50%	0.00%
	631	0.05	0	0	0	0.01%	0.00%	0.00%	0.00%
	355	0.72	0	1	0	0.20%	0.00%	0.28%	0.00%
Striped dolphin	61,201	9.48	0	9	0	0.02%	0.00%	0.01%	0.00%
Hawaiian monk seal	1,427	0.12	0	0	0	0.01%	0.00%	0.00%	0.00%
Mission Area 12: Offshore Sri Lanka									
Blue whale	3,691	0.03	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	9,176	0.29	0	0	0	0.00%	0.00%	0.00%	0.00%
Common minke whale	257,500	1.46	1	2	0	0.00%	0.00%	0.00%	0.00%
Fin whale	1,846	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	9,176	0.29	0	0	0	0.00%	0.00%	0.00%	0.00%
Sei whale	9,176	0.55	0	1	0	0.01%	0.00%	0.01%	0.00%
Blainville's beaked whale	16,867	2.21	0	2	0	0.01%	0.00%	0.01%	0.00%
Common dolphin	1,819,882	7.36	0	7	0	0.00%	0.00%	0.00%	0.00%
Common bottlenose dolphin	785,585	46.62	0	47	0	0.01%	0.00%	0.01%	0.00%
Cuvier's beaked whale	27,272	10.65	0	11	0	0.04%	0.00%	0.04%	0.00%
Deraniyagala beaked whale	16,867	11.09	0	11	0	0.07%	0.00%	0.07%	0.00%
Dwarf sperm whale	10,541	0.1	0	0	0	0.00%	0.00%	0.00%	0.00%
False killer whale	144,188	0.27	0	0	0	0.00%	0.00%	0.00%	0.00%
Fraser's dolphin	151,554	3.15	0	3	0	0.00%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Indo-Pacific bottlenose dolphin	7,850	0.47	0	0	0	0.01%	0.00%	0.00%	0.00%
Killer whale	12,593	9.78	0	10	0	0.08%	0.00%	0.08%	0.00%
Longman's beaked whale	16,867	12.13	0	12	0	0.07%	0.00%	0.07%	0.00%
Melon-headed whale	64,600	10.47	0	10	0	0.02%	0.00%	0.02%	0.00%
Pantropical spotted dolphin	736,575	4.28	0	4	0	0.00%	0.00%	0.00%	0.00%
Pygmy killer whale	22,029	1.63	0	2	0	0.01%	0.00%	0.01%	0.00%
Pygmy sperm whale	10,541	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	452,125	135.9	0	136	0	0.03%	0.00%	0.03%	0.00%
Rough-toothed dolphin	156,690	1.16	0	1	0	0.00%	0.00%	0.00%	0.00%
Short-finned pilot whale	268,751	41.32	0	41	0	0.02%	0.00%	0.02%	0.00%
Sperm whale	24,446	2.34	0	2	0	0.01%	0.00%	0.01%	0.00%
Spinner dolphin	634,108	3.21	0	3	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	674,578	69.63	0	70	0	0.01%	0.00%	0.01%	0.00%
Mission Area 13: Andaman Sea									
Blue whale	3,691	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	9,176	0.19	0	0	0	0.00%	0.00%	0.00%	0.00%
Common minke whale	257,500	1.13	2	3	0	0.00%	0.00%	0.00%	0.00%
Fin whale	1,846	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	9,176	0.19	0	0	0	0.00%	0.00%	0.00%	0.00%
Blainville's beaked whale	16,867	1.6	0	2	0	0.01%	0.00%	0.01%	0.00%
Common bottlenose dolphin	785,585	79.33	0	79	0	0.01%	0.00%	0.01%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Cuvier's beaked whale	27,272	8.11	0	8	0	0.03%	0.00%	0.03%	0.00%
Deraniyagala beaked whale	16,867	1.62	0	2	0	0.01%	0.00%	0.01%	0.00%
Dwarf sperm whale	10,541	0.09	0	0	0	0.00%	0.00%	0.00%	0.00%
False killer whale	144,188	0.31	0	0	0	0.00%	0.00%	0.00%	0.00%
Fraser's dolphin	151,554	2.45	0	2	0	0.00%	0.00%	0.00%	0.00%
Ginkgo-toothed beaked whale	16,867	1.62	0	2	0	0.01%	0.00%	0.01%	0.00%
Indo-Pacific bottlenose dolphin	7,850	0.8	0	1	0	0.01%	0.00%	0.01%	0.00%
Killer whale	12,593	7.68	0	8	0	0.06%	0.00%	0.06%	0.00%
Longman's beaked whale	16,867	14.99	0	15	0	0.09%	0.00%	0.09%	0.00%
Melon-headed whale	64,600	11.53	0	12	0	0.02%	0.00%	0.02%	0.00%
Pantropical spotted dolphin	736,575	5.49	0	5	0	0.00%	0.00%	0.00%	0.00%
Pygmy killer whale	22,029	1.63	0	2	0	0.01%	0.00%	0.01%	0.00%
Pygmy sperm whale	10,541	0.01	0	0	0	0.00%	0.00%	0.00%	0.00%
Risso's dolphin	452,125	141.56	0	142	0	0.03%	0.00%	0.03%	0.00%
Rough-toothed dolphin	156,690	1.1	0	1	0	0.00%	0.00%	0.00%	0.00%
Short-finned pilot whale	268,751	43.1	0	43	0	0.02%	0.00%	0.02%	0.00%
Sperm whale	24,446	1.58	0	2	0	0.01%	0.00%	0.01%	0.00%
Spinner dolphin	634,108	4.62	0	5	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	674,578	91.91	0	92	0	0.01%	0.00%	0.01%	0.00%
Mission Area 14: Northwest Australia									
Antarctic minke whale	90,000	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Blue whale/Pygmy blue whale	1,657	0.06	0	0	0	0.00%	0.00%	0.00%	0.00%
Bryde's whale	13,854	0.71	0	1	0	0.01%	0.00%	0.01%	0.00%
Common minke whale	257,500	28.69	16	45	0	0.01%	0.01%	0.02%	0.00%
Fin whale	38,185	1.85	1	3	0	0.00%	0.00%	0.01%	0.00%
Humpback whale	13,640	0.09	0	0	0	0.00%	0.00%	0.00%	0.00%
Omura's whale	13,854	0.71	0	1	0	0.01%	0.00%	0.01%	0.00%
Sei whale	13,854	0.02	0	0	0	0.00%	0.00%	0.00%	0.00%
Blainville's beaked whale	16,867	2.22	0	2	0	0.01%	0.00%	0.01%	0.00%
Common bottlenose dolphin	3,000	89.28	0	89	0	2.98%	0.00%	2.97%	0.00%
Cuvier's beaked whale	76,500	10.82	0	11	0	0.01%	0.00%	0.01%	0.00%
Dwarf sperm whale	10,541	0.14	0	0	0	0.00%	0.00%	0.00%	0.00%
False killer whale	144,188	0.55	0	1	0	0.00%	0.00%	0.00%	0.00%
Fraser's dolphin	151,554	4.36	0	4	0	0.00%	0.00%	0.00%	0.00%
Killer whale	12,593	18.6	0	19	0	0.15%	0.00%	0.15%	0.00%
Longman's beaked whale	16,867	15.25	0	15	0	0.09%	0.00%	0.09%	0.00%
Melon-headed whale	64,600	18.83	0	19	0	0.03%	0.00%	0.03%	0.00%
Pantropical spotted dolphin	736,575	14.59	0	15	0	0.00%	0.00%	0.00%	0.00%
Pygmy killer whale	22,029	2.79	0	3	0	0.01%	0.00%	0.01%	0.00%
Risso's dolphin	452,125	216.61	0	217	0	0.05%	0.00%	0.05%	0.00%
Rough-toothed dolphin	156,690	1.94	0	2	0	0.00%	0.00%	0.00%	0.00%
Short-finned pilot whale	268,751	71.51	0	72	0	0.03%	0.00%	0.03%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Southern bottlenose whale	599,300	3.16	0	3	0	0.00%	0.00%	0.00%	0.00%
Spade-toothed beaked whale	16,867	2.22	0	2	0	0.01%	0.00%	0.01%	0.00%
Sperm whale	24,446	2.21	0	2	0	0.01%	0.00%	0.01%	0.00%
Spinner dolphin	634,108	11.24	0	11	0	0.00%	0.00%	0.00%	0.00%
Striped dolphin	674,578	237.16	0	237	0	0.04%	0.00%	0.04%	0.00%
Mission Area 15: Northeast of Japan									
Blue whale	9,250	0.08	1	1	0	0.00%	0.01%	0.01%	0.00%
Common minke whale	25,049	7.81	6	14	0	0.03%	0.02%	0.06%	0.00%
Fin whale	9,250	1.98	25	27	0	0.02%	0.27%	0.29%	0.00%
Humpback whale	1,328	2.35	35	37	0	0.18%	2.64%	2.79%	0.00%
North Pacific right whale	922	0.05	2	2	0	0.01%	0.22%	0.22%	0.00%
Sei whale	7,000	1.59	43	45	0	0.02%	0.61%	0.64%	0.00%
Western North Pacific gray whale	140	0	0	0	0	0.00%	0.00%	0.00%	0.00%
Baird's beaked whale	5,688	72.42	0	72	0	1.27%	0.00%	1.27%	0.00%
Common dolphin	3,286,163	3337.84	0	3338	0	0.10%	0.00%	0.10%	0.00%
Cuvier's beaked whale	90,725	76.3	0	76	0	0.08%	0.00%	0.08%	0.00%
Dall's porpoise (*dalli*)	162,000	1550.82	0	1551	0	0.96%	0.00%	0.96%	0.00%
Killer whale	12,256	146.9	0	147	0	1.20%	0.00%	1.20%	0.00%
Pacific white-sided dolphin	931,000	210	0	210	0	0.02%	0.00%	0.02%	0.00%
Sperm whale	102,112	15.98	0	16	0	0.02%	0.00%	0.02%	0.00%
Stejneger's beaked whale	8,000	7.06	0	7	0	0.09%	0.00%	0.09%	0.00%
Northern fur seal	503,609	137.56	0	138	0	0.03%	0.00%	0.03%	0.00%

Table B-11. Number and Percentages of Marine Mammals Potentially Taken Annually by MMPA Level B and Level A Incidental Harassment on a 24-hour Basis by SURTASS LFA Sonar Transmissions in 15 Representative Mission Areas.

Marine Mammal Species	*Stock Abundance*	*24 Hour Takes and Percentages of Stock Affected*							
		Takes				*Percentage (%) of Stock Affected*			
		Behavioral Risk	*TTS*	*Total Level B Harassment*	*Level A Harassment*	*Behavioral Risk (%)*	*TTS (%)*	*Total Level B Harassment (%)*	*Level A Harassment (%)*
Ribbon seal	184,000	2172.84	36	2209	0	0.60%	0.01%	0.61%	0.00%
Spotted seal	460,268	5571.77	104	5676	0	1.21%	0.02%	1.23%	0.00%
Steller sea lion	71,221	0.31	0	0	0	0.00%	0.00%	0.00%	0.00%

Table B-12. Activities and Transmission Hours Per Year Expected to Occur in each of the 15 Representative Model Areas Under Alternative 1.

Model Area Number/Name	*Activity (Transmission Hours Per Year)*				
	Contractor Crew Training (80)	*MILCREW Training (64)*	*Navy Exercises (72)*	*Maintenance (48)*	*Acoustic Research Testing (96)*
1 /East of Japan		X			X
2 /North Philippine Sea	X	X	X	X	X
3 /West Philippine Sea	X	X	X	X	X
4 /Guam		X	X		X
5 /Sea of Japan		X			X
6 /East China Sea		X			X
7 /South China Sea		X	X		X
8 /Offshore Japan (25 to 40N)		X			X
9 / Offshore Japan (10 to 25N)		X			X
10 /Hawaii-North		X	X		X
11 /Hawaii-South		X	X		X
12 /Offshore Sri Lanka		X			X
13 /Andaman Sea		X			X
14 /Northwest Australia		X			X
15 /Northwest Japan		X			X

Table B-13. Activities and Transmission Hours Per Year Expected to Occur in each of the 15 Representative Model Areas Under Alternative 2/Preferred Alternative.

Model Area Number/Name	*Activity (Transmission Hours Per Year)*					
	Contractor Crew Training (80)	*MILCREW Training (96)*	*Navy Exercises (96)*	*Maintenance (64)*	*Acoustic Research Testing (160)*	*Years 5+: New LFA System Testing (96)*
1 /East of Japan		X			X	X
2 /North Philippine Sea	X	X	X	X	X	X
3 /West Philippine Sea	X	X	X	X	X	X
4 /Guam		X	X		X	X
5 /Sea of Japan		X			X	X
6 /East China Sea		X			X	X
7 /South China Sea		X	X		X	X
8 /Offshore Japan (25 to 40N)		X			X	X
9 /Offshore Japan (10 to 25N)		X			X	X
10 /Hawaii-North		X	X		X	X
11 /Hawaii-South		X	X		X	X
12 /Offshore Sri Lanka		X			X	X
13 /Andaman Sea		X			X	X
14 /Northwest Australia		X			X	X
15 /Northwest Japan		X			X	X

The final step was to multiply the results of steps two, three, and four to calculate the potential annual impacts per activity, which are then summed across the stocks for a total potential impact for all activities. The maximum estimate of the per hour impact (result of step three) was multiplied by the planned transmission hours for each activity per model area (result of step two) and by the number of model areas in which the stock might occur for that activity (result of step four). The end result is the maximum potential impact per stock for each activity, allowing flexibility for the activity to occur in any season and any of the planned model areas for that activity. To help explain the modeling process, the potential impacts to the Blainville's beaked whale are described as an illustrative example. Three stocks of Blainville's beaked whale are found in the study area, with the WNP stock occurring in Model Areas #2, 3, 4, 6, and 7; the Hawaii stock found in Model Areas #10 and 11; and the Indian Ocean stock occurring in Model Areas #12, 13, and 14. Contractor training (total of 80 transmission hr) and maintenance (total of 64 transmission hr) may occur in Model Areas #2 or 3, for a total of 144 transmission hr across both model areas or 72 transmission hr per model area (result of step two). Only the WNP stock of Blainville's beaked whale occurs in these two model areas. The potential impact in Model Area #2 is 0.68 behavioral takes per transmission hour, while in Model Area #3, 0.53 behavioral takes per transmission hour were computed. Since 0.68 behavioral takes per transmission hour is the greater or maximum take of the two model areas in which these two activities may occur, 0.68 behavioral takes per transmission hour is selected as the maximum (result of step four). The potential impact of 0.68 behavioral takes per transmission hour is multiplied by 72 transmission hours per model area and by 2 model areas (since Blainville's beaked whale may occur in both model areas; result of step three) for a total potential impact of 97.92 behavioral takes for both contractor training and maintenance activities for the WNP stock of Blainville's beaked whales.

The algebraic equation for these steps is presented below:

$$0.68\ \frac{takes}{transmission\ hr}\ x\ 72\frac{transmsion\ hr}{mission\ area}\ x\ 2\ mission\ areas = 97.92\ takes$$

The LFA sonar use as part of the Navy exercises support activity may occur in Model Areas #2, 3, 4, 7, 10, and 11 for a total of 96 transmission hours. This results in 16 transmission hours per model area, when the 96 transmission hours are divided equally among the 6 model areas (result of step two). Two stocks of Blainville's beaked whale might be exposed to transmissions from the Navy exercise support activity: the WNP stock occurs in Model Areas #2, 3, 4, and 7 (result of step three is four model areas for the WNP stock) and the Hawaii stock occurs in Model Areas #10 and 11 (result of step three is two model areas for the Hawaii stock). The maximum potential impact in any of the modeling areas in which the WNP stock occurs is 0.94 behavioral takes (result of step four); the maximum potential impact in any of the modeling areas in which the Hawaii stock occurs is 0.95 behavioral takes (result of step four). Thus for the WNP stock, the potential impact of 0.94 behavioral takes per transmission hour is multiplied by 16 transmission hours per model area and by 4 model areas for a total potential impact of 60.16 behavioral takes from SURTASS LFA use during Navy exercise support activities. For the Hawaii stock, the potential impact of 0.95 behavioral takes per transmission hour is multiplied by 16 transmission hours per model area and by 2 model areas for a total potential impact of 30.40 behavioral takes from SURTASS LFA use during Navy exercises support activities. The same process occurs for the remaining activities (MILCREW training and acoustic research in years 1 to 4, plus the addition of new LFA sonar system testing in years 5 and beyond), which may occur in all fifteen model areas.

To develop the overall potential impact from all SURTASS LFA sonar transmissions within a year to each marine mammal stock, the potential impacts to each stock from each individual activity are then summed to derive the total maximum potential impact on an annual basis for Alternative 1 (Table B-14) and Alternative 2 in Years 1 to 4 (Table B-15) and Years 5 and beyond (Table B-16). This is a conservative estimate since it is based on the maximum potential impact to a stock across all model areas in which an activity may occur. Therefore, if the activity occurs in a different model area than the area where the maximum potential impact was predicted, the actual potential impact could be less than that estimated. However, since the Navy cannot forecast where a specific activity may be conducted this far in advance, this maximum estimate provides the Navy with the flexibility to conduct its training and testing activities across all model areas identified for each activity.

These annual estimates of potential impact were used to calculate the total impact that may occur over the entire period of the Proposed Action. The Proposed Action consists of seven years of training and testing activities. The cumulative number of marine mammals potentially affected over the seven-year period was estimated for Alternative 2 (the Preferred Alternative) as part of the MMPA and ESA permit packages (Table B-17). The annual estimates of the number of individuals and the percentage of stock for Years 1 to 4 (Table B-15) and Years 5 to 7 (Table B-16) are the first four columns of take estimates, provided as the inputs upon which the final column of the seven-year totals was calculated (i.e., four years of the maximum annual estimate from the Years 1 to 4 column and three years of the maximum annual estimate from the Years to 7 column). As stated above, these are conservative estimates since the values are based on the maximum potential impact to a stock across all model areas in which an activity may occur. Therefore, if the activity occurs in a different model area than the area where the maximum potential impact was predicted, the actual potential impact could be less than that estimated.

B-4.3 Summary

The potential for PTS (MMPA Level A incidental harassment) is considered within the context of the mitigation and monitoring efforts that would occur whenever SURTASS LFA sonar is transmitting. Mitigation monitoring is designed to detect marine mammals before they are exposed to 180 dB SPL RLs. The NMFS (2018) acoustic guidance for estimating the potential for PTS defines weighted thresholds as sound exposure levels. The length of a nominal LFA sonar transmission is 60 sec, which lowers the thresholds by approximately 18 dB SEL (10xlog10 [60 sec] =17.8) if the assumption is made that all RLs are at the same SPL. In addition to signal duration, hearing sensitivity must be considered. If transmissions at 300 Hz are considered for this example, as it is in about the middle of the frequency range of LFA sonar transmissions (100 to 500 Hz), the thresholds must be appropriately weighted to account for each functional hearing group's sensitivity. This results in an increase in the thresholds of approximately 1.5, 56, 56, 15, and 20 dB, respectively, for LF, MF, HF, PW, and OW groups when considering a signal at 300 Hz. Based on simple spherical spreading (i.e., a transmission loss [TL] based on 20 × log10 [range in meters]), all functional hearing groups except LF cetaceans would need to remain within 22 ft (7 m) for the entirety of an LFA sonar transmission (60 sec) to potentially experience PTS. An LF cetacean would need to remain within 135 ft (41 m) for the entirety of an LFA sonar transmission to potentially experience PTS. Based on the mitigation procedures used during SURTASS LFA sonar activities, the chances of this occurring are negligible. Therefore, no PTS (MMPA Level A harassment) is expected with the implementation of mitigation measures.

The impact to marine mammals anticipated from SURTASS LFA sonar transmission is MMPA Level B harassment of marine mammals. For most stocks of marine mammal species, the maximum annual percent of the stock or population that may experience Level B incidental harassment is less than 15 percent. This means that during one 24-hr period during the year, less than 15 percent of the population may react to SURTASS LFA sonar by changing behavior or moving a small distance, or may experience TTS. Of the 139 stocks within the SURTASS LFA sonar study area, eight stocks under Alternative 1 and eleven stocks in years 1 to 4 and fifteen stocks in years 5 and beyond under Alternative 2 have the potential for MMPA Level B incidental harassment greater than 15 percent. The highest percentage of a population that may experience Level B harassment is the WNP stock and DPS of humpback whales at 157.68 percent under Alternative 1 and 233.84 percent and 321.49 percent in years 1 to 4 and years 5 and beyond, respectively, under Alternative 2. This means that each individual in the population may react behaviorally or have TTS one to three times during one year. The percentage of the WNP stock and DPS of humpback whales that may experience Level B harassment is influenced by the size of the population, which is small (1,328 individuals). The next highest stock is the WNP stock of killer whales, with 53.41 percent potentially experiencing Level B harassment under Alternative 1 and 85.37 percent and 117.31 percent in years 1 to 4 and years 5 and beyond, respectively, under Alternative 2.

B-5 CONCLUSION

The acoustic impact analysis integrates Navy needs with the best available data on marine mammal populations to estimate the potential impacts from incidental exposure to SURTASS LFA sonar. In this supplemental analysis, marine mammal takes incidental to the use of SURTASS LFA sonar at 15 representative mission areas have been estimated, with the results also presented in Chapter 4.

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[38]	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Antarctic minke whale	ANT	0.07	0.00%	0	0.00%	0	0.00%
Blue whale	CNP	2.14	1.64%	0	0.00%	2	1.64%
	NIND	0.27	0.00%	0	0.00%	0	0.00%
	WNP	4.48	0.00%	52	0.52%	56	0.52%
	SIND	0.37	0.03%	0	0.00%	0	0.03%
Bryde's whale	ECS	2.13	1.56%	7	4.87%	9	6.42%
	Hawaii	3.73	0.43%	0	0.00%	4	0.43%
	WNP	139.65	0.82%	145	0.63%	285	1.45%
	NIND	2.53	0.02%	2	0.02%	5	0.04%
	SIND	3.13	0.02%	1	0.01%	4	0.03%
Common minke whale	Hawaii	190.46	0.76%	201	0.82%	392	1.57%
	IND	510.04	0.18%	284	0.09%	794	0.27%
	WNP JW	2.07	0.08%	0	0.00%	2	0.08%
Common minke whale (Continued)	WNP OE	816.05	3.33%	831	3.33%	1,647	6.65%
	YS	35.83	0.80%	85	1.89%	121	2.69%
Fin whale	ECS	1.18	0.23%	4	0.89%	6	1.12%
	Hawaii	2.39	1.57%	0	0.00%	2	1.57%
	IND	0.09	0.00%	0	0.00%	0	0.00%
	SIND	8.23	0.02%	6	0.01%	14	0.03%
	WNP	167.36	1.84%	1,469	15.76%	1,636	17.60%
Humpback whale	CNP stock and Hawaii DPS	116.98	1.16%	207	2.07%	324	3.22%
	WAU stock and DPS	0.53	0.00%	0	0.00%	1	0.00%

38 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; JW=Sea of Japan; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[38]*	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Humpback whale (Continued)	WNP stock and DPS	230.16	17.40%	1,862	140.28%	2,092	157.68%
North Pacific right whale	WNP	2.42	0.21%	53	5.78%	56	5.99%
Omura's whale	NIND	2.53	0.02%	2	0.02%	5	0.04%
	SIND	3.13	0.02%	0	0.00%	3	0.02%
	WNP	10.23	0.60%	0	0.00%	10	0.60%
Sei whale	Hawaii	6.49	1.64%	6	1.64%	13	3.27%
	SIND	0.10	0.00%	0	0.00%	0	0.00%
	NP	71.64	1.03%	1,911	27.33%	1,983	28.36%
	NIND	2.46	0.02%	0	0.00%	2	0.02%
Western North Pacific gray whale	WNP stock and Western DPS	0.29	0.21%	0	0.00%	0	0.21%
Baird's beaked whale	WNP	1,716.62	30.16%	0	0.00%	1,717	30.16%
Blainville's beaked whale	Hawaii	43.07	2.03%	0	0.00%	43	2.03%
	WNP	201.53	2.47%	0	0.00%	202	2.47%
	IND	29.63	0.17%	0	0.00%	30	0.17%
Common bottlenose dolphin	4-Islands	3.21	1.70%	0	0.00%	3	1.70%
	Hawaii Island	0.28	0.24%	0	0.00%	0	0.24%
	Hawaii Pelagic	65.21	0.28%	0	0.00%	65	0.28%
	IA	66.12	0.07%	0	0.00%	66	0.07%
	IND	1,190.43	39.67%	0	0.00%	1,190	39.67%
	Japanese Coastal	1,391.09	39.54%	0	0.00%	1,391	39.54%
	Kauai/Niihau	9.07	4.91%	0	0.00%	9	4.91%
	Oahu	26.16	3.54%	0	0.00%	26	3.54%
	WNP Northern Offshore	363.00	0.36%	0	0.00%	363	0.36%
	WNP Southern Offshore	2,107.38	5.13%	0	0.00%	2,107	5.13%

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[38]*	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Common bottlenose dolphin (Continued)	WAU	396.81	13.22%	0	0.00%	397	13.22%
Common dolphin	IND	32.70	0.00%	0	0.00%	33	0.00%
	WNP	130,453.81	7.94%	0	0.00%	130,454	7.94%
Cuvier's beaked whale	Hawaii	178.28	5.84%	0	0.00%	178	5.84%
	IND	144.30	0.53%	0	0.00%	144	0.53%
	SH	48.10	0.07%	0	0.00%	48	0.07%
	WNP	4,677.12	5.24%	0	0.00%	4,677	5.24%
Dall's porpoise	SOJ *dalli* type	383.97	0.22%	0	0.00%	384	0.22%
	WNP dalli ecotype	13,785.02	8.51%	0	0.00%	13,785	8.51%
	WNP *truei* ecotype	304.55	0.18%	0	0.00%	305	0.18%
Deraniyagala's beaked whale	IND	98.60	0.58%	0	0.00%	99	0.58%
	NP	136.74	0.56%	0	0.00%	137	0.56%
Dwarf sperm whale	Hawaii	449.18	2.55%	0	0.00%	449	2.55%
	IND	1.90	0.03%	0	0.00%	2	0.03%
	WNP	314.98	0.09%	0	0.00%	315	0.09%
False killer whale	Hawaii Pelagic	39.57	2.55%	0	0.00%	40	2.55%
	IA	159.13	1.63%	0	0.00%	159	1.63%
	IND	7.33	0.00%	0	0.00%	7	0.00%
	Main Hawaiian Islands Insular stock and DPS	0.47	0.28%	0	0.00%	0	0.28%
	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%
	WNP	540.22	3.25%	0	0.00%	540	3.25%
Fraser's dolphin	CNP	363.33	2.15%	0	0.00%	363	2.15%
	Hawaii	1,332.71	2.60%	0	0.00%	1,333	2.60%
	IND	58.10	0.03%	0	0.00%	58	0.03%

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[38]*	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Fraser's dolphin (Continued)	WNP	1,787.92	0.91%	0	0.00%	1,788	0.91%
Ginkgo-toothed beaked whale	IND	7.21	0.04%	0	0.00%	7	0.04%
	NP	210.99	0.91%	0	0.00%	211	0.91%
Harbor porpoise	WNP	228.71	0.73%	0	0.00%	229	0.73%
Hubbs' beaked whale	NP	16.38	0.07%	0	0.00%	16	0.07%
Indo-Pacific bottlenose dolphin	IND	7.07	0.09%	0	0.00%	7	0.09%
Killer whale	Hawaii	4.39	3.02%	0	0.00%	4	3.02%
	IND	248.03	1.97%	0	0.00%	248	1.97%
	WNP	6,549.20	53.41%	0	0.00%	6,549	53.41%
Kogia spp.	WNP	1,016.10	0.24%	0	0.00%	1,016	0.24%
Longman's beaked whale	Hawaii	506.79	6.66%	0	0.00%	507	6.66%
	IND	203.27	1.20%	0	0.00%	203	1.20%
	WNP	324.88	4.24%	0	0.00%	325	4.24%
Melon-headed whale	Hawaiian Islands	124.01	1.42%	0	0.00%	124	1.42%
	IND	251.03	0.40%	0	0.00%	251	0.40%
	Kohala Resident	6.33	0.28%	0	0.00%	6	0.28%
	WNP	1,237.96	2.20%	0	0.00%	1,238	2.20%
Mesoplodon spp.	WNP	6.49	0.03%	0	0.00%	6	0.03%
Northern right whale dolphin	NP	0.16	0.00%	0	0.00%	0	0.00%
Pacific white-sided dolphin	NP	6,092.68	0.68%	0	0.00%	6,093	0.68%
Pantropical spotted dolphin	4-Islands	21.72	9.87%	0	0.00%	22	9.87%
	Hawaii Island	15.49	7.04%	0	0.00%	15	7.04%
	Hawaiian Pelagic	203.91	0.38%	0	0.00%	204	0.38%
	IND	194.53	0.03%	0	0.00%	195	0.03%
	Oahu	15.87	7.23%	0	0.00%	16	7.23%

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[38]*	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Pantropical spotted dolphin (Continued)	WNP	3,860.43	2.99%	0	0.00%	3,860	2.99%
Pygmy killer whale	Hawaii	269.64	2.55%	0	0.00%	270	2.55%
Pygmy killer whale (Continued)	IND	37.20	0.17%	0	0.00%	37	0.17%
	WNP	683.55	2.18%	0	0.00%	684	2.18%
Pygmy sperm whale	Hawaii	182.42	2.55%	0	0.00%	182	2.55%
	IND	0.18	0.00%	0	0.00%	0	0.00%
	WNP	131.13	0.05%	0	0.00%	131	0.05%
Risso's dolphin	Hawaii	283.95	2.46%	0	0.00%	284	2.46%
	IA	674.37	0.45%	0	0.00%	674	0.45%
	WNP	5,309.63	2.34%	0	0.00%	5,310	2.34%
	IND	2,888.07	0.63%	0	0.00%	2,888	0.63%
Rough-toothed dolphin	Hawaii	146.06	0.19%	0	0.00%	146	0.19%
	IND	25.90	0.00%	0	0.00%	26	0.00%
	WNP	1,045.55	20.88%	0	0.00%	1,046	20.88%
Short-finned pilot whale	Hawaii	271.39	1.37%	0	0.00%	271	1.37%
	IND	953.47	0.37%	0	0.00%	953	0.37%
	WNP Northern Ecotype	327.84	1.58%	0	0.00%	328	1.58%
	WNP Southern Ecotype	4,442.86	14.09%	0	0.00%	4,443	14.09%
Southern bottlenose whale	IND	14.02	0.00%	0	0.00%	14	0.00%
Spade-toothed beaked whale	IND	9.88	0.06%	0	0.00%	10	0.06%
Sperm whale	Hawaii	72.58	1.61%	0	0.00%	73	1.61%
	NIND	20.82	0.09%	0	0.00%	21	0.09%
	NP	957.91	0.85%	0	0.00%	958	0.85%

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[38]*	*Maximum Annual MMPA Level B Harassment: Alternative 1*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Sperm whale (Continued)	SIND	9.81	0.04%	0	0.00%	10	0.04%
Spinner dolphin	Hawaii Island	0.85	0.14%	0	0.00%	1	0.14%
	Hawaii Pelagic	131.28	3.92%	0	0.00%	131	3.92%
	IND	149.80	0.03%	0	0.00%	150	0.03%
	Kauai/Niihau	56.95	9.49%	0	0.00%	57	9.49%
	Kure/Midway Atoll	0.00	0.00%	0	0.00%	0	0.00%
	Oahu/4-Islands	13.51	3.83%	0	0.00%	14	3.83%
Spinner dolphin (Continued)	Pearl and Hermes Reef	0.00	0.00%	0	0.00%	0	0.00%
	WNP	399.30	0.00%	0	0.00%	399	0.00%
Stejneger's beaked whale	WNP	125.60	1.56%	0	0.00%	126	1.56%
Striped dolphin	Hawaii	184.40	0.28%	0	0.00%	184	0.28%
	IND	3,162.17	0.47%	0	0.00%	3,162	0.47%
	Japanese Coastal	2,776.49	14.17%	0	0.00%	2,776	14.17%
	WNP Northern Offshore	166.84	0.04%	0	0.00%	167	0.04%
	WNP Southern Offshore	2,487.30	4.76%	0	0.00%	2,487	4.76%
Hawaiian monk seal	Hawaii	6.27	0.44%	0	0.00%	6	0.44%
Northern fur seal	Western Pacific	5,296.89	1.07%	0	0.00%	5,297	1.07%
Ribbon seal	NP	9,657.04	2.64%	159	0.04%	9,816	2.69%
Spotted seal	Alaska stock/Bering Sea DPS	49,526.87	10.76%	924	0.20%	50,451	10.96%
	Southern stock and DPS	0.27	0.02%	0	0.00%	0	0.02%

Table B-14. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 1 (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[38]***	***Maximum Annual MMPA Level B Harassment: Alternative 1***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
Steller sea lion	Western/Asian stock, Western DPS	1.36	0.00%	0	0.00%	1	0.00%

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[39]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Antarctic minke whale	ANT	0.14	0.00%	0	0.00%	0	0.00%
Blue whale	CNP	3.12	2.39%	0	0.00%	3	2.39%
	NIND	0.43	0.00%	0	0.00%	0	0.00%
	WNP	6.58	0.07%	83	0.83%	90	0.90%
	SIND	0.81	0.07%	0	0.00%	1	0.07%
Bryde's whale	ECS	3.41	2.49%	11	7.79%	14	10.28%
	Hawaii	5.44	0.62%	0	0.00%	5	0.62%
	WNP	184.11	1.08%	194	0.86%	378	1.94%
	NIND	4.05	0.04%	4	0.04%	8	0.07%
	SIND	5.01	0.04%	2	0.02%	7	0.05%
Common minke whale	Hawaii	277.85	1.10%	294	1.19%	572	2.30%
	IND	816.07	0.28%	455	0.14%	1,271	0.43%
	WNP JW	3.31	0.12%	0	0.00%	3	0.12%
	WNP OE	1,053.71	4.29%	1,073	4.29%	2,127	8.59%
	YS	53.89	1.20%	135	2.99%	189	4.20%
Fin whale	ECS	1.88	0.37%	7	1.42%	9	1.80%
	Hawaii	3.49	2.30%	0	0.00%	3	2.30%
	IND	0.14	0.00%	0	0.00%	0	0.00%
	SIND	13.17	0.04%	9	0.02%	22	0.05%
	WNP	259.28	2.85%	2,299	24.70%	2,558	27.55%
Humpback whale	CNP stock and Hawaii DPS	175.75	1.74%	311	3.11%	487	4.85%

39 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; JW=Sea of Japan; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[39]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Humpback whale (Continued)	WAU stock and DPS	0.85	0.00%	0	0.00%	1	0.00%
	WNP stock and DPS	315.07	23.82%	2,788	210.03%	3,103	233.84%
North Pacific right whale	WNP	3.65	0.33%	85	9.24%	89	9.57%
Omura's whale	NIND	4.05	0.04%	4	0.04%	8	0.07%
	SIND	5.01	0.04%	0	0.00%	5	0.04%
	WNP	13.68	0.81%	0	0.00%	14	0.81%
Sei whale	Hawaii	9.46	2.39%	9	2.39%	19	4.78%
	SIND	0.16	0.00%	0	0.00%	0	0.00%
	NP	114.31	1.63%	3,058	43.73%	3,172	45.37%
	NIND	3.93	0.04%	0	0.00%	4	0.04%
Western North Pacific gray whale	WNP stock and Western DPS	0.45	0.33%	0	0.00%	0	0.00%
Baird's beaked whale	WNP	2,746.60	48.26%	0	0.00%	2,747	48.26%
Blainville's beaked whale	Hawaii	35.06	1.83%	0	0.00%	35	1.83%
	WNP	269.35	3.30%	0	0.00%	269	3.30%
	IND	47.41	0.27%	0	0.00%	47	0.27%
Common bottlenose dolphin	4-Islands	4.68	2.48%	0	0.00%	5	2.48%
	Hawaii Island	0.41	0.34%	0	0.00%	0	0.00%
	Hawaii Pelagic	95.14	0.41%	0	0.00%	95	0.41%
	IA	104.12	0.11%	0	0.00%	104	0.11%
	IND	1,128.21	0.14%	0	0.00%	1,128	0.14%
	Japanese Coastal	1,686.43	47.94%	0	0.00%	1,686	47.94%
	Kauai/Niihau	13.23	7.16%	0	0.00%	13	7.16%
	Oahu	38.16	5.17%	0	0.00%	38	5.17%

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[39]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Common bottlenose dolphin (Continued)	WNP Northern Offshore	580.80	0.57%	0	0.00%	581	0.57%
	WNP Southern Offshore	2,725.54	6.63%	0	0.00%	2,726	6.63%
	WAU	634.90	21.16%	0	0.00%	635	21.16%
Common dolphin	IND	52.32	0.00%	0	0.00%	52	0.00%
	WNP	203,871.30	12.24%	0	0.00%	203,871	12.24%
Cuvier's beaked whale	Hawaii	21.91	3.03%	0	0.00%	22	3.03%
	IND	230.88	0.85%	0	0.00%	231	0.85%
	SH	76.96	0.11%	0	0.00%	77	0.11%
	WNP	6,945.66	7.78%	0	0.00%	6,946	7.78%
Dall's porpoise	SOJ *dalli* type	614.35	0.36%	0	0.00%	614	0.36%
	WNP *dalli* ecotype	22,056.04	13.62%	0	0.00%	22,056	13.62%
	WNP *truei* ecotype	487.28	0.28%	0	0.00%	487	0.28%
Deraniyagala's beaked whale	IND	157.76	0.92%	0	0.00%	158	0.92%
	NP	189.69	0.77%	0	0.00%	190	0.77%
Dwarf sperm whale	Hawaii	655.27	3.72%	0	0.00%	655	3.72%
	IND	3.04	0.05%	0	0.00%	3	0.05%
	WNP	486.15	0.14%	0	0.00%	486	0.14%
False killer whale	Hawaii Pelagic	57.73	3.72%	0	0.00%	58	3.72%
	IA	251.87	2.59%	0	0.00%	252	2.59%
	IND	11.73	0.00%	0	0.00%	12	0.01%
	Main Hawaiian Islands Insular stock and DPS	0.69	0.41%	0	0.00%	1	0.41%

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[39]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
False killer whale (Continued)	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%
	WNP	1,350.01	8.15%	0	0.00%	1,350	8.15%
Fraser's dolphin	CNP	546.45	3.24%	0	0.00%	546	3.24%
	Hawaii	1,944.18	3.79%	0	0.00%	1,944	3.79%
	IND	92.96	0.05%	0	0.00%	93	0.05%
	WNP	2,287.28	1.16%	0	0.00%	2,287	1.16%
Ginkgo-toothed beaked whale	IND	11.54	0.07%	0	0.00%	12	0.07%
	NP	283.49	1.21%	0	0.00%	283	1.21%
Harbor porpoise	WNP	365.94	1.17%	0	0.00%	366	1.17%
Hubbs' beaked whale	NP	26.20	0.11%	0	0.00%	26	0.11%
Indo-Pacific bottlenose dolphin	IND	11.31	0.14%	0	0.00%	11	0.14%
Killer whale	Hawaii	6.41	4.41%	0	0.00%	6	4.41%
	IND	396.85	3.15%	0	0.00%	397	3.15%
	WNP	10,470.13	85.37%	0	0.00%	10,470	85.37%
Kogia spp.	WNP	1,316.59	0.31%	0	0.00%	1,317	0.31%
Longman's beaked whale	Hawaii	739.32	5.01%	0	0.00%	739	5.01%
	IND	325.23	1.92%	0	0.00%	325	1.92%
	WNP	470.53	6.14%	0	0.00%	471	6.14%
Melon-headed whale	Hawaiian Islands	180.90	2.07%	0	0.00%	181	2.07%
	IND	401.65	0.64%	0	0.00%	402	0.64%
Melon-headed whale (Continued)	Kohala Resident	9.23	0.41%	0	0.00%	9	0.41%
	WNP	1,605.35	2.87%	0	0.00%	1,605	2.87%
Mesoplodon spp.	WNP	10.38	0.05%	0	0.00%	10	0.05%

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[39]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Northern right whale dolphin	NP	0.26	0.00%	0	0.00%	0	0.00%
Pacific white-sided dolphin	NP	9,530.41	1.05%	0	0.00%	9,530	1.05%
Pantropical spotted dolphin	4-Islands	31.69	14.40%	0	0.00%	32	14.40%
	Hawaii Island	22.60	10.26%	0	0.00%	23	10.26%
	Hawaiian Pelagic	297.46	0.55%	0	0.00%	297	0.55%
	IND	311.25	0.05%	0	0.00%	311	0.05%
	Oahu	23.15	10.54%	0	0.00%	23	10.54%
	WNP	5,104.81	3.95%	0	0.00%	5,105	3.95%
Pygmy killer whale	Hawaii	393.36	3.72%	0	0.00%	393	3.72%
	IND	59.52	0.27%	0	0.00%	60	0.27%
	WNP	901.17	2.87%	0	0.00%	901	2.87%
Pygmy sperm whale	Hawaii	266.12	3.72%	0	0.00%	266	3.72%
	IND	0.28	0.00%	0	0.00%	0	0.00%
	WNP	202.54	0.07%	0	0.00%	203	0.07%
Risso’s dolphin	Hawaii	414.23	3.58%	0	0.00%	414	3.58%
	IA	1,045.41	0.70%	0	0.00%	1,045	0.70%
	WNP	4,347.00	3.07%	0	0.00%	4,347	3.07%
	IND	4,620.91	1.01%	0	0.00%	4,621	1.01%
Rough-toothed dolphin	Hawaii	213.07	0.28%	0	0.00%	213	0.28%
	IND	41.44	0.00%	0	0.00%	41	0.00%
	WNP	1,439.43	28.74%	0	0.00%	1,439	28.74%
Short-finned pilot whale	Hawaii	395.90	2.00%	0	0.00%	396	2.00%
	IND	1,525.55	0.59%	0	0.00%	1,526	0.59%
	WNP Northern Ecotype	524.55	2.52%	0	0.00%	525	2.52%

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[39]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Short-finned pilot whale (Continued)	WNP Southern Ecotype	5,682.72	18.03%	0	0.00%	5,683	18.03%
Southern bottlenose whale	IND	22.44	0.00%	0	0.00%	22	0.00%
Spade-toothed beaked whale	IND	15.80	0.09%	0	0.00%	16	0.09%
Sperm whale	Hawaii	105.88	2.34%	0	0.00%	106	2.34%
	NIND	33.32	0.14%	0	0.00%	33	0.14%
	NP	1,429.07	1.28%	0	0.00%	1,429	1.28%
	SIND	15.70	0.07%	0	0.00%	16	0.07%
Spinner dolphin	Hawaii Island	1.24	0.21%	0	0.00%	1	0.21%
	Hawaii Pelagic	191.51	5.72%	0	0.00%	192	5.72%
	IND	239.68	0.05%	0	0.00%	240	0.05%
	Kauai/Niihau	83.08	13.85%	0	0.00%	83	13.85%
	Kure/Midway Atoll	0.00	0.00%	0	0.00%	0	0.00%
	Oahu/4-Islands	19.70	2.88%	0	0.00%	20	2.88%
	Pearl and Hermes Reef	0.00	0.00%	0	0.00%	0	0.00%
	WNP	574.02	0.00%	0	0.00%	574	0.00%
Stejneger's beaked whale	WNP	200.96	2.49%	0	0.00%	201	2.49%
Striped dolphin	Hawaii	269.01	0.41%	0	0.00%	269	0.41%
	IND	5,059.47	0.75%	0	0.00%	5,059	0.75%
	Japanese Coastal	3,365.96	17.18%	0	0.00%	3,366	17.18%
	WNP Northern Offshore	266.95	0.07%	0	0.00%	267	0.07%
	WNP Southern Offshore	3,282.31	6.28%	0	0.00%	3,282	6.28%

Table B-15. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 1 to 4 (Marine Mammal Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[39]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 1 to 4*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Hawaiian monk seal	Hawaii	9.71	0.69%	0	0.00%	10	0.69%
Northern fur seal	Western Pacific	8,475.02	1.71%	0	0.00%	8,475	1.71%
Ribbon seal	NP	15,451.27	4.23%	254	0.07%	15,705	4.30%
Spotted seal	Alaska stock/Bering Sea DPS	79,242.99	17.21%	1,479	0.32%	80,722	17.53%
	Southern stock and DPS	0.43	0.04%	0	0.00%	0	0.00%
Steller sea lion	Western/Asian stock, Western DPS	2.17	0.00%	0	0.00%	2	0.00%

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[40]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Antarctic minke whale	ANT	0.15	0.00%	0	0.00%	0	0.00%
Blue whale	CNP	3.73	2.85%	0	0.00%	4	2.85%
	NIND	0.59	0.00%	0	0.00%	1	0.00%
	WNP	8.44	0.00%	114	1.14%	123	1.14%
	SIND	0.81	0.07%	0	0.00%	1	0.07%
Bryde's whale	ECS	4.69	3.42%	15	10.71%	19	14.13%
	Hawaii	6.50	0.74%	0	0.00%	6	0.74%
	WNP	211.47	1.24%	226	1.02%	437	2.26%
	NIND	5.57	0.05%	5	0.05%	10	0.10%
	SIND	6.89	0.05%	2	0.02%	9	0.07%
Common minke whale	Hawaii	331.63	1.32%	351	1.43%	682	2.74%
	IND	1,122.10	0.39%	626	0.20%	1,748	0.59%
	WNP JW	4.55	0.17%	0	0.00%	5	0.17%
	WNP OE	1,191.15	4.85%	1,213	4.85%	2,404	9.71%
	YS	67.65	1.51%	183	4.06%	250	5.57%
Fin whale	ECS	2.59	0.51%	10	1.96%	12	2.47%
	Hawaii	4.17	2.74%	0	0.00%	4	2.74%
	IND	0.20	0.00%	0	0.00%	0	0.00%
	SIND	18.11	0.05%	12	0.02%	30	0.07%
	WNP	347.52	3.81%	3,107	33.42%	3,455	37.23%
Humpback whale	CNP stock and Hawaii DPS	220.25	2.19%	391	3.91%	611	6.10%

40 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; JW=Sea of Japan; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[40]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Humpback whale (Continued)	WAU stock and DPS	1.17	0.00%	0	0.00%	1	0.00%
	WNP stock and DPS	381.92	28.87%	3,884	292.62%	4,266	321.49%
North Pacific right whale	WNP	4.77	0.44%	117	12.71%	122	13.15%
Omura's whale	NIND	5.57	0.05%	5	0.05%	10	0.10%
	SIND	6.89	0.05%	0	0.00%	7	0.05%
	WNP	15.97	0.95%	0	0.00%	16	0.95%
Sei whale	Hawaii	11.29	2.85%	11	2.85%	22	5.70%
	SIND	0.22	0.00%	0	0.00%	0	0.00%
	NP	156.58	2.23%	4,204	60.13%	4,361	62.37%
	NIND	5.40	0.05%	0	0.00%	5	0.05%
Western North Pacific gray whale	WNP stock and Western DPS	0.59	0.44%	0	0.00%	1	0.44%
Baird's beaked whale	WNP	3,776.57	66.36%	0	0.00%	3,777	66.36%
Blainville's beaked whale	Hawaii	47.22	2.40%	0	0.00%	47	2.40%
	WNP	311.35	3.82%	0	0.00%	311	3.82%
	IND	65.19	0.37%	0	0.00%	65	0.37%
Common bottlenose dolphin	4-Islands	5.59	2.96%	0	0.00%	6	2.96%
	Hawaii Island	0.49	0.41%	0	0.00%	0	0.00%
	Hawaii Pelagic	113.55	0.49%	0	0.00%	114	0.49%
	IA	140.04	0.15%	0	0.00%	140	0.15%
	IND	1,551.29	0.20%	0	0.00%	1,551	0.20%
	Japanese Coastal	1,789.16	50.86%	0	0.00%	1,789	50.86%
	Kauai/Niihau	15.79	8.55%	0	0.00%	16	8.55%
	Oahu	45.55	6.17%	0	0.00%	46	6.17%
	WNP Northern Offshore	798.60	0.78%	0	0.00%	799	0.78%

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[40]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Common bottlenose dolphin (Continued)	WNP Southern Offshore	3,062.72	7.45%	0	0.00%	3,063	7.45%
	WAU	872.98	29.09%	0	0.00%	873	29.09%
Common dolphin	IND	71.94	0.00%	0	0.00%	72	0.00%
	WNP	275,078.61	16.08%	0	0.00%	275,079	16.08%
Cuvier's beaked whale	Hawaii	26.15	3.62%	0	0.00%	26	3.62%
	IND	317.46	1.17%	0	0.00%	317	1.17%
	SH	105.82	0.15%	0	0.00%	106	0.15%
	WNP	8,980.39	10.04%	0	0.00%	8,980	10.04%
Dall's porpoise	SOJ *dalli* type	844.73	0.49%	0	0.00%	845	0.49%
	WNP *dalli* ecotype	30,327.05	18.72%	0	0.00%	30,327	18.72%
	WNP *truei* ecotype	670.01	0.39%	0	0.00%	670	0.39%
Deraniyagala's beaked whale	IND	216.92	1.27%	0	0.00%	217	1.27%
	NP	222.15	0.91%	0	0.00%	222	0.91%
Dwarf sperm whale	Hawaii	782.10	4.44%	0	0.00%	782	4.44%
	IND	4.18	0.07%	0	0.00%	4	0.07%
	WNP	635.07	0.18%	0	0.00%	635	0.18%
False killer whale	Hawaii Pelagic	68.90	4.44%	0	0.00%	69	4.44%
	IA	341.17	3.51%	0	0.00%	341	3.51%
	IND	16.13	0.00%	0	0.00%	16	0.00%
	Main Hawaiian Islands Insular stock and DPS	0.82	0.49%	0	0.00%	1	0.49%
	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%
	WNP	1,596.09	9.63%	0	0.00%	1,596	9.63%

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock***[40]	***Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
Fraser's dolphin	CNP	685.97	4.06%	0	0.00%	686	4.06%
	Hawaii	2,320.48	4.52%	0	0.00%	2,320	4.52%
	IND	127.82	0.07%	0	0.00%	128	0.07%
	WNP	2,558.59	1.29%	0	0.00%	2,559	1.29%
Ginkgo-toothed beaked whale	IND	15.86	0.10%	0	0.00%	16	0.10%
	NP	328.95	1.40%	0	0.00%	329	1.40%
Harbor porpoise	WNP	503.16	1.61%	0	0.00%	503	1.61%
Hubbs' beaked whale	NP	36.03	0.15%	0	0.00%	36	0.15%
Indo-Pacific bottlenose dolphin	IND	15.55	0.20%	0	0.00%	16	0.20%
Killer whale	Hawaii	7.65	5.26%	0	0.00%	8	5.26%
	IND	545.67	4.33%	0	0.00%	546	4.33%
	WNP	14,387.33	117.31%	0	0.00%	14,387	117.31%
Kogia spp.	WNP	1,494.11	0.35%	0	0.00%	1,494	0.35%
Longman's beaked whale	Hawaii	882.41	11.59%	0	0.00%	882	11.59%
	IND	447.19	2.64%	0	0.00%	447	2.64%
	WNP	574.04	7.50%	0	0.00%	574	7.50%
Melon-headed whale	Hawaiian Islands	215.92	2.47%	0	0.00%	216	2.47%
	IND	552.27	0.88%	0	0.00%	552	0.88%
	Kohala Resident	11.02	0.49%	0	0.00%	11	0.49%
	WNP	1,823.43	3.27%	0	0.00%	1,823	3.27%
Mesoplodon spp.	WNP	14.28	0.07%	0	0.00%	14	0.07%
Northern right whale dolphin	NP	0.36	0.00%	0	0.00%	0	0.00%

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[40]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Pacific white-sided dolphin	NP	12,890.33	1.41%	0	0.00%	12,890	1.41%
Pantropical spotted dolphin	4-Islands	37.82	17.18%	0	0.00%	38	17.18%
	Hawaii Island	26.97	12.25%	0	0.00%	27	12.25%
	Hawaiian Pelagic	355.04	0.66%	0	0.00%	355	0.66%
	IND	427.97	0.07%	0	0.00%	428	0.07%
	Oahu	27.63	12.58%	0	0.00%	28	12.58%
	WNP	5,883.15	4.53%	0	0.00%	5,883	4.53%
Pygmy killer whale	Hawaii	469.49	4.44%	0	0.00%	469	4.44%
	IND	81.84	0.37%	0	0.00%	82	0.37%
	WNP	1,035.09	3.30%	0	0.00%	1,035	3.30%
Pygmy sperm whale	Hawaii	317.62	4.44%	0	0.00%	318	4.44%
	IND	0.39	0.00%	0	0.00%	0	0.00%
	WNP	264.88	0.09%	0	0.00%	265	0.09%
Risso's dolphin	Hawaii	494.40	4.28%	0	0.00%	494	4.28%
	IA	1,374.49	0.92%	0	0.00%	1,374	0.92%
	WNP	4,914.00	3.47%	0	0.00%	4,914	3.47%
	IND	6,353.75	1.39%	0	0.00%	6,354	1.39%
Rough-toothed dolphin	Hawaii	254.31	0.33%	0	0.00%	254	0.33%
	IND	56.98	0.00%	0	0.00%	57	0.00%
	WNP	1,731.81	34.56%	0	0.00%	1,732	34.56%
Short-finned pilot whale	Hawaii	472.53	2.38%	0	0.00%	473	2.38%
	IND	2,097.63	0.81%	0	0.00%	2,098	0.81%
	WNP Northern Ecotype	721.26	3.47%	0	0.00%	721	3.47%
	WNP Southern Ecotype	6,302.66	19.99%	0	0.00%	6,303	19.99%

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[40]*	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Southern bottlenose whale	IND	30.85	0.00%	0	0.00%	31	0.00%
Spade-toothed beaked whale	IND	21.73	0.12%	0	0.00%	22	0.12%
Sperm whale	Hawaii	126.38	2.80%	0	0.00%	126	2.80%
	NIND	45.81	0.20%	0	0.00%	46	0.20%
	NP	1,855.21	1.68%	0	0.00%	1,855	1.68%
	SIND	21.58	0.10%	0	0.00%	22	0.10%
Spinner dolphin	Hawaii Island	1.48	0.25%	0	0.00%	1	0.25%
	Hawaii Pelagic	228.58	6.82%	0	0.00%	229	6.82%
	IND	329.56	0.07%	0	0.00%	330	0.07%
	Kauai/Niihau	99.16	16.53%	0	0.00%	99	16.53%
	Kure/Midway Atoll	0.00	0.00%	0	0.00%	0	0.00%
	Oahu/4-Islands	23.52	6.66%	0	0.00%	24	6.66%
	Pearl and Hermes Reef	0.00	0.00%	0	0.00%	0	0.00%
	WNP	720.54	0.00%	0	0.00%	721	0.00%
Stejneger's beaked whale	WNP	276.32	3.42%	0	0.00%	276	3.42%
Striped dolphin	Hawaii	321.08	0.49%	0	0.00%	321	0.49%
	IND	6,956.77	1.03%	0	0.00%	6,957	1.03%
	Japanese Coastal	3,571.00	18.23%	0	0.00%	3,571	18.23%
	WNP Northern Offshore	367.06	0.10%	0	0.00%	367	0.10%
	WNP Southern Offshore	3,728.63	7.13%	0	0.00%	3,729	7.13%
Hawaiian monk seal	Hawaii	12.75	0.91%	0	0.00%	13	0.91%
Northern fur seal	Western Pacific	11,653.16	2.35%	0	0.00%	11,653	2.35%
Ribbon seal	NP	21,245.50	5.82%	350	0.10%	21,595	5.92%

Table B-16. Maximum Total Annual MMPA Level B Harassment by SURTASS LFA Sonar Under Alternative 2 Years 5 and Beyond (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[40]	*Maximum Annual MMPA Level B Harassment: Alternative 2 Years 5+*					
		Behavior (Individuals)	*Behavior (Percent Stock)*	*TTS (Individuals)*	*TTS (Percent Stock)*	*Total Level B (Individuals)*	*Total Level B (Percent Stock)*
Spotted seal	Alaska stock/Bering Sea DPS	108,959.11	23.66%	2,034	0.44%	110,993	24.10%
	Southern stock and DPS	0.59	0.05%	0	0.00%	1	0.05%
Steller sea lion	Western/Asian stock, Western DPS	2.98	0.00%	0	0.00%	3	0.00%

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[41]	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
Antarctic minke whale	ANT	0	0.00%	0	0.00%	0
Blue whale	CNP	3	2.39%	4	2.85%	24
	NIND	0	0.00%	1	0.00%	3
	WNP	90	0.90%	123	1.14%	726
	SIND	1	0.07%	1	0.07%	7
Bryde's whale	ECS	14	10.28%	19	14.13%	116
	Hawaii	5	0.62%	6	0.74%	38
	WNP	378	1.94%	437	2.26%	2,823
	NIND	8	0.07%	10	0.10%	65
	SIND	7	0.05%	9	0.07%	55
Common minke whale	Hawaii	572	2.30%	682	2.74%	4,337
	IND	1,271	0.43%	1,748	0.59%	10,328
	WNP JW	3	0.12%	5	0.17%	27
	WNP OE	2,127	8.59%	2,404	9.71%	15,720
	YS	189	4.20%	250	5.57%	1,509
Fin whale	ECS	9	1.80%	12	2.47%	75
	Hawaii	3	2.30%	4	2.74%	24
	IND	0	0.00%	0	0.00%	0
	SIND	22	0.05%	30	0.07%	178
	WNP	2,558	27.55%	3,455	37.23%	20,597
Humpback whale	CNP stock and Hawaii DPS	487	4.85%	611	6.10%	3,781

41 ANT=Antarctic; CNP=Central North Pacific; NP=North Pacific; NIND=Northern Indian; SIND=Southern Indian; IND=Indian; WNP=Western North Pacific; ECS=East China Sea; WP=Western Pacific; SOJ=Sea of Japan; IA=Inshore Archipelago; WAU=Western Australia; YS=Yellow Sea; OE=Offshore Japan; OW=Nearshore Japan; JW=Sea of Japan/Minke; JE=Pacific coast of Japan; SH=Southern Hemisphere; DPS=distinct population segment

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[41]*	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
Humpback whale (Continued)	WAU stock and DPS	1	0.00%	1	0.00%	7
	WNP stock and DPS	3,103	233.84%	4,266	321.49%	25,210
North Pacific right whale	WNP	89	9.57%	122	13.15%	722
Omura's whale	NIND	8	0.07%	10	0.10%	65
	SIND	5	0.04%	7	0.05%	41
	WNP	14	0.81%	16	0.95%	104
Sei whale	Hawaii	19	4.78%	22	5.70%	138
	SIND	0	0.00%	0	0.00%	0
	NP	3,172	45.37%	4,361	62.37%	25,771
	NIND	4	0.04%	5	0.05%	31
Western North Pacific gray whale	WNP stock and Western DPS	0	0.00%	1	0.44%	3
Baird's beaked whale	WNP	2,747	48.26%	3,777	66.36%	22,319
Blainville's beaked whale	Hawaii	35	1.83%	47	2.40%	281
	WNP	269	3.30%	311	3.82%	2,009
	IND	47	0.27%	65	0.37%	383
Common bottlenose dolphin	4-Islands	5	2.48%	6	2.96%	38
	Hawaii Island	0	0.00%	0	0.00%	0
	Hawaii Pelagic	95	0.41%	114	0.49%	722
	IA	104	0.11%	140	0.15%	836
	IND	1,128	0.14%	1,551	0.20%	9,165
	Japanese Coastal	1,686	47.94%	1,789	50.86%	12,111
	Kauai/Niihau	13	7.16%	16	8.55%	100

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[41]	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
Common bottlenose dolphin (Continued)	Oahu	38	5.17%	46	6.17%	290
	WNP Northern Offshore	581	0.57%	799	0.78%	4,721
	WNP Southern Offshore	2,726	6.63%	3,063	7.45%	20,093
	WAU	635	21.16%	873	29.09%	5,159
Common dolphin	IND	52	0.00%	72	0.00%	424
	WNP	203,871	12.24%	275,079	16.08%	1,640,721
Cuvier's beaked whale	Hawaii	22	3.03%	26	3.62%	166
	IND	231	0.85%	317	1.17%	1,875
	SH	77	0.11%	106	0.15%	626
	WNP	6,946	7.78%	8,980	10.04%	54,724
Dall's porpoise	SOJ *dalli* type	614	0.36%	845	0.49%	4,991
	WNP *dalli* ecotype	22,056	13.62%	30,327	18.72%	179,205
	WNP *truei* ecotype	487	0.28%	670	0.39%	3,958
Deraniyagala's beaked whale	IND	158	0.92%	217	1.27%	1,283
	NP	190	0.77%	222	0.91%	1,426
Dwarf sperm whale	Hawaii	655	3.72%	782	4.44%	4,966
	IND	3	0.05%	4	0.07%	24
	WNP	486	0.14%	635	0.18%	3,849
False killer whale	Hawaii Pelagic	58	3.72%	69	4.44%	439
	IA	252	2.59%	341	3.51%	2,031
	IND	12	0.01%	16	0.00%	96

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[41]	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
False killer whale (Continued)	Main Hawaiian Islands Insular stock and DPS	1	0.41%	1	0.49%	7
	Northwestern Hawaiian Islands	0	0.00%	0	0.00%	0
	WNP	1,350	8.15%	1,596	9.63%	10,188
Fraser's dolphin	CNP	546	3.24%	686	4.06%	4,242
	Hawaii	1,944	3.79%	2,320	4.52%	14,736
	IND	93	0.05%	128	0.07%	756
	WNP	2,287	1.16%	2,559	1.29%	16,825
Ginkgo-toothed beaked whale	IND	12	0.07%	16	0.10%	96
	NP	283	1.21%	329	1.40%	2,119
Harbor porpoise	WNP	366	1.17%	503	1.61%	2,973
Hubbs' beaked whale	NP	26	0.11%	36	0.15%	212
Indo-Pacific bottlenose dolphin	IND	11	0.14%	16	0.20%	92
Killer whale	Hawaii	6	4.41%	8	5.26%	48
	IND	397	3.15%	546	4.33%	3,226
	WNP	10,470	85.37%	14,387	117.31%	85,041
Kogia spp.	WNP	1,317	0.31%	1,494	0.35%	9,750
Longman's beaked whale	Hawaii	739	5.01%	882	11.59%	5,602
	IND	325	1.92%	447	2.64%	2,641
	WNP	471	6.14%	574	7.50%	3,606
Melon-headed whale	Hawaiian Islands	181	2.07%	216	2.47%	1,372

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[41]*	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
Melon-headed whale (Continued)	IND	402	0.64%	552	0.88%	3,264
	Kohala Resident	9	0.41%	11	0.49%	69
	WNP	1,605	2.87%	1,823	3.27%	11,889
Mesoplodon spp.	WNP	10	0.05%	14	0.07%	82
Northern right whale dolphin	NP	0	0.00%	0	0.00%	0
Pacific white-sided dolphin	NP	9,530	1.05%	12,890	1.41%	76,790
Pantropical spotted dolphin	4-Islands	32	14.40%	38	17.18%	242
	Hawaii Island	23	10.26%	27	12.25%	173
	Hawaiian Pelagic	297	0.55%	355	0.66%	2,253
	IND	311	0.05%	428	0.07%	2,528
	Oahu	23	10.54%	28	12.58%	176
	WNP	5,105	3.95%	5,883	4.53%	38,069
Pygmy killer whale	Hawaii	393	3.72%	469	4.44%	2,979
	IND	60	0.27%	82	0.37%	486
	WNP	901	2.87%	1,035	3.30%	6,709
Pygmy sperm whale	Hawaii	266	3.72%	318	4.44%	2,018
	IND	0	0.00%	0	0.00%	0
	WNP	203	0.07%	265	0.09%	1,607
Risso's dolphin	Hawaii	414	3.58%	494	4.28%	3,138
	IA	1,045	0.70%	1,374	0.92%	8,302
	WNP	4,347	3.07%	4,914	3.47%	32,130
	IND	4,621	1.01%	6,354	1.39%	37,546
Rough-toothed dolphin	Hawaii	213	0.28%	254	0.33%	1,614

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[41]	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
Rough-toothed dolphin (Continued)	IND	41	0.00%	57	0.00%	335
	WNP	1,439	28.74%	1,732	34.56%	10,952
Short-finned pilot whale	Hawaii	396	2.00%	473	2.38%	3,003
	IND	1,526	0.59%	2,098	0.81%	12,398
	WNP Northern Ecotype	525	2.52%	721	3.47%	4,263
	WNP Southern Ecotype	5,683	18.03%	6,303	19.99%	41,641
Southern bottlenose whale	IND	22	0.00%	31	0.00%	181
Spade-toothed beaked whale	IND	16	0.09%	22	0.12%	130
Sperm whale	Hawaii	106	2.34%	126	2.80%	802
	NIND	33	0.14%	46	0.20%	270
	NP	1,429	1.28%	1,855	1.68%	11,281
	SIND	16	0.07%	22	0.10%	130
Spinner dolphin	Hawaii Island	1	0.21%	1	0.25%	7
	Hawaii Pelagic	192	5.72%	229	6.82%	1,455
	IND	240	0.05%	330	0.07%	1,950
	Kauai/Niihau	83	13.85%	99	16.53%	629
	Kure/Midway Atoll	0	0.00%	0	0.00%	0
	Oahu/4-Islands	20	2.88%	24	6.66%	152
	Pearl and Hermes Reef	0	0.00%	0	0.00%	0
	WNP	574	0.00%	721	0.00%	4,459
Stejneger's beaked whale	WNP	201	2.49%	276	3.42%	1,632

Table B-17. Maximum MMPA Level B Harassment by SURTASS LFA Sonar for Alternative 2 Years 1 to 4 and Years 5 to 7 (Annual Totals) and Total Overall for 7-Year Period (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[41]	*Maximum Annual Level B Harassment, Years 1-4*		*Maximum Annual Level B Harassment, Years 5-7*		*Total Overall Level B Harassment for 7-year Period (Individuals)*
		Individuals	*Percent Stock*	*Individuals*	*Percent Stock*	
Striped dolphin	Hawaii	269	0.41%	321	0.49%	2,039
	IND	5,059	0.75%	6,957	1.03%	41,107
	Japanese Coastal	3,366	17.18%	3,571	18.23%	24,177
	WNP Northern Offshore	267	0.07%	367	0.10%	2,169
	WNP Southern Offshore	3,282	6.28%	3,729	7.13%	24,315
Hawaiian monk seal	Hawaii	10	0.69%	13	0.91%	79
Northern fur seal	Western Pacific	8,475	1.71%	11,653	2.35%	68,859
Ribbon seal	NP	15,705	4.30%	21,595	5.92%	127,605
Spotted seal	Alaska stock/Bering Sea DPS	80,722	17.53%	110,993	24.10%	655,867
	Southern stock and DPS	0	0.00%	1	0.05%	3
Steller sea lion	Western/Asian stock, Western DPS	2	0.00%	3	0.00%	17

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APPENDIX C: MARINE MAMMAL OFFSHORE BIOLOGICALLY IMPORTANT AREAS

APPENDIX C: MARINE MAMMAL OFFSHORE BIOLOGICALLY IMPORTANT AREAS

This appendix builds off Chapter 5 to include more detailed information about the Navy and NMFS' comprehensive assessment of marine areas as potential marine mammal OBIAs for SURTASS LFA sonar. In particular, detailed herein is the listing of marine areas that the Navy and NMFS assessed spatially to determine whether they met the OBIA geographic criteria of being located outside the coastal standoff range (>12 nmi [22 km]) and within the study area for SURTASS LFA sonar. Secondly, to be further considered as an OBIA, the marine area must have relevance to marine mammals. These first appendix sections describe and illustrate the initial steps of the Navy and NMFS' assessment of each potential marine area against the geographic OBIA criteria and basic taxa relevance. Areas not located in the SURTASS LFA study area of the eastern Indian Ocean or western and central North Pacific Ocean or that were important to any other taxa than marine mammal species under NMFS jurisdiction or designated to protect any other type of marine resources were not further considered. Navy and NMFS are currently evaluating the data in support of potential OBIAs and final determinations on new OBIAs will be included in the FSEIS/FOSEIS.

Navy and NMFS's comprehensive assessment of marine areas as potential OBIA candidates included a thorough review of the Important Marine Mammal Areas (IMMAs), Ecologically or Biologically Significant Marine Areas (EBSAs), and IUCN Green List of Protected and Conserved Areas that are located within the study area for SURTASS LFA sonar (Appendix Table C-1). Additionally, OBIA Watchlist areas that are located within the study area were also reexamined.

C1. Reassessment of OBIA Watchlist Marine Areas

The Navy and NMFS began the marine area assessment by first evaluating those areas on the OBIA Watchlist that occurred within the study area. As noted in Chapter 5, the majority of the marine areas on the OBIA Watchlist are not located in the current study area for SURTASS LFA sonar in the eastern Indian Ocean or central or western North Pacific Ocean. The OBIA Watchlist areas located within the study area that were re-considered for this SEIS/SOEIS include the British Indian Ocean Territory-Chagos Islands Marine Protected Area (MPA), the Pacific Remote Islands Marine National Monument (MNM), Marianas Trench MNM, and the Papahānaumokuākea MNM.

The Navy and NMFS assessed the portions of this MPA and Marine NMs that were located outside the coastal standoff range but within the study area for SURTASS LFA sonar . Not all units of the Pacific Remote Islands Marine NM are located within the study area for SURTASS LFA sonar—only the Wake and Johnson atoll units are located wholly within the study area and only the very small northern part of the Kingman Reef/Palmyra Atoll unit is located in the study area (Appendix Figure C-1). The Marianas Trench Marine NM is divided into three units, with only one of those units, the Islands Unit, including waters and submerged lands while the Volcanic Unit/Arc of Fire and Trench Units only include submerged lands (USFWS, 2016). The Islands Unit includes three of the northernmost Mariana Islands: Farallon de Pajaros (also known as Uracus), Maug, and Asuncion with their geographic boundary extending from shore seaward to 50 nmi (93 km) (Appendix Figure C-2). A large part of the Papahānaumokuākea MNM is located beyond the coastal standoff range within the study area for SURTASS LFA sonar (Appendix Figure C-3).

The waters and islands of the Northwestern Hawaiian Islands that are contained in the Papahānaumokuākea MNM include the principal distributional range of the critically endangered Hawaiian monk seal as well as its ESA designated critical habitat. Thus, a great deal of data and information about the importance of this marine area are available for further assessment. The waters

Table C-1. Number and Types of Marine Areas Assessed as Potential Offshore Biologically Important Areas (OBIAs) and Their Location Relative to the Study Area and Coastal Standoff Range (12 nmi) for SURTASS LFA Sonar.

Marine Area Region	*Number of Marine Areas Relevant to Marine Mammals*	*Number of Marine Areas Located Within Study Area for SURTASS LFA Sonar*	*Number of Marine Areas Located Outside the Coastal Standoff Range*	*Number of Marine Areas Further Assessed*
OBIA Watchlist Areas				
Northwest Pacific Ocean	3	3	3	3
Central Indian Ocean	1	1	1	0
ESA Critical Habitat				
Central North Pacific Ocean	2	2	2	2
EBSAs				
Northeast Indian Ocean	5	5	4	4
South and Western Indian Ocean	14	1	0	0
East Asian Seas	11	9	6	7
North Pacific Ocean	15	4	4	4
Western South Pacific Ocean	0	9	0	0
Total	45	28	14	15
Important Marine Mammal Areas (IMMAs)				
Western and Central North Pacific Ocean	6	3	3	3
Green List of Protected and Conserved Areas				
Asian Pacific	0	0	0	0

of the Marianas Island MNM's Island Unit are not as well surveyed for marine mammals, but Carberra et al. (2017) note that up to 29 species of marine mammals may be present in the waters of the Island Unit. Marine mammals are known to occur in the units of the Pacific Remote Islands MNM that lie within the study area for SURTASS LFA sonar, although few survey data appear to be available. Regardless, the units of the three MNM in the western North Pacific Ocean waters of the study area are carried forward for critical assessment of the biological and hearing criteria.

The British Indian Ocean Territory (BIOT)-Chagos Islands MPA is large, encompassing an area of 158,605 nmi^2 (544,000 km^2) in the central Indian Ocean, the majority of which lies outside the coastal standoff range for SURTASS LFA sonar. However, little information is available on marine mammals that use these remote waters or of what important biological activities of marine mammals may be conducted in these waters. Available literature and information was researched and reviewed, but the Navy and NMFS' conclusion on this area remains the same, that insufficient data are available to demonstrate that the waters of this MPA are important biologically to marine mammals. Accordingly, the Navy and NMFS are retaining the BIOT-Chagos Islands MPA on the OBIA Watchlist.

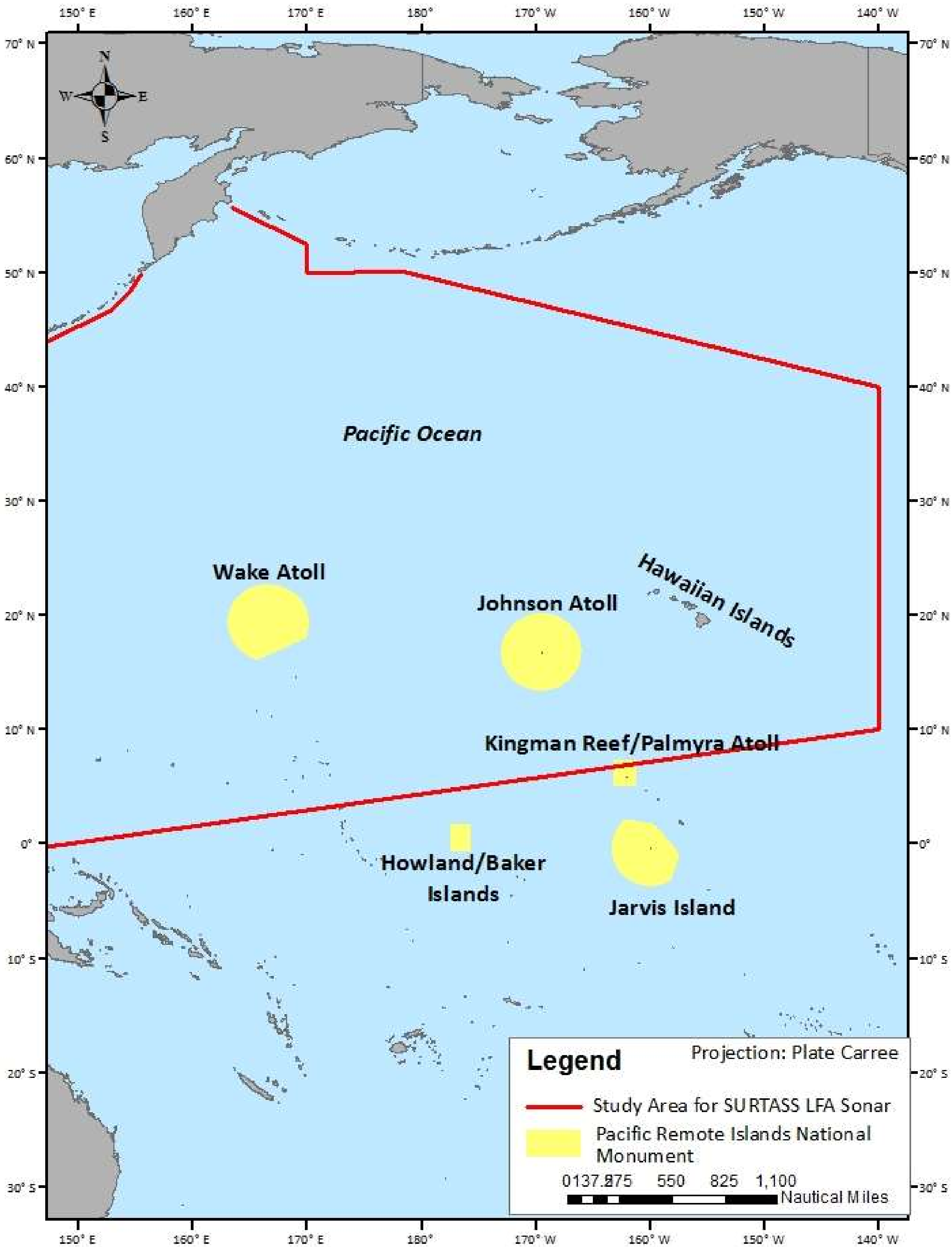

Figure C-3. Units of the Pacific Remote Islands Marine National Monument in Relation to the Study Area for SURTASS LFA Sonar.

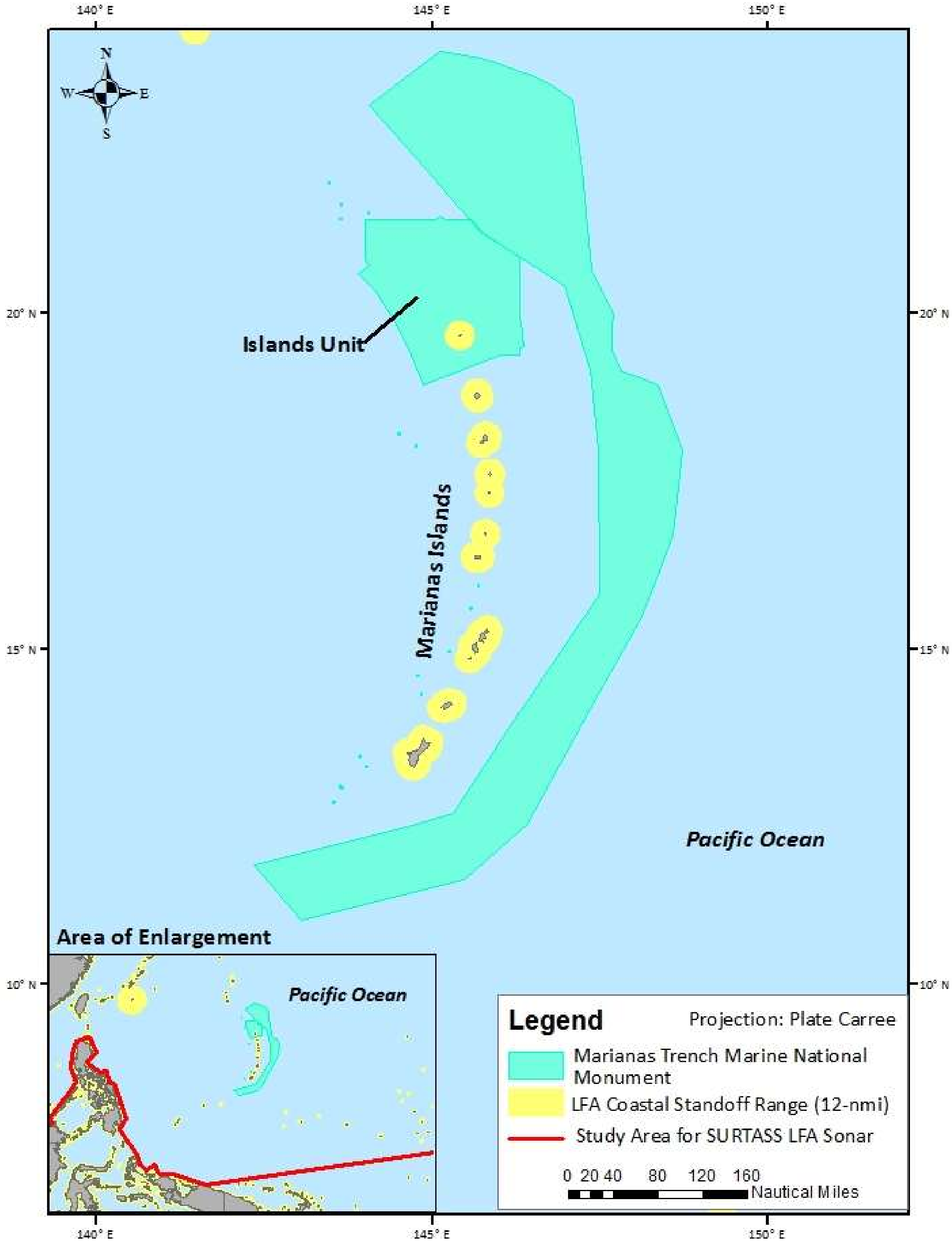

Figure C-4. Location of the Islands Unit of the Marianas Trench Marine National Monument in the Study Area for SURTASS LFA Sonar.

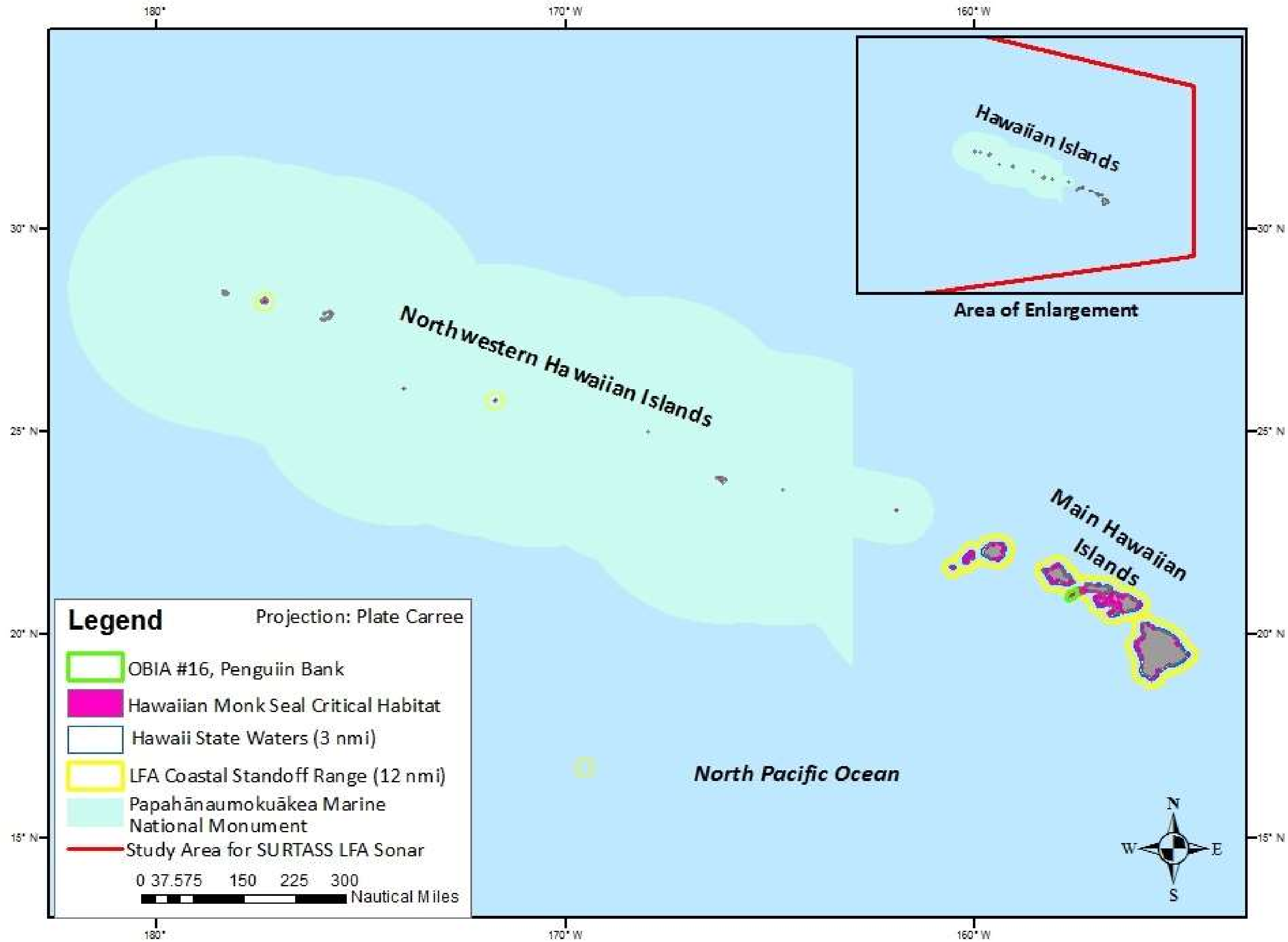

Figure C-3. Location of Papahānaumokuākea Marine National Monument and Hawaiian Monk Seal Critical Habitat (NMFS, 2015) in the Study Area for SURTASS LFA Sonar.

C2. ESA Critical Habitat Areas

Critical habitat has been designated for two species of marine mammals in the Hawaiian waters of the study area for SURTASS LFA sonar: the Hawaiian monk seal (NOAA, 2015; Figure C-3) and the Main Hawaiian Islands Insular DPS of false killer whales (NOAA, 2018; Figure C-4). Since critical habitat is one of the biologial criteria for consideration of a marine area as a marine mammal OBIA for SURTASS LFA sonar, the critical habitat areas outside the coastal standoff range for these two species in Hawaiian waters would be considered as OBIAs.

C3. Important Marine Mammal Areas (IMMAs)

IMMAs are marine areas identified and defined by the Marine Mammal Protected Area Task Force (MMPATF), which is a joint effort of the IUCN World Commission of Protected Areas (WCPA) and Species Survival Commission (SSC) and the International Committee on Marine Mammal Protected Areas (ICMMPA). IMMAs are defined as discrete portions of habitat that are important to one or more marine mammal species; represent priority sites for marine mammal conservation worldwide without management implications; and merit protection and monitoring (IUCN WCPA-SSC Joint Task Force on Biodiversity and Protected Areas and IUCN WCPA-SSC Joint Task Force on Marine Mammal Protected Areas [IUCN-WCPA-SSC JTFBP and IUCN-WCPA-SSC JTFMMPA, 2018). The IMMA selection criteria are designed to capture aspects of the biology, ecology, and population structure of marine mammals. The IMMA criteria are not hierarchical but prospective IMMAs are assessed sequentially in the given criteria order. As such, candidate IMMAs must only satisfy one of the criteria and/or sub-criteria to successfully qualify for IMMA status. IMMAs are selected according to the following criteria (IUCN-WCPA-SSC JTFMMPA, 2018):

- Criterion A—Species or Population Vulnerability
- Criterion B—Distribution and Abundance
- Criterion C—Key Life Activities
- Criterion D—Special Attributes.

To date, IMMAs have been identified in the western and central Pacific Ocean and Mediterranean Sea (MMPATF, 2018). The IMMAs in the western and central North Pacific Ocean are divided into three categories: IMMAs, candidate IMMAs, and areas of interest (AOIs). Only areas designated as IMMAs have met the IMMA selection criteria. The IMMAs in the central Pacific Ocean that are located within the study area for SURTASS LFA sonar were assessed for their potential as OBIAs.

Three IMMAs are located within the study area, but only two of the IMMAs have some part of their area located outside the coastal standoff range for SURTASS LFA sonar (Appendix Figure C-5). These two IMMAs carried forward to further analysis of the OBIA hearing and biological criteria are: Northwestern Hawaiian Islands IMMA and the Main Hawaiian Archipelago IMMA.

C4. Greenlist of Protected and Conserved Areas

Greenlist of Protected and Conserved Areas have been designated in four global geographic regions, but only the Asia Pacific region is located in or near the study area of SURTSS LFA sonar Although 11 IUCN Greenlist of Protected and Conserved Areas are located in the Asia Pacific region, none are located within the study area for SURTASS LFA sonar. The majority of these areas are terrestrial parks, reserves, or conservation areas, and only one is located in the marine environment, but Montague Island Nature Reserve is located entirely on the island with no adjacent waters conserved. The 11 Green List Protected and Conserved Areas in the Asia Pacific Region are:

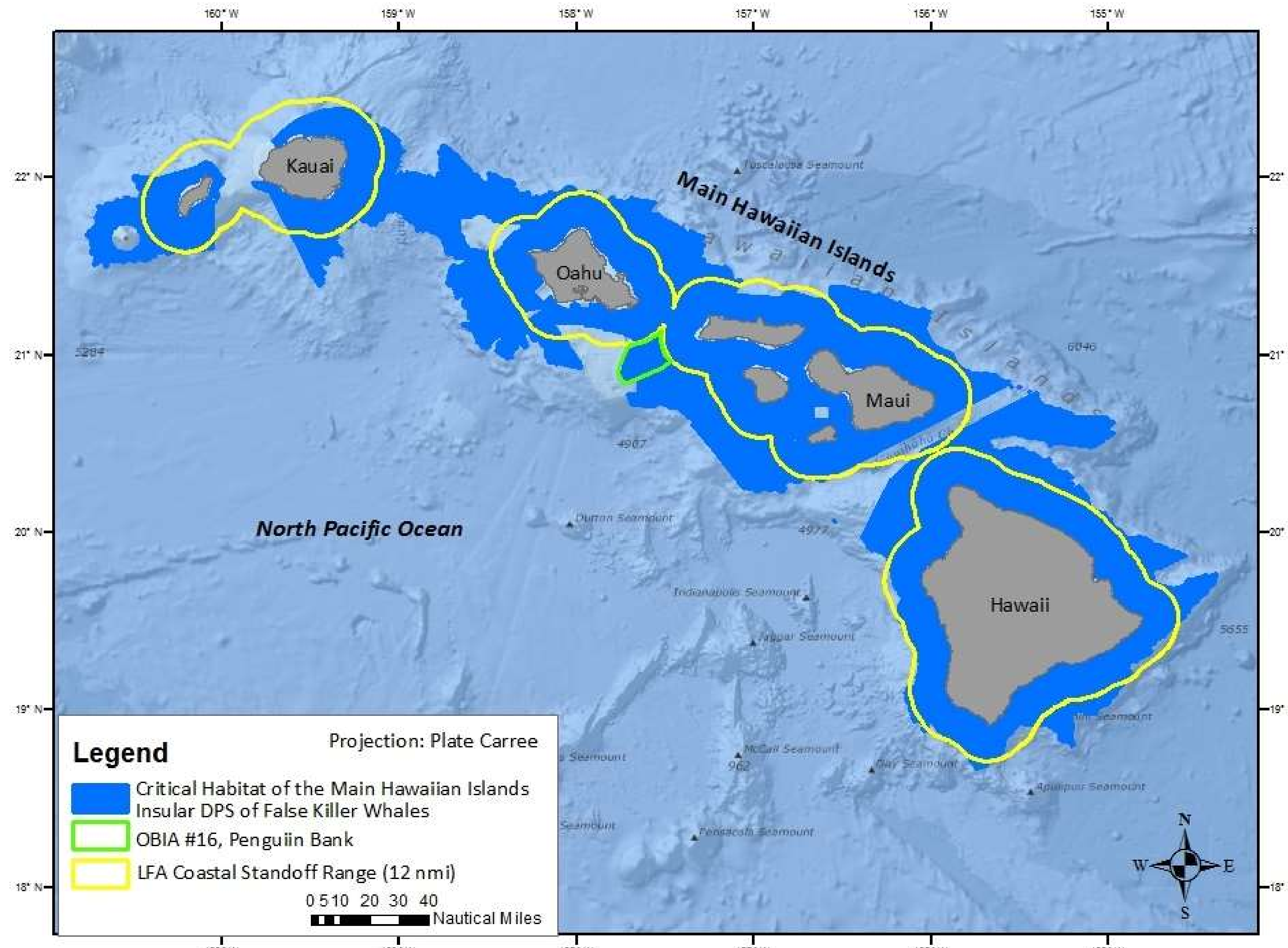

Figure C-4. Location of Critical Habitat for the Main Hawaiian Islands Insular DPS of False Killer Whale (NMFS, 2018) in the Study Area for SURTASS LFA Sonar.

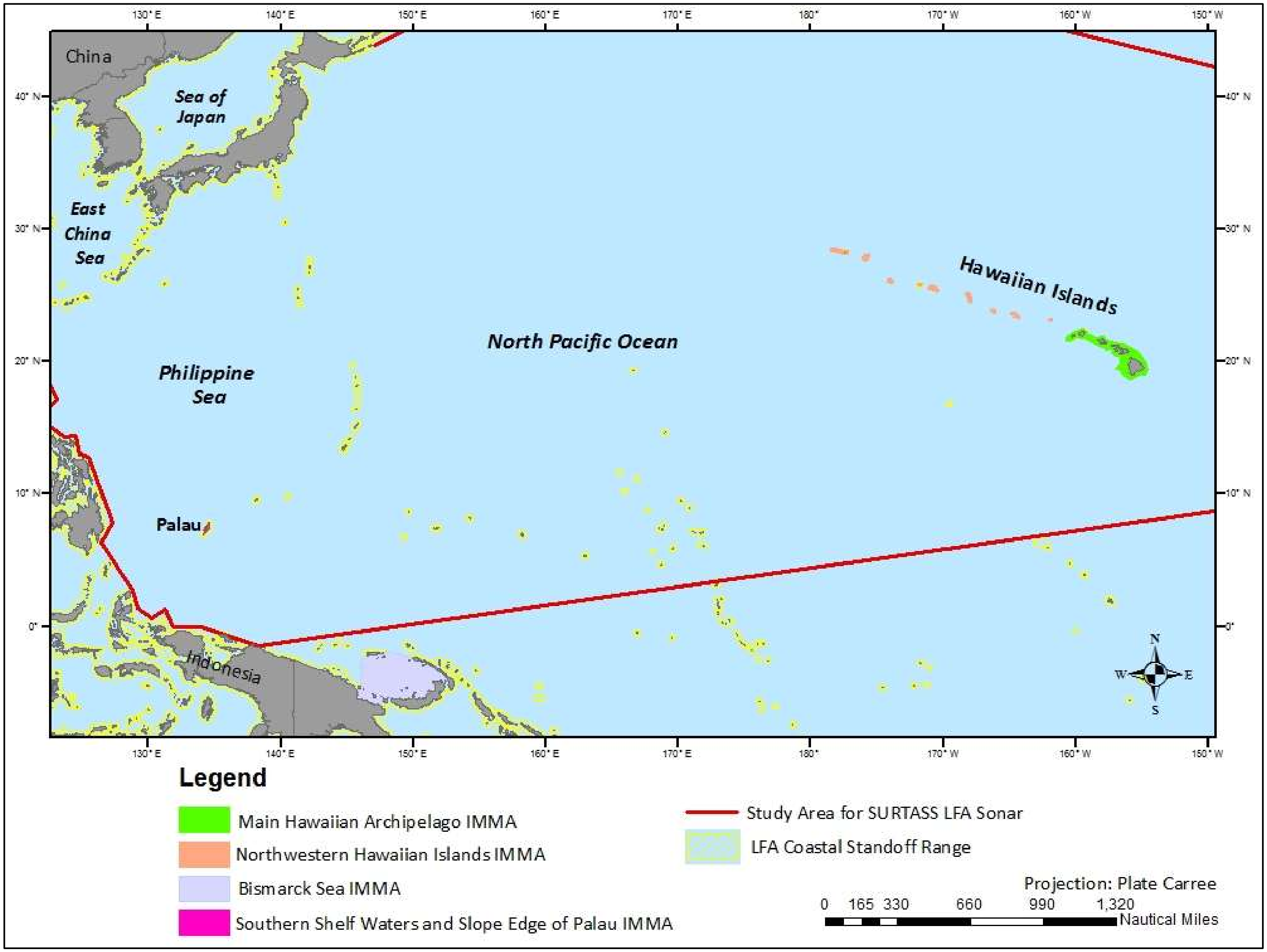

Figure C-5. Locations of the Important Marine Mammal Areas (IMMAs) in the Study Area for SURTASS LFA Sonar (IUCN-MMPATF, 2017).

- Korea Jirisan National Park
- Korea Odaesan National Park
- Korea Seoraksan National Park
- Australia Montague Island Nature Reserve
- Australia Arakwal National Park and Cape Byron State Conservation Area
- China Longwanqun National Forest Park
- China Sichuan Tangjiahe National Nature Reserve
- China Eastern Dongting Lake National Nature Reserve
- China Mount Huangshan Scenic Area
- China Wudalianchi Geological Park
- China Shaanxi Changqing National Nature Reserve.

None of the IUCN Green List Areas has relevance to marine mammals or lies within the study area for SURTASS LFA sonar. Accordingly, no IUCN Green List areas are carried forward for further consideration as OBIAs.

C5. Ecologically or Biologically Significant Areas (EBSAs)

EBSAs are an effort of the Convention on Biological Diversity (CBD), which was initiated by the United Nations Environment Programme (UNEP). The CBD is an international legal instrument for the conservation and sustainable use of biological diversity. EBSAs are special marine areas that serve important purposes that ultimately support the healthy functioning of oceans and thus should have increased protection and sustainable management. To support effective policy action by countries and competent international and regional organizations, it is critical to build a sound understanding of the most ecologically and biologically important ocean areas that support healthy marine ecosystems.

EBSAs from five geographic regions in the Indian and North Pacific oceans in which all or part of the study area for SURTASS LFA sonar is located were assessed as potential OBIAs. The five pertinent geographic regions were: North-East Indian Ocean, Southern Indian Ocean, East Asian Seas, North Pacific Ocean, and Western South Pacific Ocean. All 130 EBSAs in these regions were assessed to determine if any marine mammals under NMFS's jurisdiction were associated with the waters of the EBSAs. Of the 130 EBSAs, only 45 had relevance to marine mammals under NMFS's jurisdiction (Appendix Table C-2). The EBSAs in the five regions were also spatially assessed to determine which occurred within the study area and outside the coastal standoff range for SURTASS LFA sonar, at least in part. Twenty-one EBSAs were located within the study area for SURTASS LFA sonar (Appendix Table C-2; Figures C-6 and C-7), of which 14 EBSAs met the preliminary relevance and geographic criteria for OBIAs and have been carried forward for further review (Table 5-2). In addition, the Ogasawara Islands EBSA is also being carried forward for additional review, even though it is located entirely within the coastal standoff range for SURTASS LFA sonar. Since the Ogasawara area is such an important reproductive area for the endangered WNP DPS and stock of humpback whales, the waters beyond the coastal standoff range of the Ogasawara Islands would be assessed to determine if an areal extent can be defined in which the important reproductive behavior of humpback whales occurs and if data are sufficient to supports the determination.

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
Northeast Indian Ocean						
Olive Ridley Sea Turtle Migratory Corridor in the Bay of Bengal	N	NA	NA	Y	Y	N
Upwelling Zone of the Sumatra-Java Coast	N	NA	NA	Y	Y	N
Baa Atoll	N	NA	NA	Y	Y	N
Rasdhoo Atoll Reef	N	NA	NA	Y	Y	N
Trincomalee Canyon and Associated Ecosystems	Y	Sperm and blue (pygmy) whales	Foraging	Y	Part	Y
Coastal and Offshore Gulf of Mannar	Y	Dugong	Foraging	Y	Part	N
Southern Coastal/Offshore Waters between Galle and Yala National Park	Y	Blue whale	Foraging, small distinct population	Y	Part	Y; expansion of OBIA #26
Trang, Home of the Dugongs	Y	Dugong	Foraging	Y	N	N
Lower Western Coastal Sea	Y	Dugong	Foraging	Y	Part	N
Shelf Break Front	N	NA	NA	Y	Y	N
Southern and Western Indian Ocean						
Sri Lankan Side of Gulf of Mannar	Y	Dugong	Foraging	Y	N	N
Due South of Great Australian Bight	N	NA	NA	N	NA	N
South of Java Island	N	NA	NA	Y	Y	N
East Broken Ridge Guyot	N	NA	NA	Y	Y	N
Fool's Flat	N	NA	NA	Y	Y	N
Agulhas Front	Y	Southern right whale and pinnipeds	Foraging	N	NA	N
Rusky	N	NA	NA	N	NA	N
Central Indian Ocean Basin	N	NA	NA	Y	Y	N
Saya de Malha Bank	Y	Pygmy blue and sperm whales	Foraging	N	NA	N
Blue Bay Marine Park	N	NA	NA	N	NA	N
Atlantis Seamount	N	NA	NA	N	NA	N

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
Mahe, Alphonse and Amirantes Plateau	N	NA	NA	N	NA	N
Tromelin Island	N	NA	NA	N	NA	N
Southern Madagascar (part of the Mozambique Channel)	Y	Blue, Bryde's, southern right, sperm, and humpback whale	Foraging	N	NA	N (OBIA #14 encompasses area)
Prince Edward Islands, Del Cano Rise and Crozet Islands	N	NA	NA	N	NA	N
Moheli Marine Park	Y	Humpback whale	Breeding	N	NA	N
Northern Mozambique Channel	Y	Dugong	NK	N	NA	N
Coral Seamount and Fracture Zone Feature	N	NA	NA	N	NA	N
Walters Shoals	Y	Pygmy blue whale	Possible foraging	N	NA	N
Lamu-Kiunga Area	N	NA	NA	N	NA	N
The Iles Éparses (part of the Mozambique Channel)	N	NA	NA	N	NA	N
Mozambique Channel	Y	Humpback whale	Calving	N	NA	N
Pemba Bay - Mtwara (part of the Mozambique Channel)	Y	Dugong	?	N	NA	N
Watamu Area	Y	Humpback whale	Migration	N	NA	N
Rufiji – Mafia- Kilwa	N	NA	NA	N	NA	N
Baixo Pinda – Pebane (Primeiras and Segundas Islands)	N	NA	NA	N	NA	N
Zanzibar (Unguja) – Saadani	Y	Dugong, dolphins	Foraging?	N	NA	N
Pemba-Shimoni-Kisite	N	NA	NA	N	NA	N
Tanga Coelacanth Marine Park	N	NA	NA	N	NA	N
Quelimane to Zuni River (Zambezi River Delta)	N	NA	NA	N	NA	N
Morrumbene to Zavora Bay (Southern Mozambique)	N	NA	NA	N	NA	N

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
Save River to San Sebastian (Central Mozambique)	Y	Dugongs	Foraging	N	NA	N
Delagoa Shelf Edge, Canyons and Slope	Y	Humpback whale	Migration	N	NA	N
Incomati River to Ponta do Ouro (Southern Mozambique)	Y	Dugong	Foraging	N	NA	N
Natal Bight	N	NA	NA	N	NA	N
Protea Banks and Sardine Route	N	NA	NA	N	NA	N
Offshore of Port Elizabeth	N	NA	NA	N	NA	N
Agulhas Slope and Seamounts	N	NA	NA	N	NA	N
Agulhas Bank Nursery Area	N	NA	NA	N	NA	N
East Asia Seas						
Hydrothermal Vent Community on the Slope of the South West Islands	N	NA	NA	Y	Y	N
Bluefin Spawning Area	Y	Humpback whale	Breeding/ Calving	Y	Part	Y
Sulu-Sulawesi Marine Ecoregion	N	NA	NA	N	NA	N
Redang Island Archipelago and Adjacent Area	N	NA	NA	Y	N	N
Hainan Dongzhaigang Mangrove National Natural Reserve	N	NA	NA	Y	N	N
Northeastern Honshu	N	NA	NA	Y	N	N
Kuroshio Current South of Honshu	Y	Finless porpoise	Breeding	Y	Part	N
Kyushu Palau Ridge	Y	Sperm whale	NR	Y	Y	Y
Convection Zone East of Honshu	Y	Baleen whales	Foraging	Y	Y	Y
Sagami Trough and Island and Seamount Chain of Izu-Ogasawara	N	NA	NA	Y	Y	N
Nankai Trough	N	NA	NA	Y	Part	N

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
West Kuril Trench, Japan Trench, Izu-Ogasawara Trench and North of Mariana Trench	N	NA	NA	Y	Y	N
Ryukyu Trench area	N	NA	NA	Y	Y	N
Northern Coast of Hyogo, Kyoto, Fukui, Ishikawa and Toyama Prefectures	N	NA	NA	Y	N	N
Ogasawara Islands	Y	Humpback whale	Breeding	Y	N	Y
South Kyushu including Yakushima and Tanegashima Islands	N	NA	NA	Y	N	N
Southern Coastal Areas of Shikoku and Honshu Islands	N	NA	NA	Y	N	N
Inland Sea Areas of Western Kyushu	N	NA	NA	Y	N	N
Southwest Islands	N	NA	NA	Y	N	N
Eastern Hokkaido	N	NA	NA	Y	N	N
Benham Rise	N	NA	NA	Y	Y	N
Atauro Island	Y	Dugong	Migration	N	NA	N
Raja Ampat and Northern Bird's Head	Y	Bryde's, false killer, killer, and sperm whales; dolphins (Indo Pacific humpback, pantropical spotted, Fraser's); dugong	Migration, small distinct population,	Part	Part	Y
Lampi Marine National Park	Y	Dugong	Foraging	Y	N	N

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
Koh Rong Marine National Park	Y	False killer and short-finned pilot whales, dolphins (common, pantropical spotted, Irrawaddy, finless, and dwarf spinner), and dugong	?	Y	N	N
Tioman Marine Park	N	NA	NA	Y	N	N
Halong Bay-Catba Limestone Island Cluster	N	NA	NA	Y	N	N
Upper Gulf of Thailand	Y	Bryde’s whale, dolphins (finless, Irrawaddy, Indo-Pacific humpback, Indo-Pacific bottlenose)	Foraging, Breeding, Calving for Bryde’s whale	Y	Part	Y
Nino Konis Santana National Park	Y	Dolphins and whales	?	N	NA	N
Southern Straits of Malacca	N	NA	NA	Y	N	N
Intertidal Areas of East Asian Shallow Seas	N	NA	NA	Y	N	N
Muan Tidal Flat	N	NA	NA	Y	N	N
Cold Seeps	N	NA	NA	Y	Y	N
Nanji Islands Marine Reserve	N	NA	NA	Y	N	N
Shankou Mangrove National Nature Reserve	N	NA	NA	Y	N	N
North Pacific Ocean						
Coronado Islands	Y	Gray whale	Migration	N	NA	N
Juan de Fuca Ridge Hydrothermal Vents	N	NA	NA	N	NA	N
Yamskie Islands and Western Shelikhov Bay	Y	Steller sea lion; beluga and bowhead whales	Breeding and foraging	N	NA	N
Guadalupe Island	Y	Guadalupe fur seal	Breeding, pupping	N	NA	NA

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
Upper Gulf of California Region	Y	Fin whale; common and bottlenose dolphins; California sea lion; vaquita	Foraging; small, distinct population	N	NA	NA
Alijos Islands	N	NA	NA	N	NA	N
Midriff Islands Region	Y	Sperm, blue, fin, Bryde's, minke, and killer whales; common dolphins; sea lions	Foraging, pupping	N	NA	N
Coastal Waters Off Baja California	Y	Gray whale	Calving	N	NA	N
Emperor Seamount Chain and Northern Hawaiian Ridge	N	NA	NA	Y	Y	N
Focal Foraging Areas For Hawaiian Albatrosses During Egg-Laying And Incubation	N	NA	NA	Y	Y	N
North-east Pacific Ocean Seamounts	N	NA	NA	N	NA	N
North Pacific Transition Zone	Y	Elephant seal	Foraging	Part	Y	Y
Peter the Great Bay	Y	Ringed and spotted seals	Breeding	Y	Small Part	Y
Commander Islands Shelf and Slope	Y	Northern fur seal; Steller sea lion; killer whale; sea otter	Breeding, pupping, foraging	N	NA	N
Shantary Islands Shelf, Amur and Tugur Bays	Y	Bowhead, North Pacific right, fin, minke, humpback, killer, Baird's beaked, and beluga whales; Dall's and harbor porpoises; common dolphin	Foraging	N	NA	N

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
East and South Chukotka Coast	Y	Bowhead and beluga whales; walrus	Foraging, migration	N	NA	N
Moneron Island Shelf	Y	Steller sea lion, bearded seal	Breeding, pupping	Y	Small Part	Y
Eastern Shelf of Sakhalin Island	Y	Gray whale	Foraging	N	NA	N (OBIA #12 encompasses area)
West Kamchatka Shelf	Y	Steller sea lion; northern fur seal; spotted seal; sea otter; beluga, fin, gray, and North Pacific right whales	Foraging	N	NA	N
Southeast Kamchatka Coastal Waters	Y	Killer whale; harbor seal; Steller sea lion	Foraging	Y	Small part	Y
Western South Pacific Ocean						
Tongan Archipelago	Y	Humpback whale	Breeding/calving	N	NA	N
Palau Southwest	N	NA	NA	Y	Y	N
Niue Island and Beveridge Reef	Y	Humpback whale	Migration	N	NA	N
Manihiki Plateau	N	NA	NA	N	NA	N
Taveuni and Ringgold Islands	Y	Humpback whale	?	N	NA	N
Northern New Zealand/South Fiji Basin	N	NA	NA	N	NA	N
Northern Lord Howe Ridge Petrel Foraging Area	N	NA	NA	N	NA	N
Clipperton Fracture Zone Petrel Foraging Area	N	NA	NA	N	NA	N
Western South Pacific High Aragonite Saturation State Zone	N	NA	NA	N	NA	N
Central Louisville Seamount Chain	N	NA	NA	N	NA	N
Equatorial High-Productivity Zone	Y	Sperm whale	?	N	NA	N

Table C-2. Ecologically or Biologically Significant Areas (EBSAs) Reviewed as Potential Marine Mammals Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

EBSA Name	*Important to Marine Mammal(s)*	*Relevant Marine Mammal(s)*	*Important Biological Behavior*	*In LFA Study Area*	*Outside LFA Coastal Standoff Range*	*Further Review as Potential OBIA*
South Tasman Sea	N	NA	NA	N	NA	N
Vatu-i-Ra/Lomaiviti, Fiji	Y	Humpback whale, spinner dolphin	Migration, calving (humpback)	N	NA	N
South of Tuvalu/Wallis and Fortuna/North of Fiji Plateau	N	NA	NA	N	NA	N
Suwarrow National Park	Y	Humpback whale	Calving, breeding	N	NA	N
Samoan Archipelago	Y	Humpback whale	?	N	NA	N
Rarotonga Outer Reef Slopes	Y	Humpback whale	Calving, breeding	N	NA	N
New Hebrides Trench Region	N	NA	NA	N	NA	N
New Britain Trench Region	N	NA	NA	N	NA	N
Monowai Seamount	N	NA	NA	N	NA	N
Kermadec-Tonga-Louisville Junction	N	NA	NA	N	NA	N
Kadavu and the Southern Lau Region	Y	Humpback, minke, sei, and sperm whales	Migration	N	NA	N
Remetau group: South-West Caroline Islands and Northern New Guinea	N	NA	NA	Part	Y	N
Seamounts of West Norfolk Ridge	N	NA	NA	N	NA	N
Ua Puakaoa Seamounts	N	NA	NA	N	NA	N
Phoenix Islands	N	NA	NA	N	NA	N

NR=not recorded; NA=Not applicable

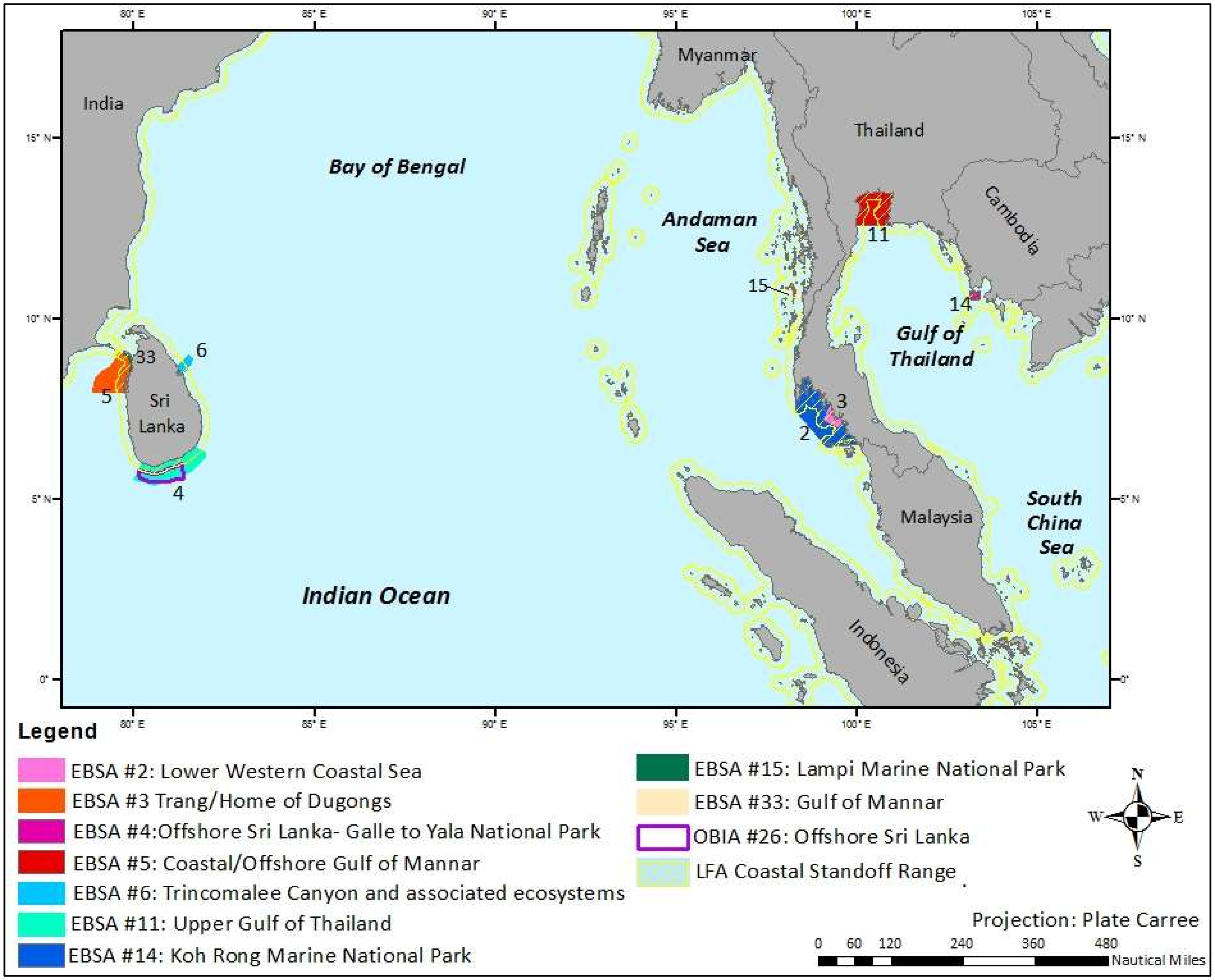

Figure C-6. Locations of Ecologically or Biologically Significant Areas (EBSAs) (CBD, 2018) in the Eastern Indian Ocean Study Area that have been Assessed as Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

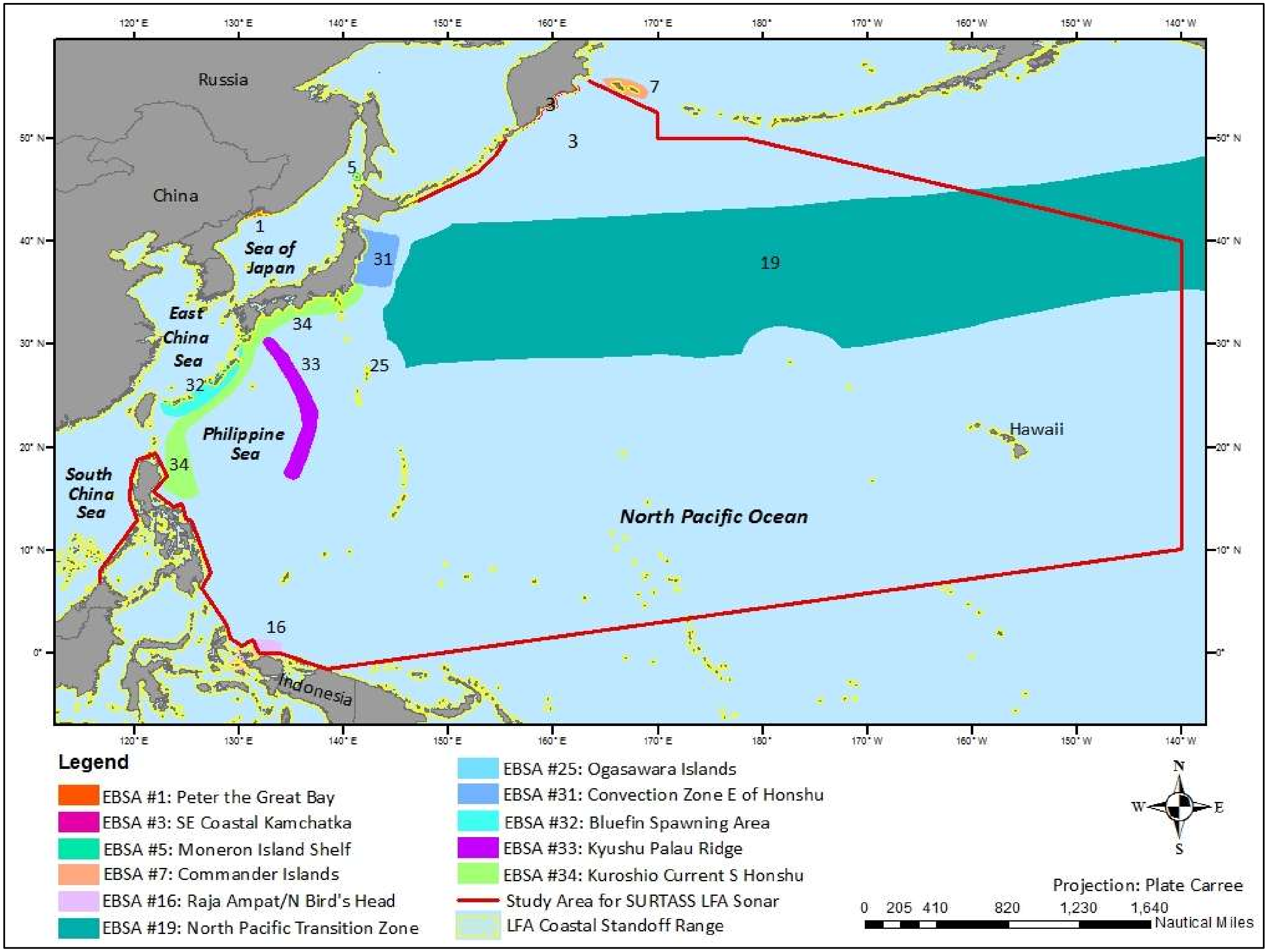

Figure C-7. Locations of the Ecologically or Biologically Significant Areas (EBSAs) (CB, 2018) in the Western and Central North Pacific Ocean Study Area that have been Assessed as Marine Mammal Offshore Biologically Important Areas for SURTASS LFA Sonar.

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APPENDIX D: DENSITY AND ABUNDANCE INFORMATION FOR POTENTIALLY AFFECTED MARINE MAMMAL STOCKS IN THE WESTERN AND CENTRAL NORTH PACIFIC AND EASTERN INDIAN OCEANS

APPENDIX D: DENSITY AND ABUNDANCE INFORMATION FOR POTENTIALLY AFFECTED MARINE MAMMAL STOCKS IN THE WESTERN AND CENTRAL NORTH PACIFIC AND EASTERN INDIAN OCEANS

This appendix describes the estimation approach and scientific literature sources used to derive density and stock abundance estimates for the marine mammal species potentially occurring in each of the SURTASS LFA sonar model areas. Information is listed by model area with marine mammal species occurring in each model area listed in alphabetical order by common name within the three general taxonomic groups: mysticetes, odontocetes, and pinnipeds.

D-1. MODEL AREA 1—EAST OF JAPAN

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage in the Philippine Sea, there was some coverage near the Kamchatka Peninsula and along the western Aleutian Islands chain. All calls recorded on these hydrophones were northwest Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the North Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977, Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde's whales in the western North Pacific: Solomon Islands/Southeast Asia, East China Sea, and offshore western North Pacific. The International Whaling Commission (IWC) provides the best available population estimate for the western North Pacific stock of 20,501 whales (IWC, 2009). The all-season density estimate (0.0006 animals/km^2) for the western North Pacific (WNP) stock is derived from whaling sighting data (Ohsumi, 1977). Bradford et al. (2013) observed Bryde's whales around the Hawaiian Islands, calculating a similar density estimate (0.00033 animals/km^2) to that derived for the WNP stock.

Common minke whale: Several stocks of minke whales are recognized in the western North Pacific Ocean, including the western North Pacific "O" east (WNP OE) stock, and the western North Pacific "J" west (WNP JW) stock (Miyashita & Okamura, 2011; Wade & Baker, 2011). Minke whales potentially occurring in the waters of this model area are believed to be part of the "WNP OE" stock. Buckland et al. (1992) conducted sighting surveys during July and August in the western North Pacific Ocean and Sea of Okhotsk, from which density (0.0022 animals/km^2) and abundance (25,049 individuals) estimates for the WNP "OE" stock were derived (Buckland et al., 1992). The density estimates that Ferguson and Barlow (2001; 2003) computed for this species in the offshore areas of the eastern tropical Pacific (ETP) are an order of a magnitude lower than those derived from Buckland et al. (1992).

Fin whale: Seasonal density, 0.0002 animals/km^2, and abundance, 9,250 individuals, estimates for fin whales in the WNP stock were derived from encounter rates during Japanese whaling in the northwest Pacific Ocean (Tillman, 1977; Mizroch et al., 2009). The seasonal density is comparable to that derived in offshore areas of the ETP (Ferguson and Barlow 2001, 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast, though sightings off northern Japan have been documented. Thus, humpback whales are only expected to occur in the East of Japan model area during summer and fall. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales (Calambokidis et al., 2008), which has increased annually to an abundance estimate of 1,328 individuals (Bettridge et al., 2015). A density of 0.00036 animals/km^2 was estimated for the WNP stock of humpback whales (Calambokidis et al., 2008; LGL, 2008). Approximately one-quarter of the animals were estimated to stay in water depths of less than 1,000 m (3,281 ft) as part of nearshore feeding aggregations.

North Pacific right whale: The WNP stock of North Pacific right whales is considered distinct from the eastern North Pacific population, arbitrarily separated by the 180° line of longitude (Best et al., 2001). Data from Japanese sighting cruises in the Okhotsk Sea provide an abundance estimate of 922 animals for the WNP stock (CV=0.433, 95% CI=404-2,108) (Best et al., 2001). No density estimates are available for this very rare marine mammal species, therefore, the nominal minimum density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during winter and spring seasons.

Sei whale: Tillman (1977) derived an abundance estimate of 8,600 individuals for sei/Bryde's[42] whale in the North Pacific from whaling catch statistics. Mizroch et al. (2015) estimated the size of the pelagic migratory stock in 1975 at approximately 4,000 animals, but their “single stock” (coastal and pelagic) state space analysis estimated a population size of 7,000 animals in 1974, which is used here as the best available data. Initial estimates for a portion of the sei whale population off Japan indicate abundance estimates of similar magnitude (7,744 for May to June and 5,406 for July to September; Hakamada et al., 2009). Sighting survey data from the Guam/Marianas Island regions derived a density estimate of 0.00029 animals/km^2 for the sei whale’s North Pacific (NP) stock (Fulling et al., 2011). This is similar to that calculated for around Hawaii (0.00016 animals/km^2; Bradford et al., 2017).

Baird's beaked whale: Based on Kasuya’s (1986) encounter rate and effective search width from 25 years of aerial surveys and shipboard sightings in 1984 off the Pacific coast of Japan, an all-season density estimate of 0.0029 animals/km^2 was derived for this species. Kasuya and Perrin (2017) cited an abundance estimate by Miyashita (1986, 1990) of 5,688, and is the abundance estimated for the WNP stock of Baird’s beaked whales.

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). Due to this lack of information, population data derived from ETP surveys of 3,286,163 animals and 0.0761 animals/km^2 (Ferguson and Barlow, 2001, 2003) are the most appropriate to represent the WNP stock of common dolphins.

42 Sei and Bryde’s whales are difficult to distinguish from one another at sea.

Common bottlenose dolphin: Kasuya and Perrin (2017) define a WNP Northern Offshore Stock for this region. Using a subset of the survey data from Miyashita (1993), Kasuya and Perrin (2017) report an abundance estimate of 100,281 individuals (CV=0.261). Miyashita (1993) reported a density estimate (0.0171 animals/km^2) for common bottlenose dolphins off the Pacific coast of Japan. Miyashita's (1993) density is comparable to that observed for common bottlenose dolphins in nearshore Hawaii waters (0.0103 animals/km^2; Mobley et al., 2000) but is an order of magnitude larger than that from habitat-based modeling (0.00118 animals/km^2; Forney et al., 2015).

Cuvier's beaked whale: No density or abundance estimate data are available for Cuvier's beaked whales of the WNP stock. Considering habitat preferences (e.g., water temperature and bathymetry), the best population data available to extrapolate for the Cuvier's WNP stock located in this model area are the Ferguson and Barlow (2001 and 2003) long-time series from the ETP, from which a density of 0.0031 animals/km^2 and an abundance of 90,725 animals were estimated. This density estimate is greater than that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but comparable to the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Dall's porpoise: Dall's porpoise are found only in the North Pacific, primarily north of 36°N in the western North Pacific Ocean. This species has two distinct color morphs: one with a white flank patch that extends forward to the dorsal fin (*dalli* type) and one with a flank patch extending all the way to the front flippers (*truei* type). These morphological differences have been noted between animals from the Pacific coast of Japan (the *truei*-type), the Sea of Japan, and Sea of Okhotsk (the *dalli*-type), and the offshore northwestern Pacific and western Bering Sea (the *dalli*-type) (Hayano et al., 2003). Hayano et al. (2003) conducted genetic studies on the three populations and found a low, but significant, difference between the Sea of Japan-Okhotsk population and the other two populations. Kasuya and Perrin (2017) cite Miyashita (2007) for an abundance estimate of 178,157 animals in this region. Based on surveys of the eastern North Pacific, a density estimate of 0.0520 animals/km^2 was derived for the WNP stock, with ¼ less (0.0390 animals/km^2) during the winter season (Ferguson and Barlow, 2001, 2003). This density estimates a concentration of Dall's porpoises probably larger than what would be encountered by LFA operations in the western North Pacific since it includes survey effort in nearshore waters where animals are more often found.

False killer whale: Miyashita (1993) estimated the abundance (16,668 animals, CV=0.263) of false killer whales from 34 sighting cruises associated with the Japanese drive fishery and also derived density estimates in 1° latitude by 1° longitude boxes from which an average density, 0.0036 animals/km^2, was derived for the WNP Pelagic stock of false killer whales in this model area. Miyashita's (1993) density is comparable to the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015).

Ginkgo-toothed beaked whale: The ginkgo-toothed whale is only known from strandings in the temperate and tropical waters of the Pacific (Palacios, 1996; Dalebout et al., 2014). Since no data on density or abundance estimates are available for ginkgo-toothed beaked whales in the western North Pacific Ocean, the best population estimations from which to extrapolate for this species in this region are those derived for *Mesoplodon* spp. from the ETP (Ferguson and Barlow, 2001 and 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density of 0.0005 animals/km^2 and an abundance of 22,799 animals are estimated for the North Pacific (NP) stock of ginkgo-toothed whales.

This derived density estimate is comparable to that computed for unidentified *Mesoplodon* whales in the Hawaiian EEZ (0.0021 animals/km^2, Bradford et al., 2013) and the mean predicted density estimate for *Mesoplodon* spp. in the ETP (0.0003 animals/km^2; Ferguson et al., 2006).

Harbor porpoise: Little is known about the harbor porpoises that are found off the northern coasts of Japan (Gaskin et al., 1993). Off the U.S. east coast and U.S. west coast, animals are found almost exclusively at water depths of less than 100 m (323 ft) (Read and Westgate, 1997; Carretta et al., 2001) and fine-scale stock structure exists (Carretta et al., 2014; Waring et al., 2014). Preliminary analysis of mitrochondrial DNA suggests that Japanese harbor porpoises mix with Alaskan animals to form a genetically distinct group (Taguchi et al., 2010).Therefore, using survey data corrected for sighting biases, the abundance estimate (31,046 animals) and density estimate (0.19 animals/km^2) of the Gulf of Alaska stock are most appropriate (Hobbs and Waite, 2010; Allen and Angliss, 2014).

Hubbs' beaked whale: All known occurrences to date of Hubb's beaked whales in the western North Pacific Ocean having been strandings along Japan's shore (MacLeod et al., 2006). Miyazaki et al. (1987) reported five strandings of Hubbs' beaked whales along the Pacific coast of northern Honshu. Since no data on density or stock estimates are available for the Hubb's beaked whale in the waters of this model area, *Mesoplodon* spp. data from the ETP (Ferguson and Barlow, 2001 and 2003) are considered to be the most appropriate population estimates available from which to extrapolate population estimates for this beaked whale in this model area. Using the northernmost strata from Ferguson and Barlow's (2001, 2003) data, a density of 0.0005 animals/km^2 and an abundance of 22,799 animals are estimated for the NP stock of Hubb's beaked whales. Ferguson and Barlow's (2001, 2003) density is comparable to that estimated for unidentified *Mesoplodon* whales in the Hawaii EEZ (0.0021 animals/km^2; Bradford et al., 2013) and the mean predicted density estimated for the ETP *Mesoplodon* spp. (0.0003 animals/km^2; Ferguson et al., 2006).

Killer whale: Killer whales have been observed off the southeast coast of Honshu but none were taken in Japanese drive fisheries (Miyashita, 1993). With no population data for killer whales to estimate the WNP stock, the best available data from which to extrapolate abundance estimate is the ETP time series data, where Ferguson and Barlow (2001, 2003) derived an abundance estimate of 12,256 animals. A density of 0.0001 animals/km^2 was estimated from LGL (2011) data. The LGL (2011) density estimated for the WNP stock is comparable to the density, 0.00004 animals/km^2, estimated for killer whales in the Hawaii EEZ (Bradford et al., 2013).

***Kogia* spp.**: Few occurrence data are available for *Kogia* spp. in the western North Pacific. In the ETP, Ferguson and Barlow (2001; 2003) summed the abundances of *Kogia breviceps, Kogia sima,* and *Kogia* spp. for an estimated overall abundance of 350,553 animals. Although only *Kogia breviceps* (pygmy sperm whale) is expected at the northern latitude of this area, the abundance from the ETP remains the best estimate for the WNP stock of *Kogia* spp. The density estimate of 0.0031 animals/km^2 calculated for *Kogia* spp. from the ETP at about 30° N is considered the best estimate (Ferguson and Barlow, 2001; 2003) from which to extrapolate a density of undifferentiated *Kogia* in the WNP stock. Ferguson and Barlow's (2001, 2003) density is comparable to the density estimates for pygmy sperm whale (0.00291 animals/km^2 [CV=1.12]) and dwarf sperm whale (0.00714 animals/km^2 [CV=0.74]) estimated within the Hawaii EEZ (Barlow, 2006).

Pacific white-sided dolphin: No data on density or abundance estimates are available for this gregarious, pelagic species in this model area (Miyashita, 1993). Recent research on genetic differentiation suggests that animals found in coastal Japanese waters and the Sea of Japan belong to a different Pacific white-sided dolphin population than animals found in offshore North Pacific waters (Hayano et al., 2004). Data from sighting surveys in the North Pacific were analyzed to estimate an abundance of 931,000 individuals in the WNP stock of Pacific white-sided dolphins (Buckland et al., 1993). This estimate is over an order of magnitude larger than the abundance estimated for this species in waters of the eastern North Pacific (Ferguson and Barlow, 2001, 2003). Ferguson and Barlow's (2001, 2003) density estimates of 0.0082 animals/km^2 from the ETP is appropriate to extrapolate as a density for the WNP stock in this model area. No sightings of Pacific white-sided dolphins were reported in Hawaiian surveys (Mobley et al., 2000; Barlow, 2006; Bradford et al., 2017).

Pantropical spotted dolphin: Gilpatrick et al. (1987) described a known distribution of pantropical spotted dolphins occurring east of Japan. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) and Miyashita (1993) reports a seasonal density estimate, 0.0259 animals/km^2, for pantropical spotted dolphins occurring east of Japan. In the high latitude waters of this model area, pantropical spotted dolphins are not expected to occur during winter or spring. Miyashita's (1993) density for the WNP stock of pantropical spotted dolphins can be compared to that observed in nearshore Hawaii waters (0.0407 animals/km^2; Mobley et al., 2000), although it is an order of magnitude higher than that estimated for pantropical spotted dolphins in the Hawaii EEZ (0.00369 animals/km^2; Forney et al., 2015).

Pygmy killer whale: Kishiro and Kasuya (1993) reported that no pygmy killer whales were taken in Japanese drive fisheries, but Leatherwood and Reeves (1983) reported that pygmy killer whales were seen relatively frequently in the waters of the tropical Pacific off Japan. However, since no population data are available for pygmy killer whales in the western North Pacific Ocean, density (0.0021 animals/km^2) and abundance (30,214 individuals) estimates were extrapolated from the ETP data (Ferguson and Barlow, 2001 and 2003) and used to reflect the population levels of the WNP stock of pygmy killer whales. Ferguson and Barlow's (2001 and 2003) density is comparable to that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017).

Risso's dolphin: Kanaji et al. (2018) report an abundance for the WNP stock of 143,374 individuals (CV=0.69) and Miyashita (1993) reports a density estimate of 0.0097 animals/km^2 derived for Risso's dolphins in waters off the Pacific coast of Japan. Miyashita's (1993) density is comparable to that observed for this species in the Hawaii EEZ (0.00474 animals/km^2; Bradford et al., 2017).

Rough-toothed dolphin: The best available density estimate (0.00224 animals/km^2) is from habitat-based models in the central North Pacific (Forney et al., 2015). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. While the density estimated for rough-toothed dolphins in the waters of the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) is comparable, the density estimated for nearshore Hawaii waters is slightly lower (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). Using the results of Miyashita (1993), an abundance estimate of 20,884 individuals (CV=0.332) was calculated and an average density estimate (0.0128 animals/km^2) was derived to represent the WNP northern stock. This density estimate is higher than that found in pelagic waters of the Hawaii EEZ (0.0051 animals/km^2; Bradford et al., 2013).

Sperm whale: Sperm whale stock structure in the western North Pacific Ocean is not well defined. Kasuya and Miyashita's (1988) data suggest that there are two stocks of sperm whales in the western

North Pacific: a northwestern stock whose females summer off the Kuril Islands (~50°N) and winter off Hokkaido and Sanriku (~40°N) and a southwestern stock whose females summer off Hokkaido and Sanriku (~40°N) and winter around the Bonin Islands (~25°N). The males of both stocks are thought to occur north of the corresponding female's ranges, i.e., in the Bering Sea (~55°N) and off Hokkaido and Sanriku (~40°N), respectively, during the summer (Kasuya and Miyashita, 1988). Since population level data are not available to quantify two North Pacific stocks, abundance can be estimated for only the North Pacific (NP) stock as a whole. The best available population estimate for sperm whales occurring in the NP stock is Kato and Miyashita's (1998) estimate of 102,112 animals (CV=0.155). The density estimate of sperm whales, 0.00123 animals/km^2, calculated from the winter/spring survey around Guam and the Mariana Islands, is the best representative estimate for the NP stock of sperm whales in this model area (Fulling et al., 2011). This is comparable to the density estimate of sperm whales in the Hawaii EEZ (0.00158 animals/km^2; Forney et al., 2015).

Spinner dolphin: The spinner dolphin is not mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993), and no data on density or abundance estimates are available for this species in the western North Pacific Ocean (Miyashita, 1993). Due to this lack of information, the abundance for the WNP stock, 1,015,059 animals, is estimated from the ETP population data (Ferguson and Barlow, 2001 and 2003) while the density, 0.00083 animals/km^2, is estimated from offshore stratum of the Hawaii EEZ survey data (Barlow, 2006); no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013). Due to the high latitude at which this model area occurs, spinner dolphins are only expected to occur in these waters during summer and fall.

Stejneger's beaked whale: Strandings along the Pacific coast of Japan in winter and spring suggest a migratory pattern (Mead, 1989; Yamada, 1997), but density or stock estimate data are not available for the WNP stock in this region. Considering habitat preferences (e.g., water temperature, bathymetry), the most appropriate density estimate for Stejneger's beaked whale is 0.0005 animals/km^2, which is derived from ETP data (Ferguson and Barlow, 2001, 2003), with the most appropriate abundance (8,000 animals) extrapolated from the abundance estimate derived for the WNP stock of Baird's beaked whales (Kasuya, 1986).

Striped dolphin: Kasuya and Perrin (2017) recognize a northern offshore population, with an abundance estimate of 497,725 individuals (CV=0.179) (Miyashita, 1993). Miyashita (1993) derived a density estimate of 0.0111 animals/km^2. This is slightly higher than the density estimate of striped dolphins in the Hawaii EEZ (0.0084 animals/km^2; Bradford et al., 2013).

Northern fur seal: Northern fur seals in this region are part of the Western Pacific stock. Northern fur seals only go ashore on their breeding grounds further north; after breeding and molting, many northern fur seals travel southward, where they remain at sea and may be found in this region during the winter and spring (Buckland et al., 1993; Allen and Angliss, 2015). The Western Pacific stock is estimated at 503,609 animals (Gelatt et al., 2015; Kuzin, 2015). Horimoto et al. (2016) estimated a density of 0.368 animals/km^2 in nearshore waters during winter, with half that density in spring.

D-2. MODEL AREA 2—NORTH PHILIPPINE SEA

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage in the Philippine Sea, there was some coverage near the Kamchatka Peninsula and along the western Aleutian Islands chain. All calls recorded on these hydrophones were northwest Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the North Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977, Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde's whales in the western North Pacific: Solomon Islands/Southeast Asia, East China Sea, and offshore western North Pacific. The International Whaling Commission (IWC) provides the best available population estimate for the western North Pacific stock of 20,501 whales (IWC, 2009). The all-season density estimate (0.0006 animals/km^2) for the western North Pacific (WNP) stock is derived from whaling sighting data (Ohsumi, 1977). Bradford et al. (2013) observed Bryde's whales around the Hawaiian Islands, calculating a similar density estimate (0.00033 animals/km^2) to that derived for the WNP stock.

Common minke whale: Several stocks of minke whales are recognized in the western North Pacific Ocean, including the western North Pacific "O" east (WNP OE) stock, and the western North Pacific "J" west (WNP JW) stock (Miyashita & Okamura, 2011; Wade & Baker, 2011). Minke whales potentially occurring in the waters of this model area are believed to be part of the "WNP OE" stock. Buckland et al. (1992) conducted sighting surveys during July and August in the western North Pacific Ocean and Sea of Okhotsk, from which the density estimate, 0.0044 animals/km^2, for minke whales in this area was derived from the encounter rates and effective search widths for the offshore population (standard error (SE) = 0.17), while the stock estimate for the WNP "OE" stock is estimated as 25,049 individuals by Buckland et al. (1992). Ferguson and Barlow (2001; 2003) computed density estimates in offshore areas of the ETP that are an order of magnitude lower than those derived from Buckland et al. (1992).

Fin whale: Seasonal density, 0.0002 animals/km^2, and abundance, 9,250 individuals, estimates for fin whales in the WNP stock were derived from encounter rates during Japanese whaling in the northwest Pacific Ocean (Tillman, 1977; Mizroch et al., 2009). The seasonal density is comparable to that derived in offshore areas of the ETP (Ferguson and Barlow 2001, 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are only expected to occur in the North Philippine Sea model area during winter, spring, and fall. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales (Calambokidis et al., 2008), which has increased annually to an abundance estimate of 1,328 individuals (Bettridge et al., 2015). A density of 0.00089 animals/km^2 was estimated for the WNP stock of humpback whales (Calambokidis et al., 2008; LGL, 2008).

North Pacific right whale: The WNP right whale population is considered distinct from the eastern north Pacific population, arbitrarily separated by the 180° line of longitude (Best et al., 2001). Data from

Japanese sighting cruises in the Okhotsk Sea provide an abundance estimate of 922 animals (CV=0.433, 95% CI=404-2,108) (Best et al., 2001) for the WNP stock of North Pacific right whales. The WNP population may occur in the waters of the North Philippine Sea only in winter and spring. No density estimates are available for this very rare marine mammal species, therefore, the nominal minimum density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during winter and spring seasons.

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) is used (0.00004 animals/km^2).

Blainville's beaked whale: Without any data on abundance or density estimates of the Blainville's beaked whale for the western North Pacific, extrapolation from ETP data is appropriate (Ferguson and Barlow, 2001, 2003). A density estimate of 0.0005 animals/km^2 represents the WNP stock of Blainville's beaked whales in model area 2. The abundance estimate of 8,032 individuals was derived by adding the *Mesoplodon densirostris* abundance estimate to one-fifth of the *Mesoplodon* spp. abundance estimate (Ferguson and Barlow, 2001, 2003). The ETP density estimate is similar to the density of Blainville's beaked whales estimated in the Hawaii EEZ (0.00086 animals/km^2; Bradford et al., 2017) and the mean predicted density estimate (0.000296 animals/km^2; Ferguson et al., 2006) for the ETP, but lower than the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001).

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). Due to this lack of information, population data derived from ETP surveys of 3,286,163 animals and 0.0562 animals/km^2 (Ferguson and Barlow, 2001, 2003) are the most appropriate to represent the WNP stock of common dolphins.

Common bottlenose dolphin: Kasuya and Perrin (2017) define a Japanese Coastal Stock for this region. Kanaji et al. (2018) report an abundance estimate of 3,516 individuals. Miyashita (1993) density (0.0146 animals/km^2) estimates for common bottlenose dolphins off southern Japan were used to represent the WNP stock, which occurs in this model area. Miyashita's (1993) density is comparable to that derived for the bottlenose dolphins in nearshore Hawaii waters (0.0103 animals/km^2; Mobley et al., 2000) but is an order of magnitude larger than that that from habitat-based modeling (0.00118 animals/km^2; Forney et al., 2015).

Cuvier's beaked whale: No density or abundance estimate data are available for the Cuvier's beaked whale in this region. Considering the Cuvier's habitat preferences (e.g., water temperature, bathymetry), the best data available to represent the WNP stock of Cuvier's beaked whales is the density (0.0054 animals/km^2) and abundance (90,725 animals) estimated for the Cuvier's in the ETP (Ferguson and Barlow, 2001 and 2003). This density estimate is greater than that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but comparable to the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

False killer whale: Miyashita (1993) estimated an abundance of 16,668 (CV=0.263) individuals from 34 sighting cruises associated with the Japanese drive fishery and derived a density estimate of 0.0029 animals/km^2 for the WNP Pelagic stock of false killer whales. Miyashita's (1993) density is much higher than the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015

Fraser's dolphin: Without data on abundance or density estimates for the western North Pacific, Ferguson and Barlow's (2001, 2003) abundance estimate of 220,789 animals is extrapolated to represent the WNP stock of Fraser's dolphins, which occurs in this model area. However, the density estimate derived for Hawaiian waters, 0.0069 animals/km^2 (Bradford et al., 2013), is most appropriate and representative of the stock.

Ginkgo-toothed beaked whale: The ginkgo-toothed whale is only known from strandings in the temperate and tropical waters of the Pacific (Palacios, 1996; Dalebout et al., 2014). With no data available on density or abundances of the NP stock of ginkgo-toothed beaked whales, the best population estimations are those extrapolated from the ETP derivations of Ferguson and Barlow (2001 and 2003) for *Mesoplodon* spp. Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density of 0.0005 animals/km^2 and an abundance of 22,799 animals are estimated. Ferguson and Barlow's density estimate is an order of magnitude less than that for unidentified beaked whales in the Hawaii EEZ (0.0.0021 animals/km^2; Bradford et al., 2013) but comparable to the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al. 2006).

Killer whale: Killer whales have been observed off the southeast coast of Honshu, Japan, but no killer whales were taken in Japanese drive fisheries (Miyashita, 1993). Without any population or occurrence data on killer whales for the western North Pacific, the best available data to use as a proxy for the WNP stock of killer whales are from the long time-series in the ETP, where Ferguson and Barlow (2001, 2003) derived an abundance estimate of 12,256 animals. The most appropriate density, 0.00009 animals/km^2, is derived by LGL (2011). LGL's (2011) density can be compared to the density estimate of 0.00004 animals/km^2 estimated for killer whales in the Hawaii EEZ (Bradford et al., 2013).

***Kogia* spp.**: Few occurrence data are available for *Kogia* spp. in the western North Pacific. In the ETP, Ferguson and Barlow (2001; 2003) summed the abundances of *Kogia breviceps, Kogia sima,* and *Kogia* spp. for an estimated overall abundance of 350,553 animals. Although only *Kogia breviceps* (pygmy sperm whale) is expected at the northern latitude of this model area, the abundance from the ETP remains the best population estimate for the WNP stock of *Kogia* spp. The density estimate of 0.0031 animals/km^2 calculated for *Kogia* spp. from the ETP at about 30°N is considered the best estimate for *Kogia* spp. in this western region of the North Pacific (Ferguson and Barlow, 2001, 2003). Ferguson and Barlow's (2001, 2003) density is comparable to the density estimates for pygmy sperm whale (0.00291 animals/km^2, CV=1.12) and dwarf sperm whale (0.00714 animals/km^2, CV=0.74) observed within the Hawaii EEZ (Barlow, 2006).

Longman's beaked whale: Longman's beaked whales are known from tropical waters of the Pacific and Indian Oceans (Pitman et al., 1999; Dalebout et al., 2003). Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings in their surveys were south of 25ºN. Considering the lack of occurrence or population data for the WNP stock of Longman's beaked whales, the abundance of 7,619 animals estimated for Longman's beaked whales in offshore Hawaiian waters (Bradford et al., 2017) and the density of 0.00025 animals per km^2 (LGL, 2011) derived from the Marianas region are considered most appropriate to represent the WNP stock of Longman's beaked whale.

Melon-headed whale: An abundance estimated by Kanaji et al. (2018) from the Pacific coast of Japan of 56,213 animals (CV=0.56) and a density estimated by Fulling et al. (2011) of 0.00428 animals/km^2 from the Marianas Islands region were the best available data to use to represent the WNP stock of melon-headed whales. The density of Fulling et al. (2011) is higher than the density (0.0021 animals/km^2) estimated by Mobley et al. (2000) for melon-headed whales near the Main Hawaiian Islands.

Pacific white-sided dolphin: No data on density or abundance estimates are available on the Pacific white-sided dolphin in the western North Pacific (Miyashita, 1993). Recent research on genetic differentiation suggests that Pacific white-sided dolphins found in coastal Japanese waters and the Sea of Japan belong to a different population than Pacific white-sided dolphins found in offshore North Pacific waters (Hayano et al., 2004). Sighting surveys in the North Pacific were analyzed to estimate the abundance of Pacific white-sided dolphins in the WNP stock as 931,000 individuals (Buckland et al., 1993). This estimate is over an order of magnitude larger than the abundance estimated for this species in the eastern North Pacific by Ferguson and Barlow (2001, 2003). Without any data on density estimates for the western North Pacific (Miyashita, 1993), the density estimate of 0.0119 animals/km^2 from the ETP (Ferguson and Barlow, 2001, 2003) are most appropriate as a proxy to represent the WNP stock of Pacific white-sided dolphins occurring in this model area during winter and spring. No sightings of Pacific white-sided dolphins were reported in Hawaii surveys (Barlow, 2006; Bradford et al., 2017; Mobley et al., 2000).

Pantropical spotted dolphin: Gilpatrick et al. (1987) described a known distribution of pantropical spotted dolphins occurring east of Japan. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) and Miyashita (1993) reports a seasonal density estimate, 0.0137 animals/km^2, for pantropical spotted dolphins occurring east of Japan. Miyashita's density is comparable to the density derived for the species in nearshore Hawaii waters (0.0407 animals/km^2; Mobley et al., 2000) but is higher than that derived for these dolphins in the Hawaii EEZ (0.00369 animals/km^2; Forney et al., 2015).

Pygmy killer whale: Kishiro and Kasuya (1993) reported that no pygmy killer whales were taken in Japanese drive fisheries, but Leatherwood and Reeves (1983) reported that pygmy killer whales were seen relatively frequently in the tropical Pacific off Japan. With no population data available for the WNP stock of pygmy killer whales, a density of 0.0021 animals/km^2 and abundance of 30,214 animals estimated from eastern Pacific by Ferguson and Barlow (2001, 2003) were used to represent the WNP stock. Ferguson and Barlow's (2001, 2003) density estimate is comparable to that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017). No pygmy killer whales were sighted in nearshore Hawaii waters (Mobley et al., 2000).

Risso's dolphin: Kanaji et al. (2018) report an abundance for the WNP stock of 143,374 individuals (CV=0.69) and Miyashita (1993) reported a density estimate of 0.0106 animals/km^2 for Risso's dolphins in waters off the Pacific coast of Japan. Miyashita's (1993) density is comparable to that observed for this species in the Hawaii EEZ (0.00474 animals/km^2; Bradford et al., 2017).

Rough-toothed dolphin: Rough-toothed dolphins are reportedly rare off Japan and in the heavily studied ETP. Since there are no data on abundance or density estimates for the WNP stock of rough-toothed dolphins, the best available density estimate (0.00224 animals/km^2) is from habitat-based models in the central North Pacific (Forney et al., 2015). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. This density is comparable to those observed for this species in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). Using the results of Miyashita (1993), an abundance estimate of 31,396 individuals (CV=0.65) was calculated and an average density estimate (0.0153 animals/km^2) was derived to represent the WNP southern stock. This density estimate is higher than that found in pelagic waters of the Hawaii EEZ (0.0051 animals/km^2; Bradford et al., 2013).

Sperm whale: Stock structure of this species has not been completely delineated for sperm whales in the North Pacific. NMFS considers historical and current abundance estimates to be unreliable (Allen and Angliss, 2013). Sightings collected by Kasuya and Miyashita (1988) suggest that two stocks of sperm whales occur in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands (~50°N) and winter off Hokkaido and Sanriku (~40°N) and a southwestern North Pacific stock with females that summer off Hokkaido and Sanriku (~40°N) and winter around the Bonin Islands (~25°N); the males of these two stocks are found north of the range of the corresponding females, i.e., in the Bering Sea (~55°N) and off Hokkaido and Sanriku (~40°N), respectively, during the summer. Since the stock structure has not been well delineated, an abundance is estimated for the NP stock of sperm whales as 102,112 individuals (CV=0.155) (Kato and Miyashita, 1998). The density estimate of sperm whales, 0.00123 animals/km^2, calculated from the winter/spring survey around Guam and the Mariana Islands is the best representative estimate for sperm whales in this model area (Fulling et al., 2011). This is comparable to the density estimate of sperm whales in the Hawaii EEZ (0.00158 animals/km^2; Forney et al., 2015).

Spinner dolphin: Gilpatrick et al. (1987) did not report any sightings from the Pacific coast of Japan, and this species was not mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993). No data on density or abundance estimates are available for spinner dolphins in this region (Miyashita, 1993). Lacking density or abundance data on the WNP stock of spinner dolphins, the abundance estimate, 1,015,059 animals, derived for spinner dolphins in waters of the ETP (Ferguson and Barlow, 2001, 2003) at a similar latitude is appropriate to characterize this stock in this region. Barlow's (2006) density estimate, 0.00083 animals/km^2, derived for spinner dolphins in the waters of the outer Hawaii EEZ, is the best available; no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013).

Striped dolphin: Kasuya and Perrin (2017) recognize a Japanese coastal population, with an abundance estimate of 19,631 individuals (CV=0.696) (Miyashita, 1993). Miyashita (1993) estimated a density of striped dolphins off southern Japan/east Taiwan as 0.0329 animals/km^2. This is higher than the density estimate of striped dolphins in the Hawaii EEZ (0.00385 animals/km^2; Forney et al., 2015).

D-3. MODEL AREA 3—WEST PHILIPPINE SEA

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage in the Philippine Sea, there was some coverage near the Kamchatka Peninsula and along the western Aleutian Islands chain. All calls recorded on these hydrophones were northwest Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the North

Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977, Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde's whales in the western North Pacific: Solomon Islands/Southeast Asia, East China Sea, and offshore western North Pacific. The International Whaling Commission (IWC) provides the best available population estimate for the western North Pacific stock of 20,501 whales (IWC, 2009). The all-season density estimate (0.0006 animals/km^2) for the western North Pacific (WNP) stock is derived from whaling sighting data (Ohsumi, 1977). Bradford et al. (2013) observed Bryde's whales around the Hawaiian Islands, calculating a similar density estimate (0.00033 animals/km^2) to that derived for the WNP stock.

Common minke whale: Several stocks of minke whales are recognized in the western North Pacific Ocean, including the western North Pacific "O" east (WNP OE) stock, and the western North Pacific "J" west (WNP JW) stock (Miyashita & Okamura, 2011; Wade & Baker, 2011). Minke whales potentially occurring in the waters of this model area are believed to be part of the "WNP OE" stock. Buckland et al. (1992) conducted sighting surveys during July and August in the western North Pacific Ocean and Sea of Okhotsk, from which the density estimate, 0.0033 animals/km^2, for minke whales in this area was derived from the encounter rates and effective search widths for the offshore population (standard error (SE) = 0.17), while the stock estimate for the WNP "OE" stock is estimated as 25,049 individuals. Ferguson and Barlow (2001; 2003) computed density estimates in offshore areas of the ETP that are an order of magnitude lower than those derived from Buckland et al. (1992).

Fin whale: Since fin whales migrate south from offshore waters of the western North Pacific Ocean, the density of 0.0002 animals/km^2 for winter and spring and the abundance of 9,250 animals for the WNP stock were estimated from encounter rates of Japanese scouting boats in the northwest Pacific Ocean (Tillman, 1977; Mizroch, 2009). This density estimated for fin whales in the WNP stock are comparable to the density estimated for this species in offshore areas of the ETP (Ferguson and Barlow, 2001 and 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are only expected to occur in the Western Philippine Sea model area during winter, spring, and fall. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales (Calambokidis et al., 2008), which has increased annually to an abundance estimate of 1,328 individuals (Bettridge et al., 2015). A density of 0.00089 animals/km^2 was estimated for the WNP stock of humpback whales (Calambokidis et al., 2008; LGL, 2008).

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) is used (0.00004 animals/km^2).

Blainville's beaked whale: Lacking data on population estimates for the Blainville's beaked whale in the western North Pacific, the data derived for this species in waters of the ETP (Ferguson and Barlow, 2001, 2003) are deemed most appropriate to represent the species in the WNP stock. Ferguson and Barlow's (2001, 2003) abundance derived for *Mesoplodon densirostris* added to one-fifth of the *Mesoplodon* spp. abundance provides an estimate of 8,032 animals to represent this stock. The density estimate for *Mesoplodon* spp. at the same latitudes in the eastern Pacific, 0.0005 animals/km^2; is most appropriate (Ferguson and Barlow, 2001 and 2003). This density estimate is similar to the density of Blainville's beaked whales estimated in the Hawaii EEZ (0.00086 animals/km^2; Bradford et al., 2017) and the mean predicted density estimate (0.000296 animals/km^2; Ferguson et al., 2006) for the ETP, but lower than the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001).

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). Due to this lack of information, population data derived from ETP surveys of 3,286,163 animals (Ferguson and Barlow, 2001, 2003) and density estimate from a line-transect survey off the North American west coast (Carretta et al., 2011a; 0. 1158 animals/km^2) are the most appropriate to represent the WNP stock of common dolphins.

Common bottlenose dolphin: Kasuya and Perrin (2017) define a WNP Southern Offshore Stock for this region. Kanaji et al. (2018) report an abundance estimate of 40,769 individuals. Miyashita (1993) estimated density as 0.0146/km^2, which is similar to that observed in the nearshore Hawaii waters (0.0103/km^2; Mobley et al., 2000) but is an order of magnitude larger than that that from habitat-based modeling (0.00118 animals/km^2; Forney et al., 2015).

Cuvier's beaked whale: No data are available for Cuvier's beaked whales in this region. Considering Cuvier's habitat preferences (e.g., water temperature, bathymetry), the best data available to use as a proxy for the WNP stock of Cuvier's beaked whales that occur in model area #3 are Ferguson and Barlow's (2001 and 2003) density estimate of 0.0003 animals/km^2 and abundance estimate of 90,725 animals derived for the species in waters at the same latitudes in the eastern Pacific. This eastern Pacific density is comparable to that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) and less than the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Deraniyagala's beaked whale: Dalebout et al. (2014) conducted genetic and molecular analyses to demonstrate that *Mesoplodon hotaula* was genetically distinct from the ginkgo-toothed beaked whale (*M. ginkgodens*). Little is known about this beaked whale species, but a stranding in the southern Philippines suggests this species may occur in this model area (Lacsamana et al., 2015). No abundance or stock information is available for the Deraniyagala's beaked whale. Given that this species was synonymous with the ginkgo-toothed beaked whale, which is part of the *Mesoplodon* spp. complex, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density estimate of 0.0005 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the Deraniyagala's beaked whale in this model area.

False killer whale: From 34 sighting cruises associated with the Japanese drive fishery, Miyashita (1993) estimated an abundance of 16,668 (CV=0.263) and an average density of 0.0029 animals/km^2 of false killer whales in the WNP stock. Miyashita's (1993) density is comparable to the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015).

Fraser's dolphin: Lacking occurrence or population data on the Fraser's dolphins in the western North Pacific, the abundance estimated at 220,789 animals for the species in the waters of the ETP by Ferguson and Barlow (2001, 2003) and the density of 0.0069 animals/km^2 estimated for Fraser's dolphins in the waters of the Hawaii EEZ by Bradford et al. (2013) best represented the WNP stock of Fraser's dolphins.

Ginkgo-toothed beaked whale: Since no data on density or stock estimates are available for the Ginkgo-toothed beaked whale in this region, the density of 0.0005 animals/km^2 and abundance of 22,799 animals was estimated for *Mesoplodon* spp. at the same latitudes in the eastern Pacific (Ferguson and Barlow, 2001, 2003) are most appropriate to represent the North Pacific stock of ginkgo-toothed beaked whales in this region. The ETP density estimate is an order of magnitude less than that for unidentified beaked whales in the Hawaii EEZ (0.0.0021 animals/km^2; Bradford et al., 2013) but comparable to the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Killer whale: Killer whales have been observed off the southeast coast of Honshu, Japan, but no killer whales were taken in Japanese drive fisheries (Miyashita, 1993). Without any population or occurrence data on killer whales for the western North Pacific, the best available abundance estimate of 12,256 animals is from Ferguson and Barlow's (2001, 2003) long time series in the ETP while the best available density estimate of 0.00009 animals/km^2 is from LGL (2011) compilation of data for the Marianas area. LGL's (2011) density is comparable to the density, 0.00004 animals/km^2, estimated for killer whales in the Hawaii EEZ (Bradford et al., 2013).

***Kogia* spp.**: Evans (1987) reported records of *Kogia* spp. off the Japanese coast with primarily an oceanic distribution that are not believed to be concentrated anywhere specific. Summing the abundances of *Kogia breviceps, Kogia sima, and Kogia* spp. in the geographic strata defined by Ferguson and Barlow (2001, 2003), an overall abundance of 350,553 animals was computed in the ETP. Considering the lack of data for the western North Pacific, Ferguson and Barlow's (2001, 2003) data are the most appropriate to represent *Kogia* spp. in this model area. At this latitude, *Kogia breviceps* and *Kogia sima* are both expected to occur. Reviewing density estimates calculated in the eastern Pacific Ocean at about 20°N (Ferguson and Barlow, 2001, 2003), a density estimate of 0.0017 animals/km^2 was derived, which is considered the best available for the WNP stock of *Kogia* spp. Ferguson and Barlow's (2001, 2003) density is slightly lower than the densities for pygmy sperm whale (0.00291 animals/km^2, CV=1.12) and dwarf sperm whale (0.00714 animals/km^2, CV=0.74) estimated within the Hawaii EEZ (Barlow, 2006).

Longman's beaked whale: Longman's beaked whales are known from tropical waters of the Pacific Ocean (Pitman et al., 1999; Dalebout et al., 2003). Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings in their ETP surveys were south of 25ºN. Considering the lack of occurrence or population data for the WNP stock of Longman's beaked whales, the abundance of 7,619 animals estimated for Longman's beaked whales in offshore Hawaiian waters (Bradford et al., 2017) and the density of 0.00025animals per km^2 (LGL, 2011) derived from the Marianas regions are considered most appropriate to represent the WNP stock.

Melon-headed whale: An abundance estimated by Kanaji et al. (2018) from the Pacific coast of Japan of 56,213 animals (CV=0.56) and a density estimated by Fulling et al. (2011) of 0.00428 animals/km^2 derived for the Marianas region are the best available estimations for the WNP stock. The Fulling et al. (2011) density value is higher than the estimate from Mobley et al. (2000) for near the Main Hawaiian Islands: 0.0021 animals/km^2.

Pantropical spotted dolphin: Gilpatrick et al. (1987) described a known distribution of pantropical spotted dolphins occurring east of Japan. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) and Miyashita (1993) reports a seasonal density estimate, 0.0137 animals/km^2. Miyashita's (1993) density is higher than that observed in the Hawaii EEZ (0.00369 animals/km^2; Forney et al., 2015) but is comparable to that derived for nearshore Hawaii waters (0.0407 animals/km^2; Mobley et al., 2000).

Pygmy killer whale: Lacking data on the pygmy killer whale in the western North Pacific, density, 0.0021 animals/km^2, and abundance, 30,214 animals, estimates from eastern Pacific (Ferguson and Barlow, 2001 and 2003) were considered the best available to use as a proxy to represent the WNP stock of pygmy killer whales in this model area. The Ferguson and Barlow density is comparable to that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017), while no pygmy killer whales were sighted in nearshore Hawaii waters (Mobley et al., 2000).

Risso's dolphin: Kanaji et al. (2018) report an abundance for the WNP stock of 143,374 individuals (CV=0.69). Miyashita's (1993) density estimate of 0.0106 animals/km^2 derived for Risso's dolphins off southern Japan/east Taiwan were used to represent the WNP stock of Risso's dolphin in this region. Miyashita's (1993) density is an order of magnitude larger than that observed in the Hawaii EEZ (0.00474 animals/km^2; Bradford et al., 2017); no Risso's dolphins were observed in nearshore Hawaii waters (Mobley et al., 2000).

Rough-toothed dolphin: Rough-toothed dolphins are reportedly rare off Japan and in the heavily studied ETP. Since there are no data on abundance or density estimates for the WNP stock of rough-toothed dolphins, the best available density estimate (0.00224 animals/km^2) is from habitat-based models in the central North Pacific (Forney et al., 2015). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. This density is comparable to those observed in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). Using the results of Miyashita (1993), an abundance estimate of 31,396 individuals (CV=0.65) was calculated for the WNP southern stock and an average density estimate (0.0076 animals/km^2) was derived for the West Philippine Sea. This density estimate is similar to that found in pelagic waters of the Hawaii EEZ (0.0051 animals/km^2; Bradford et al., 2013).

Sperm whale: Stock structure of this species has not been completely delineated in the North Pacific Ocean. Even though sightings collected by Kasuya and Miyashita (1988) were interpreted to indicate that two stocks of sperm whales exists in the western North Pacific Ocean, insufficient population-level data exist to adequately define a fine-scale population structure, except for the populations of sperm whales in U.S. EEZ waters (Allen and Angliss, 2013). For this reason, the number of sperm whales in the entire North Pacific stock is taken from Kato and Miyashita's (1998) estimate of 102,112 animals (CV=0.155). Since no densities of sperm whales have been estimated for this region, the density of 0.00123 animals/km^2 (Fulling et al., 2011), calculated from the winter/spring survey around Guam and the Mariana Islands, is the best representative estimate for this model area. This is comparable to the density estimate of sperm whales in the Hawaii EEZ (0.00158 animals/km^2; Forney et al., 2015).

Spinner dolphin: Records of spinner dolphins are not mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993), and no data on density or abundance estimates for this species are available (Miyashita, 1993). Lacking data on abundance or density estimates for the WNP stock of spinner dolphins, Ferguson and Barlow's (2001, 2003) abundance of 1,015,059 animals derived from the ETP, while the density estimated by Barlow (2006) of 0.00083 animals/km^2 from the offshore stratum of the outer Hawaiian EEZ are considered most appropriate to represent this stock in this model area; no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013).

Striped dolphin: Kasuya and Perrin (2017) recognize a southern offshore population, with an abundance estimate of 52,682 individuals (Miyashita, 1993). Density, 0.0164 animals/km^2, was estimated as one-half of Miyashita's (1993) density estimate from off southern Japan/east Taiwan. This is higher than the density estimate of striped dolphins in the Hawaii EEZ (0.0084 animals/km^2; Bradford et al., 2013).

D-4. MODEL AREA 4—GUAM

Eldredge (1991) compiled the first list of published and unpublished records or marine mammals in the waters of the Guam and the lower Marianas Islands, reporting 19 species. The waters in the vicinity of Guam and nearby Marianas Islands were most recently surveyed for marine mammals from January to April 2007 (Fulling et al., 2011), in August 2007 (Mobley, 2007), and from February to March 2010, when waters around Guam and Saipan were surveyed by small-boat (Ligon et al., 2011).

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage around Guam, there was some coverage near the Kamchatka Peninsula, along the western Aleutian Islands chain, and near Hawaii. All calls recorded near Kamchatka and along the Aleutians were northwest Pacific blue whale calls, whereas calls around Hawaii were split between northwest (30 percent) and northeast (70 percent) Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the North Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977; Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Bryde's whale: The IWC provides the best available population estimate for the WNP stock at 20,501 whales (IWC, 2009). Sightings from the Fulling et al. (2011) 2007 surveys in the Marianas region produced an abundance of 233 Bryde's whales. The best available density estimate (0.00041 animals/km^2) is calculated from the winter/spring survey around Guam and the Mariana Islands (Fulling et al., 2011). The Fulling et al. (2011) density is comparable to density estimates from the ETP (0.0009/km^2) (Ferguson and Barlow, 2001, 2003) and the Hawaii EEZ (0.00033 animals/km^2; Bradford et al., 2013).

Common minke whale: Several stocks of minke whales are recognized in the western North Pacific Ocean, including the western North Pacific "O" east (WNP OE) stock, and the western North Pacific "J" west (WNP JW) stock (Miyashita & Okamura, 2011; Wade & Baker, 2011). Minke whales potentially occurring in the waters of this model area are believed to be part of the "WNP OE" stock. Minke whales were heard but not sighted during recent surveys in Guam and the Mariana Islands waters (Fulling et al., 2011), with a density estimate of 0.00015 animals/km^2 (Norris et al., 2017) . Buckland et al. (1992) conducted sighting surveys during July and August in the western North Pacific Ocean and Sea of Okhotsk, from which the abundance estimate, 25,049 individuals, was derived. The best available density estimate for common minke whales in this region is based on the Ferguson and Barlow (2001; 2003) computed density estimates (0.0003 animals/km^2) in offshore areas of the ETP.

Fin whale: Fin whales are not typically expected to occur south of 20°N (Mizroch et al., 2009), and during recent surveys, no fin whales were detected (Fulling et al., 2011). Due to the lack of data available for fin whales in this region, any rare fin whales potentially occurring in this region are considered part of the WNP stock, with an abundance estimated as 9,250 whales (Tillman, 1977; Mizroch, 2009). The nominal minimum density estimate of 0.00001 was used, which is comparable to the average calling fin whale density estimate of 0.000027 animals/km^2 by McDonald and Fox (1999) based on recordings north of Oahu, Hawaii and similar to that estimated from a shipboard line-transect survey around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are only expected to occur in the Guam model area during winter, spring, and fall. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales, which has increased annually to an abundance estimate of 1,328 individuals (Calambokidis et al., 2008; Bettridge et al., 2015). A density of 0.00089 animals/km2 was estimated for the WNP stock of humpback whales (Calambokidis et al., 2008; LGL, 2008).

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) was used (0.00004 animals/km^2).

Sei whale: The IWC recognizes one stock of sei whales in the North Pacific (Donovan, 1991), although some evidence exists for several populations (Carretta et al., 2015). Very few sightings of sei whales have occurred in any region of the North Pacific. Until the recent survey conducted in the waters of the Mariana Islands (Fulling et al., 2011), during which a total of 16 sei whale sightings were observed, sei whales were considered rare in the Marianas region. The best density estimate is 0.00029 animals/km^2, derived from the 2007 surveys (Fulling et al., 2011). This is similar to that calculated for around Hawaii (0.00016 animals/km^2; Bradford et al., 2017). The Marianas 2007 surveys derived an abundance estimate of 177 animals, which is similar to other site-specific estimates in the eastern North Pacific where limited sightings have occurred (Carretta et al., 2015). Tillman (1977) derived an abundance estimate of 8,600 individuals for sei/Bryde's[42] whale in the North Pacific from whaling catch statistics. Mizroch et al. (2015) estimated the size of the pelagic migratory stock in 1975 at approximately 4,000 animals, but their "single stock" (coastal and pelagic) state space analysis estimated a population size of 7,000 animals in 1974, which is used here as the best available data. Initial estimates for a portion of the sei whale population off Japan indicate abundance estimates of similar magnitude (7,744 for May to June and 5,406 for July to September; Hakamada et al., 2009).

Blainville's beaked whale: The density estimate of 0.00086 animals/km^2 (CV=1.13) derived for the Hawaii EEZ (Bradford et al., 2017) is the most appropriate for this species in this model area. Lacking abundance data for this region, Ferguson and Barlow's (2001 and 2003) abundance estimate from the eastern Pacific that included the *Mesoplodon densirostris* estimate added to one-fifth of the *Mesoplodon* spp. abundance estimate, resulting in a total of 8,032 animals, was considered best to represent the WNP stock. Bradford et al.'s (20017) density estimate is comparable to that for Blainville's beaked whales in the eastern Pacific (0.0013 animals/km^2; Ferguson and Barlow, 2003), in the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001), and the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296/km^2; Ferguson et al., 2006).

Common bottlenose dolphin: Kasuya and Perrin (2017) define a WNP Southern Offshore Stock for this region. Kanaji et al. (2018) report an abundance estimate of 40,769 individuals. The best available density estimate, 0.00899 animals/km^2 (CV=0.57), is calculated from the Hawaii EEZ survey data (Bradford et al., 2017). This density is comparable to that derived for this species in the eastern North Pacific at similar latitudes (0.0025 animals/km^2) (Ferguson and Barlow, 2003).

Cuvier's beaked whale: With few population data available for the western North Pacific Ocean, the best data available density and abundance estimates for the WNP stock of Cuvier's beaked whales are 0.0003 animals/km^2 (CV=0.69) for the Hawaii EEZ (Bradford et al., 2017) and 90,725 animals from the ETP (Ferguson and Barlow, 2001, 2003). The Hawaii density is less than the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Deraniyagala beaked whale: Dalebout et al. (2014) conducted genetic and molecular analyses to demonstrate that *Mesoplodon hotaula* was genetically distinct from the ginkgo-toothed beaked whale (*M. ginkgodens*). Little is known about this beaked whale species, and no abundance or stock information is available for the Deraniyagala beaked whale. Given that this species was synonymous with the ginkgo-toothed beaked whale, which is part of the *Mesoplodon* spp. complex, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001,

2003) northernmost strata, a density estimate of 0.00093 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the Deraniyagala beaked whale in this model area.

Dwarf sperm whale: Ferguson and Barlow's (2001 and 2003) derived an abundance estimate for *Kogia* spp. of 350,553 in the ETP, which is the most appropriate to use as an abundance proxy for the dwarf sperm whale in the Guam area. The 0.0071 animals/km^2 (CV=0.74) for dwarf sperm whales derived for the Hawaii EEZ (Barlow, 2006) is the best available density for the dwarf sperm whale in the Guam region.

False killer whale: Miyashita (1993) estimated the abundance of false killer whales as 16,668 animals (CV=0.263) from 34 sighting cruises associated with the Japanese drive fishery. The best available density estimate (0.0011 animals/km^2) for the WNP Pelagic stock is calculated from the winter/spring surveys in the waters of Guam and the Mariana Islands (Fulling et al., 2011). This is comparable to the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015.

Fraser's dolphin: With few population data available for the WNP stock, the estimated density of 0.02104 animals/km^2 (CV=0.66) (Bradford et al., 2017) and abundance of 16,992 (Bradford et al., 2013) for Fraser's dolphins in Hawaiian waters is the most appropriate in this model area. Although Fraser's dolphins are estimated to occur regularly and year-round in the Mariana region's waters of the Guam model area, no Fraser's dolphins were observed during the 2007 surveys of this area (Fulling et al., 2011).

Ginkgo-toothed beaked whale: Since no data on density or stock estimates are available for this species, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density estimate of 0.0009 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the ginkgo-toothed beaked whale in this model area.

Killer whale: Killer whales are considered rare with limited sightings reported, and during the 2007 surveys of this area, no killer whales were observed (Fulling et al., 2011; Carretta et al., 2015). The best available density estimate, 0.00006 animals/km^2 (CV=0.96), is for killer whales in the Hawaii EEZ (Bradford et al., 2017). An abundance of 12,256 animals was estimated by Ferguson and Barlow (2001 and 20003) and is the most appropriate for this region. Mobley et al. (2000) did not report any sightings in their surveys of waters within 25 nm of the Main Hawaiian Islands.

Longman's beaked whale: Few population data are available for this rarely observed beaked whale. No density estimates for Longman's beaked whales are available from the Mariana Islands area (Fulling et al., 2011), so the best available data are a density estimate of 0.00311 animals/km^2 (CV = 0.66) and an abundance estimate of 7,619 animals estimated for offshore Hawaiian waters (Bradford et al., 2013, 2017).

Melon-headed whale: Kanaji et al. (2018) estimated abundance for the Pacific coast of Japan (56,213 animals; CV=0.58). The best available density (0.00428 animals/km^2) estimates for the melon-headed whale's Northern Mariana Island stock found in this model area are derived from the winter/spring 2007 surveys around Guam and the Mariana Islands (Fulling et al., 2011). This is higher than the density estimate calculated in nearshore Hawaii waters (0.0021 animals/km^2) during the spring, summer and fall (Mobley et al., 2000).

Pantropical spotted dolphin: Gilpatrick et al. (1987) cited a known distribution of pantropical spotted dolphins east of Japan. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43). The best available density estimate, 0.0226 animals/km^2, is calculated from the winter/spring surveys around Guam and the Mariana Islands (Fulling et al., 2011). This density is greater than that observed in the Hawaii EEZ (0.00369 animals/km^2; Forney et al., 2015) and comparable to that observed in nearshore waters of Hawaii (0.0407 animals/km^2; Mobley et al., 2000).

Pygmy killer whale: One sighting of six animals was observed during the 2007 surveys around the Mariana Islands, from which a density estimate (0.00014 animals/km^2) was derived (Fulling et al., 2011). Data from the eastern North Pacific was used to derive a stock-wide abundance estimate (30,214 animals) (Ferguson and Barlow, 2001 and 2003) for the WNP stock of pygmy killer whales. The density for this model area for this species is an order of magnitude less than that observed in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017), but no pygmy killers were sighted in nearshore Hawaii waters (Mobley et al., 2000).

Pygmy sperm whale: Ferguson and Barlow's (2001 and 2003) derived an abundance estimate for *Kogia* spp. of 350,553 for in the ETP, which is the best estimate available for the WNP stock in the Guam model area. The combined densities of 0.00291 animals/km^2 (CV=1.12) for pygmy sperm whales was derived for the Hawaii EEZ (Barlow, 2006) and was used for this species in the Guam model area. Mobley et al. (2000) observe two pods of five individuals during the 1993 to 1998 surveys in Hawaii, but no density or abundance estimates were derived.

Risso's dolphin: Neither Fulling et al. (2011) or Mobley et al. (2000) collected sufficient sighting data to derive density or abundance estimates for this species. Kanaji et al. (2018) report a WNP stock estimate of 143,374 animals (CV=0.69). The density estimate of 0.00474 animals/km^2 (CV=0.43) used for the WNP stock in this model area was derived from surveys in the Hawaii EEZ (Bradford et al., 2017). This density is comparable to the density estimate calculate for the eastern North Pacific (0.0007 animals/km^2; Ferguson and Barlow, 2003).

Rough-toothed dolphin: Rough-toothed dolphins are reportedly rare off Japan and in the heavily studied ETP. Since there are no data on abundance or density estimates for the WNP stock of rough-toothed dolphins, the best available density estimate (0.00185 animals/km^2) is from LGL (2011). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific).

Short-finned pilot whale: The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). Using the results of Miyashita (1993), an abundance estimate of 31,396 individuals (CV=0.65) was calculated for the WNP southern stock. The best available density estimate (0.00797 animals/km^2, CV=0.49) is calculated from the Hawaii EEZ (Bradford et al., 2017). This density is an order of magnitude less than in nearshore Hawaii waters (0.0237 animals/km^2) during the spring, summer and fall (Mobley et al., 2000).

Sperm whale: Insufficient population-level data exist to currently adequately define the stock structure of sperm whales in the North Pacific, except in U.S. EEZ waters, where for management purposes, three stocks have been defined: a North Pacific stock that migrates between Alaska and the western North Pacific, a central North Pacific stock around Hawaii, and a California/Oregon/Washington stock off the

U.S. west coast (Allen and Angliss, 2014). Further, NMFS considers both currently available and historical population estimates for the North Pacific stock to be unreliable (Allen and Angliss, 2014). The IWC recognizes two stocks in the North Pacific Ocean (eastern and western stocks), but stock boundaries delineation and review by the IWC are woefully out of date (Donovan, 1991). Sperm whales in the Guam model area are part the NP stock. Since an abundance estimate is needed for the calculation of impacts, the best available abundance estimate for the NP stock is the estimate of 102,112 individuals (Kato and Miyashita, 1998). In the 2007 surveys of the southern Mariana Islands, including Guam, Fulling et al. (2011) reported that the sperm whale was the most frequently encountered marine mammal. The density estimated for sperm whales in waters of the southern Marianas Islands, 0.00123 animals/km^2, was calculated from the 2007 winter/spring surveys reported in Fulling et al. (2011). This is comparable to the density estimate of sperm whales in the Hawaii EEZ (0.00158 animals/km^2; Forney et al., 2015).

Spinner dolphin: Although a stock structure incorporating an inshore (insular) and pelagic stock of spinner dolphins has been suggested for the Marianas region following the stock delineation for the species in the Hawaiian archipelago (i.e., DoN, 2013a), currently sufficient population level abundance data are not available to designate insular and pelagic stocks of spinner dolphins, as are needed for computation of the percentage of the stocks affected by SURTASS LFA sonar. Similarly, in the American Samoan Islands, NMFS currently is only able to define one stock of spinner dolphins, and no stocks are designated in the Marianas Islands (Carretta et al., 2014). Thus, for the purposes of this LOAs application, spinner dolphins in the Marianas region are estimated to be part of the WNP stock, with an estimated abundance of 1,015,059 animals, as derived from Ferguson and Barlow (2001, 2003) ETP data estimates. Further, the best available density estimate for the WNP stock of spinner dolphins, 0.00083 animals/km^2, is derived from the Hawaiian pelagic survey data (Barlow, 2006); no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013). The density of Barlow (2006) is an two orders of magnitude less than that observed in nearshore waters of Hawaii (0.0443 animals/km^2; Mobley et al., 2000).

Striped dolphin: Kasuya and Perrin (2017) recognize a southern offshore population, with an abundance estimate of 52,682 individuals (Miyashita, 1993). The best available density estimate (0.00616 animals/km^2) is calculated from the winter/spring survey around Guam and the Mariana Islands (Fulling et al., 2011). This is comparable to that observed in the Hawaii EEZ (0.0084 animals/km^2; Bradford et al., 2013) and in nearshore waters of Hawaii (0.0016 animals/km^2; Mobley et al., 2000).

D-5. MODEL AREA 5—SEA OF JAPAN

Bryde's whale: Omura (1977) refers to four major whaling grounds on the coast of Japan: waters off Bonin Islands, Sanriku, Wakayama (Taiji), and West Kyushu, although none of these are located in the Sea of Japan. However, Evans (1987) described the Bryde's whale range from northern Japan to the equator in the western North Pacific. Considering habitat preferences (e.g., water temperature, bathymetry), the best density data available are the long-term time series from the ETP (Ferguson and Barlow, 2001 and 2003), with an appropriate density estimate (0.0001 animals/km^2) to represent the WNP stock in this area. The IWC population estimate of 20,501 whales for the WNP stock was used for in analyses for this model area (IWC, 2009). Bradford et al. (2013) observed Bryde's whales around the Hawaiian Islands, calculating a similar density estimate (0.00033 animals/km^2) to that derived for the WNP stock.

Common minke whale: Minke whales have been reported from the Sea of Okhotsk, Sea of Japan, and East China Sea (Yellow Sea), with recent sighting surveys by Japan and Korea designed to update abundance through the International Whaling Commission (Miyashita and Okamura, 2011). In addition, the stock structure is being re-evaluated, with the current hypothesis that there are five stocks: one in the Yellow Sea ("Y" stock), one in the Sea of Japan ("JW" stock), a J-like stock along the Pacific coast of Japan ("JE" stock), and two O-like stocks in the nearshore and offshore Western North Pacific ("OE" and "OW" stocks, respectively) (Wade and Baker, 2011). Minke whales in the Sea of Japan are believed to be from the JW stock. The sighting surveys from Japan and Korea estimate an abundance for the JW stock of 2,611 animals (Miyashita and Okamura, 2011), with a density of 0.00016 animals/km^2 extrapolated from the eastern North Pacific (Ferguson and Barlow, 2001, 2003).

Fin whale: Fin whales are known to winter in the Sea of Japan, with documented catches occurring in all months from September through May (Mizroch et al., 2009). There is some suggestion that animals may occur year-round, though this is based on a limited sample size. An historic stock estimate for the WNP stock of fin whales, 9,250 animals, was derived from encounter rates of Japanese scouting boats in the northwest Pacific (Tillman, 1977). The current density estimate (0.0009 animals/km^2) for the WNP stock is roughly estimated from data of the ETP (Ferguson and Barlow, 2001, 2003), which is an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

North Pacific right whale: The western North Pacific right whale population is considered distinct from the eastern population, arbitrarily separated by the 180° line of longitude (Best et al., 2001). The Okhotsk Sea, Kuril Islands, and eastern Kamchatka coast represent major feeding grounds for the western population (Brownell et al., 2001) where animals are typically found May through September (Clapham et al., 2004). Various areas have been proposed for breeding and calving grounds, including the Ryukyu Islands, Yellow Sea, Sea of Japan, offshore waters far from land, and the Bonin Islands, but a lack of winter sightings (December to February) makes a definitive assessment impossible (Brownell et al., 2001). Clapham et al. (2004) note the extensive offshore component to the right whale's distribution in the 19th century data. Movement north in spring (peak months of February to April) and south in fall (peak months September to December) suggest the possibility of two putative sub-populations in the western population that are kept apart by the Japanese islands, though this seems unlikely (Brownell et al., 2001, Clapham et al., 2004). Data from Japanese sighting cruises in the Okhotsk Sea provide an abundance estimate of 922 animals (CV=0.433, 95% CI=404 to 2,108) (Best et al., 2001) for the WNP population. No density estimates are available for this very rare marine mammal species, therefore, the nominal minimum density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during winter and spring seasons.

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) was used (0.00004 animals/km^2).

Western North Pacific gray whale: Gray whales in the western North Pacific Ocean are genetically distinct from those gray whales occurring in the eastern North Pacific Ocean (LeDuc et al., 2002). New data photographing western North Pacific gray whales off the U.S. west coast has prompted NMFS to draft the first ever stock assessment report for this population (Carretta et al., 2015). The present day distribution of the WNP gray whale stock appears to range from summering grounds in west central

Okhotsk Sea off the northeast coast of Sakhalin Island to wintering grounds in the South China Sea (Meier et al., 2007; Weller et al., 2002). However, some individuals that summer off Sakhalin Island have also been documented off the west coast of North America (Carretta et al., 2015). The WNP stock of gray whales migrates through the Sea of Japan in November to December. The exact migration route is not known, and Omura (1988) indicated that gray whales were caught along the Chinese and North Korea coasts in the Sea of Japan. Gray whales presumably maintain a shallow water/nearshore affinity throughout the southern portion of their range. Photo-identification studies off Sakhalin Island estimate a population size of 140 (CV=0.043) animals in the WNP stock (Cooke et al., 2013; Carretta et al., 2015). With no density estimate for this rare species available, a minimal density of 0.0001 animals/km^2 was used in risk computation for this model area to reflect the extremely low potential for this species occurring.

Baird's beaked whale: Kasuya (1986) reported catches of Baird's in the Sea of Japan around approximately 37°N (Toyama Bay) and off southern Hokkaido (41°-42°N). From Kasuya's (1986) encounter rate and effective search widths, a density of 0.0003 animals/km^2 was derived for a region from about 32° to 40°N and seaward of the Pacific Japanese coast out to about 150°E. This density estimate is comparable to that derived from the ETP by Ferguson and Barlow, 2001 and 2003. Kasuya and Perrin (2017) cited an abundance estimate by Miyashita (1986, 1990) of 5,688, and is the abundance estimated for the WNP stock of Baird's beaked whales.

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). The best density estimate (0.1158 animals/km^2) and abundance estimate (279,182 animals) are from a line-transect survey off the North American west coast (Carretta et al., 2011a).

Common bottlenose dolphin: Kishiro and Kasuya (1993) reported that bottlenose dolphins were caught at Ohmishima in Yamaguchi Prefecture in the Sea of Japan. Miyashita (1993) reported that reproductive differences suggest that animals from the Sea of Japan and East China Sea are members of an inshore Archipelago stock that are separate from animals in the WNP stock found in the waters of the western North Pacific Ocean. Kishiro and Kasuya (1993) cite Miyashita (1986) as estimating the abundance of the stock in the East China Sea as 35,046. Since these data represent only about one-third of the habitat of bottlenose dolphins in the East China Sea, the population estimate is tripled to derive an abundance for the inshore Archipelago stock estimate as 105,138 animals. No density estimates are available for the inshore Archipelago stock; therefore, the density estimate (0.00077 animals/km^2) was calculated from LGL (2011) data.

Cuvier's beaked whale: No density or stock estimate data are available for this region, but Leatherwood and Reeves (1983) state that Cuvier's beaked whales are relatively common in the Sea of Japan. Considering habitat preferences (e.g., water temperature, bathymetry), the best available density and abundance data are derived from Ferguson and Barlow (2001, 2003) ETP survey estimates, with a representative density for the WNP stock in this area estimated as 0.0031 animals/km^2 and an abundance estimated as 90,725 animals. This density estimate is greater than that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but comparable to the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Dall's porpoise: Dall's porpoise are found only in the North Pacific, primarily north of 36°N in the western North Pacific Ocean. This species has two distinct color morphs: one with a white flank patch that extends forward to the dorsal fin (*dalli* type) and one with a flank patch extending all the way to the front flippers (*truei* type). These morphological differences have been noted between animals from the Pacific coast of Japan (the *truei*-type), the Sea of Japan, and Sea of Okhotsk (the *dalli*-type), and the offshore northwestern Pacific and western Bering Sea (the *dalli*-type) (Hayano et al., 2003). Hayano et al. (2003) conducted genetic studies on the three populations and found a low, but significant, difference between the Sea of Japan-Okhotsk population and the other two populations. Based on surveys of the eastern North Pacific, a density estimate of 0.0520 animals/km^2 (Ferguson and Barlow, 2001, 2003)and an abundance estimate of 76,720 animals (IWC, 2008) best represent the Sea of Japan stock in this model area. This density estimates a concentration of Dall's porpoises probably larger than what would be encountered by LFA operations in the Sea of Japan since it includes survey effort in nearshore waters where animals are more often found.

False killer whale: Kishiro and Kasuya (1993) reviewed the history of Japanese coastal whaling, reporting that false killer whales were caught in the Sea of Japan along the Noto coast of Japan. Miyashita (1993) suggested that animals summering in the Sea of Japan were probably from a separate, inshore Archipelago stock, by analogy from Pacific white-sided dolphins, than animals found in the western North Pacific. Kishiro and Kasuya (1993) cited Miyashita (1986) as estimating the population wintering in Iki Island waters (in the Korea Strait) and part of the East China Sea at 3,259 animals. Since these data represent only about one-third of the habitat of false killer whales in the East China Sea, the population estimate is tripled for the inshore Archipelago stock estimate of 9,777 animals. This is smaller than the estimated abundance of false killer whales off the Pacific coast of Japan (16,668 animals CV=0.263) (Miyashita, 1993). Since no sightings of false killer whales were made during the survey effort in the Sea of Japan and East China Sea (Miyashita, 1993), the density estimate (0.0027 animals/km^2) for this inshore Archipelago stock is derived from the northernmost region of eastern North Pacific (Ferguson and Barlow, 2001 and 2003). This is higher than the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015.

Harbor porpoise: Little is known about the harbor porpoises that are found off the northern coasts of Japan (Gaskin et al., 1993). Off the U.S. east coast and U.S. west coast, animals are found almost exclusively at water depths of less than 100 m (323 ft) (Read and Westgate, 1997; Carretta et al., 2001) and fine-scale stock structure exists (Carretta et al., 2014; Waring et al., 2014). Preliminary analysis of mitrochondrial DNA suggests that Japanese harbor porpoise group with Alaskan animals to form a genetically distinct group (Taguchi et al., 2010).Therefore, using survey data corrected for sighting biases, the abundance estimate (31,046 animals) and density estimate (0.019 animals/km^2) of the Gulf of Alaska stock are most appropriate (Hobbs and Waite, 2010; Allen and Angliss, 2014).

Killer whale: Killer whales are considered rare with limited sightings reported (Carretta et al., 2014). The best available density estimate (0.00009 animals/km^2) was derived from LGL (2011) data. The most representative abundance estimate of 12,256 animals for the WNP stock was calculated from the Ferguson and Barlow's (2001 and 2003) eastern North Pacific data. Mobley et al. (2000) did not report any sightings in their surveys of waters within 25 nm of the Main Hawaiian Islands, nor did the Fulling et al. (2011) surveys around the Mariana Islands.

***Kogia* spp.:** With no available population data available for the WNP stock in the Sea of Japan, Ferguson and Barlow's (2001, 2003) abundance estimated for *Kogia* spp. of 350,553 in the ETP and their density of

0.0017 animals/km^2 were deemed the best estimate available for the Sea of Japan area. Mobley et al. (2000) observe two pods of five individuals during the 1993 to 1998 surveys in Hawaii, but no density or abundance estimates were derived.

Pacific white-sided dolphin: Recent research on genetic differentiation suggests that animals found in coastal Japanese waters and the Sea of Japan belong to a separate, inshore archipelago stock than animals found in offshore North Pacific waters (Hayano et al., 2004; Miyashita, 1993). Sighting surveys in the North Pacific were analyzed to estimate the abundance of Pacific white-sided dolphins as 931,000 individuals (Buckland et al. 1993). This estimate is over an order of magnitude larger than the abundance estimate in the eastern North Pacific (Ferguson and Barlow, 2001, 2003). Without any data for the inshore archipelago stock, it is roughly estimated that the abundance estimate from the WNP (931,000 animals) and the density estimate (0.0030 animals/km^2) from the ETP (Ferguson and Barlow, 2001, 2003) are most appropriate to represent the inshore archipelago stock. No sightings of Pacific white-sided dolphins were reported in Hawaii surveys (Barlow, 2006; Bradford et al., 2017; Mobley et al., 2000).

Risso's dolphin: Kishiro and Kasuya (1993) reported that Risso's dolphins were caught on islands in the Korea Strait. Miyashita (1993) reported sightings in the Sea of Japan during June surveys (no effort during other months) and suggested by analogy to bottlenose dolphins and Pacific white-sided dolphins that Risso's summering in the Sea of Japan represent a separate, inshore Archipelago stock separate from the WNP stock. There are no separate data reported for the Sea of Japan or East China Sea, however. Therefore, the WNP stock estimate (143,374 animals, CV=0.69; Kanaji et al., 2018) and density estimate (0.0073 animals/km^2) derived from the Pacific coast of Japan (Miyashita, 1993) are most appropriate to represent the inshore Archipelago stock that occurs in the Sea of Japan. This stock density is comparable to that observed in the Hawaii EEZ (0.0067 animals/km^2; Bradford et al., 2013), and no Risso's dolphins were observed in nearshore Hawaii waters (Mobley et al., 2000), or around Guam and the Mariana Islands (Fulling et al., 2011).

Rough-toothed dolphin: With the absence of population data for this dolphin in the Sea of Japan, the best available data are for the WNP stock of rough-toothed dolphins. The best available density estimate (0.00224 animals/km^2) is from habitat-based models in the central North Pacific (Forney et al., 2015). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. This density is comparable to that observed in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000).

Sperm whale: Stock structure of sperm whales in the North Pacific Ocean remains unclear except in U.S. EEZ waters (Allen and Angliss, 2014). Kasuya and Miyashita (1988) reported no Japanese whaling stations processing sperm whales in the Sea of Japan (Leatherwood and Reeves, 1983). Gregr and Trites (2001) reviewed sperm whale catch data off the coast of British Columbia to determine habitat preferences, and it is possible that the Sea of Japan provides adequate habitat conditions for sperm whales. The density, 0.00123 animals/km^2, estimated for sperm whales from the dedicated surveys in the waters around the Mariana Islands (Fulling et al., 2011) represents the best available density for this model area. Kato and Miyashita's (1998) sperm whale abundance estimate of 102,112 animals for the NP stock that migrates between Alaska and the western North Pacific is the best currently available for the overall stock. The Sea of Japan density is comparable to that (0.00158 animals/km^2) estimated for the main Hawaiian Islands (Forney et al., 2015).

Spinner dolphin: Gilpatrick et al. (1987) reported a high density of sightings in the Korea Strait and adjacent waters to the north but no spinner dolphin sightings were reported from the Sea of Japan. This species is not mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993), and there are no data on density or stock estimates (Miyashita, 1993). Thus, the best available density estimate (0.00083 animals/km^2) for possible occurrence in summer and fall is derived from the Hawaii EEZ (Barlow, 2006), which is an order of magnitude less than that observed in nearshore waters of Hawaii (0.0443 animals/km^2; Mobley et al., 2000); no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013). The best data available abundance estimate (1,015,059 animals) for spinner dolphins in the WNP stock is that derived from ETP surveys (Ferguson and Barlow, 2001, 2003).

Stejneger's beaked whale: Miyazaki et al. (1987) reported four Stejneger's beaked whales stranded in the Sea of Japan at about 37°N, 135°E. Density or stock estimate data are not available for the WNP stock in this region. Considering habitat preferences (e.g., water temperature, bathymetry), the most appropriate Stejneger's density estimate of 0.0005 animals/km^2 is derived from ETP data of Ferguson and Barlow (2001, 2003), with the most appropriate abundance (8,000 animals) approximated from that derived for the WNP stock of Baird's beaked whales (Kasuya, 1986).

Northern fur seal: Northern fur seals in this region are part of the Western Pacific stock. Northern fur seals only go ashore on their breeding grounds further north; after breeding and molting, many northern fur seals travel southward, where they remain at sea and may be found in this region during the winter and spring (Buckland et al., 1993; Allen and Angliss, 2015). The Western Pacific stock is estimated at 503,609 animals (Gelatt et al., 2015; Kuzin, 2015). Horimoto et al. (2016) estimated a density of 0.368 animals/km^2 in nearshore waters during winter, with half that density in spring.

Spotted seal: The Southern DPS of spotted seals consists of breeding concentrations in the Yellow Sea (particularly the Bohai Sea, both of which are northern parts of the East China Sea), and Peter the Great Bay (northwestern Sea of Japan). Beyond limited information on select haul-out locations, very little information exists on their spatial and/or seasonal distribution. The most current population estimate of the Southern DPS is 3,500 seals (Boveng et al., 2009; Han et al., 2010; Nesterenko and Katin, 2008). No density estimates are available, so a default minimum density estimate of 0.0001 animals/km^2 was estimated to reflect the very low probability of occurrence.

D-6. MODEL AREA 6—EAST CHINA SEA

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde's whales in the western North Pacific: Solomon Islands/Southeast Asia stock (mainly Philippine waters and the Gulf of Thailand), East China Sea, and offshore western North Pacific. Animals within this model area belong to the East China Sea (ECS) stock. The best available population estimate for the ECS stock is estimated by the IWC as 137 whales (IWC, 1996). Without survey information for the region, the best available density estimate is from the 2010 Hawaii EEZ survey (0.0003 animals/km^2; Bradford et al., 2013), which is comparable to the ETP (0.0009 animals/km^2; Ferguson and Barlow, 2001, 2003) and Guam and the Mariana Islands (0.00041 animals/km^2) (Fulling et al., 2011).

Common minke whale: Minke whales have been reported from the Sea of Okhotsk, Sea of Japan, and East China Sea (Yellow Sea), with recent sighting surveys by Japan and Korea designed to update abundance through the International Whaling Commission (Miyashita and Okamura, 2011). Minke whales in the East China Sea are believed to be part of the Yellow Sea "Y" stock, with an abundance estimate for the Y stock of 4,492 animals (Hakamada and Hatanaka, 2010; Miyashita and Okamura, 2011). A density estimate of 0.0018 animals/ km^2 (SE=0.17) was derived based on encounter rates (Buckland et al., 1992).

Fin whale: Fin whales winter in the East China Sea and Yellow Sea. The East China Sea population of fin whales is thought to be resident and is considered to represent a distinct population (Evans, 1987). There are limited data on distribution and abundance, however, for fin whales in this region (Mizroch et al., 2009). Density and stock estimates for the East China Sea stock of fin whales were thus derived from encounter rates of Japanese scouting boats in the northwest Pacific (Tillman, 1977; Mizroch et al., 2009), resulting in an abundance estimate of 500 individuals and a density estimate of 0.0002 animals/km^2. This density is comparable to density estimates in the ETP (Ferguson and Barlow, 2001, 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

North Pacific right whale: The WNP right whale population is considered distinct from the eastern population, arbitrarily separated by the 180° line of longitude (Best et al., 2001). The Okhotsk Sea, Kuril Islands, and eastern Kamchatka coast represent major feeding grounds for the western population (Brownell et al., 2001) where animals are typically found May through September (Clapham et al., 2004). Various areas have been proposed for breeding and calving grounds, including the Ryukyu Islands, Yellow Sea, Sea of Japan, offshore waters far from land, and the Bonin Islands, but a lack of winter sightings (December to February) makes a definitive assessment impossible (Brownell et al., 2001). Clapham et al. (2004) noted the extensive offshore component to the right whale's distribution in the 19th century data. Movement north in spring (peak months of February to April) and south in fall (peak months September to December) suggest the possibility of two putative sub-populations in the western population that are kept apart by the Japanese islands, though this seems unlikely (Brownell et al., 2001, Clapham et al., 2004). Data from Japanese sighting cruises in the Okhotsk Sea provide an abundance estimate of 922 animals (CV=0.433, 95% CI=404-2,108) (Best et al., 2001) for the WNP population. No density estimates are available for this very rare marine mammal species, therefore, the nominal minimum density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during winter and spring seasons.

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) was used (0.00004 animals/km^2).

Western North Pacific gray whale: Gray whales in the western North Pacific Ocean are genetically distinct from those gray whales occurring in the eastern North Pacific Ocean (LeDuc et al., 2002). New data photographing western North Pacific gray whales off the U.S. west coast has prompted NMFS to draft the first ever stock assessment report for this population (Carretta et al., 2015). The exact location of winter breeding grounds for this species is not known, though it is hypothesized that western Pacific gray whales overwinter in the East and South China Seas, in the vicinity of Korea and China (Evans, 1987, Omura, 1988). The exact migration route is not known, but western North Pacific gray whales are believed to migrate directly across the East China Sea, which is one of the few times that they leave their shallow, nearshore habitat (Omura, 1988). During migration, WNP gray whales may be found up to 741 km (400 nmi) offshore (Weller et al., 2002). In addition, some individuals that summer off Sakhalin Island have also been documented off the west coast of North America (Carretta et al., 2015). Photo-identification studies off Sakhalin Island estimate a population size of 140 (CV=0.043) animals in the WNP stock (Cooke et al., 2013; Carretta et al., 2015). With no density estimate for this rare species available, a minimal density of 0.0001 animals/km^2 was used in risk computation for this model area to reflect the extremely low potential for this species occurring.

Blainville's beaked whale: With no population data available for this species in the East China Sea, the best available data are the density estimate (0.0005 animals/km^2) and abundance estimate of 8,032 animals derived from the eastern Pacific survey data (Ferguson and Barlow, 2001, 2003). The *Mesoplodon densirostris* estimate was added to one-fifth of the *Mesoplodon* spp. abundance estimate for an estimate of 8,032 animals. The density estimate is comparable to that for Blainville's beaked whales in the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001), in the Hawaii EEZ (0.00086 animals/km^2; Bradford et al., 2017), and the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296/km^2; Ferguson et al., 2006).

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). The best density estimate (0.1158 animals/km^2) and abundance estimate (279,182 animals) are from a line-transect survey off the North American west coast (Carretta et al., 2011a).

Common bottlenose dolphin: Kishiro and Kasuya (1993) reported that bottlenose dolphins were caught in the Korea Strait and off Goto Island in the East China Sea. Miyashita (1993) reported that reproductive differences suggest that animals from the Sea of Japan and East China Sea are a separate, inshore Archipelago stock from animals in the western North Pacific. Kishiro and Kasuya (1993) cited Miyashita (1986) as estimating the abundance of the stock in the East China Sea as 35,046. Since these data represent only about one-third of the habitat of bottlenose dolphins in the East China Sea, this population estimate is tripled to represent the inshore Archipelago stock estimate (105,138 animals). No density estimates were available for this stock; therefore, a density estimate of 0.00077 animals/km^2 was derived from LGL (2011). This is appropriate since bottlenose dolphins were sighted in the East China Sea survey effort (Miyashita, 1993). This density estimate is lower than that of Mobley et al. (2000) estimate around Hawaii (0.0103 animals/km^2) but is more comparable to that derived for offshore waters around Hawaii (0.0025 animals/km^2; Bradford et al., 2013).

Cuvier's beaked whale: No density or stock estimate data are available for this region for Cuvier's beaked whales. Considering habitat preferences (e.g., water temperature, bathymetry) of this species elsewhere in the North Pacific Ocean, the best data available to represent the WNP stock are those derived for the ETP with a density estimate 0.0003 animals/km^2 and an abundance estimate of 90,725 animals (Ferguson and Barlow, 2001, 2003). This density estimate is comparable to that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017).

False killer whale: Miyashita (1993) suggested that animals summering in the eastern Asian continental seas are probably from a separate, inshore Archipelago stock than animals offshore in the western North Pacific (i.e., WNP stock) by analogy from Pacific white-sided dolphins. Kishiro and Kasuya (1993) cited Miyashita (1986) as estimating the population wintering in the East China Sea at 3,259 animals. Since these data represent only about one-third of the habitat of false killer whales in the East China Sea, the population estimate of 3,259 animals was tripled to represent the inshore Archipelago stock estimate (9,777 animals). There are no data on density estimates for the East China Sea. Thus, the best available density estimate (0.0011 animals/km^2) to represent the inshore Archipelago stock is derived from the winter/spring survey around Guam and the Mariana Islands (Fulling et al., 2011). This density is comparable to the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015).

Fraser's dolphin: Kishiro and Kasuya (1993) reported catches off the Pacific coast of Japan in drive fisheries. With no data available on stock or density estimates for the western North Pacific or the East China Sea, the population estimate (220,789 animals) from the ETP (Ferguson and Barlow, 2001, 2003) is most appropriate for application to this area, while Bradford et al.'s (2013) density estimate (0.0069 animals/km^2) derived for the Hawaiian EEZ is the most appropriate density for this model area.

Ginkgo-toothed beaked whale: Miyazaki et al. (1987) reported no strandings of ginkgo-toothed beaked whales in the East China Sea. Although the ginkgo-toothed beaked whales in the East China Sea probably represent a separate population from that of the offshore western North Pacific, no data are available for a distinct stock. With no data on density or stock estimates available for this species, density was roughly estimated as 0.0005 animals/km^2 and abundance estimated at 22,799 animals for *Mesoplodon* spp. at the same latitude from the eastern Pacific survey data (Ferguson and Barlow, 2001, 2003). This density estimate is an order of magnitude less than that for unidentified beaked whales in the Hawaii EEZ (0.0.0021 animals/km^2; Bradford et al., 2013) but comparable to the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Killer whale: Killer whales are considered rare with limited sightings reported (Carretta et al., 2014). The best available density estimate (0.00009 animals/km^2) is estimated from LGL (2011) data for the WNP stock while the best abundance estimate (12,256 animals) are derived from the eastern North Pacific by Ferguson and Barlow (2001, 2003). Mobley et al. (2000) did not report any sightings in their surveys of waters within 25 nmi of the Main Hawaiian Islands, nor did the Fulling et al. (2011) surveys around the Mariana Islands.

***Kogia* spp.:** At the latitude of this modeling area, *Kogia breviceps* and *Kogia sima* are both expected to occur. However, no density or abundance estimates are available for these species in this region. Summing the abundances of *Kogia breviceps, Kogia sima, and Kogia* spp. in the geographic strata defined by Ferguson and Barlow (2001, 2003), an overall abundance of 350,553 animals is computed in the ETP, and this abundance is thus deemed most appropriate to represent the WNP stock of *Kogia* spp. Reviewing density estimates calculated in the eastern Pacific Ocean at about 20°N (Ferguson and Barlow, 2001, 2003), a density estimate of 0.0017 animals/km^2 was considered the best available for this stock in this region. This density estimate is comparable to that derived for pygmy sperm whale (0.00291 animals/km^2 (CV=1.12) and dwarf sperm whale (0.00714 animals/km^2 (CV=0.74) observed within the Hawaii EEZ (Barlow, 2006).

Longman's beaked whale: Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings were south of 25°N. No population estimates are available for this beaked whale in this model area. Therefore, the density estimate of 0.00025 animals/km^2 derived from LGL (2011) data and the abundance estimate of 7,619 animals in offshore Hawaiian waters (Bradford et al., 2017) were considered best to represent the WNP stock, animals of which potentially occur in the East China Sea.

Melon-headed whale: Very few records of melon-headed whales are available for this region. The first record of melon-headed whales in Korean waters occurred in January 2009 with the stranding of an adult male reported from the southeast corner of the country (Kim et al., 2010). Melon-headed whales are probably uncommon in the colder waters of the East China Sea. The best available density estimate (0.00428 animals/km^2) to represent the WNP stock is calculated from the winter/spring survey around Guam and the Mariana Islands (Fulling et al., 2011). This is comparable to the density estimate calculated in nearshore Hawaii waters (0.0021 animals/km^2) during the spring, summer and fall (Mobley et al., 2000). An abundance estimate of 56,213 animals (CV=0.58) was derived from surveys off the Pacific coast of Japan (Kanaji et al., 2018).

Pacific white-sided dolphin: Recent research on genetic differentiation suggests that animals found in continental eastern Asian seas belong to a separate, inshore Archipelago (IA) stock than animals found in offshore North Pacific waters (Miyashita, 1993; Hayano et al., 2004). Sighting surveys in the North Pacific were analyzed to estimate the abundance of Pacific white-sided dolphins as 931,000 individuals (Buckland et al., 1993). This estimate is over an order of magnitude larger than the abundance estimate in the eastern North Pacific (Ferguson and Barlow, 2001, 2003). However, with no other data available to represent the IA population, the abundance of 931,000 animals was roughly estimated from the western North Pacific, and the density estimate (0.0028 animals/km^2) from the ETP (Ferguson and Barlow, 2001, 2003) was most appropriate to represent the occurrences of this dolphin in this area during winter and spring. No sightings of Pacific white-sided dolphins were reported in Hawaii surveys (Barlow, 2006; Mobley et al., 2000).

Pantropical spotted dolphin: Gilpatrick et al. (1987) reported some animals from along the chain of the Ryukyu Islands. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) and Miyashita's (1993) density estimated at 0.01374 animals/km^2 for the WNP stock is the best available. This density is comparable to those observed in the Hawaii EEZ (0.0067 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0407 animals/km^2; Mobley et al., 2000).

Pygmy killer whale: There was no mention of pygmy killer whale sightings in Japanese whaling records (Kishiro and Kasuya, 1993), and no data on density or stock estimates off Japan or Taiwan have been reported (Miyashita, 1993). The best available density estimate (0.00014 animals/km^2) is calculated from the winter/spring surveys around Guam and the Mariana Islands (Fulling et al., 2011). This is an order of magnitude less than that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017). No pygmy killer whales were seen in nearshore aerial during the spring, summer and fall (Mobley et al., 2000). An abundance of 30,214 animals was estimated from Ferguson and Barlow's (2001, 2003) eastern North Pacific data and is considered the best available to represent the WNP stock of pygmy killer whales.

Risso's dolphin: Kishiro and Kasuya (1993) reported that Risso's dolphin inhabit the East China Sea. Miyashita (1993) reported sightings in the East China Sea during June and September surveys (no effort during other months) and suggested, by analogy to bottlenose dolphins and Pacific white-sided dolphins, that animals summering in this area represent a separate, IA stock from the WNP stock. However, no population data have been reported for the Sea of Japan or East China Sea. Consequently, abundance estimated for the WNP stock (143,374 animals, CV=0.69; Kanaji et al., 2018) and density estimated as 0.0106 animals/km^2 (Miyashita, 1993) were used to represent the IA stock in this model area. For comparison, no density estimates were available from Mobley et al. (Mobley et al., 2000) and Fulling et al. (2011), and an estimate of 0.0067 animals/km^2 was reported in the offshore waters of Hawaii (Bradford et al., 2013).

Rough-toothed dolphin: With the absence of population data for this dolphin in the East China Sea, the best available data are for the WNP stock of rough-toothed dolphins. The best available density estimate (0.00224 animals/km^2) is from habitat-based models in the central North Pacific (Forney et al., 2015). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. This density is comparable to that observed in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000).

Sperm whale: Stock structure of sperm whales in the North Pacific Ocean remains unclear except in U.S. EEZ waters (Allen and Angliss, 2014), and all sperm whales occurring in the North Pacific are currently classified as one stock, the NP stock. De Boer (2000) sighted sperm whales in the South China Sea and suggested that whales seen west of the Balabac Strait might be migrating between the South China and Sulu Seas. Based on such movements, sperm whales might also be found in the East China Sea, where habitat characteristics suggest that conditions are conducive for sperm whale occurrence. The best available abundance estimate for the sperm whales potentially occurring in the East China Sea model area is that of the NP population of sperm whales, 102,112 individuals (CV=0.155), which was derived by Kato and Miyashita (1998). The most appropriate density estimate (0.00123 animals/km^2) is derived from recent survey data collected in the southern Mariana Islands (Fulling et al., 2011). This density estimate is comparable to the Forney et al. (2015) Hawaii estimate (0.00158 animals/km^2).

Spinner dolphin: Gilpatrick et al. (1987) reported a high density of spinner dolphin sightings in the Korea Strait and adjacent waters to the north, but no spinner dolphin sightings were reported from the East China Sea. Neither is this species mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993), and no data on density or stock estimates are available (Miyashita, 1993). Given this lack of available data, the best available density estimate (0.00083 animals/km^2) is calculated from the Hawaii EEZ survey data (Barlow, 2006), which is an order of magnitude less than that observed in nearshore waters of Hawaii (0.0443 animals/km^2; Mobley et al., 2000); no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013). The best data available abundance estimate for spinner dolphins is (1,015,059 animals) is derived from surveys of the ETP (Ferguson and Barlow, 2001, 2003).

Spotted seal: The Southern DPS of spotted seals consists of breeding concentrations in the Yellow Sea (particularly the Bohai Sea, both of which are northern parts of the East China Sea) and Peter the Great Bay (northwestern Sea of Japan). Beyond limited information on select haul-out locations, very little information exists on their spatial and/or seasonal distribution. The most current population estimate of the total Southern DPS is 3,500 seals, though an estimated population of approximately 1,000 animals occur in the Bohai Sea, so this value was used for the abundance in this model area (Boveng et al., 2009; Han et al., 2010; Nesterenko and Katin, 2008). No density estimates are available, so a default minimum density estimate of 0.0001 animals/km^2 was estimated to reflect the very low probability of occurrence.

D-7. MODEL AREA 7—SOUTH CHINA SEA

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde's whales in the western North Pacific: Solomon Islands/Southeast Asia stock (mainly Philippine waters and the Gulf of Thailand), East China Sea, and offshore western North Pacific. Bryde's found in this model area are considered part of the WNP stock. De Boer (2000) sighted Bryde's whales in this region but reported no stock data; therefore, the IWC (2009) population estimate of 20,501 whales is considered the most appropriate. Ohsumi's (1977) western North Pacific density estimate is most appropriate (0.0006 animals/km^2) and is comparable to that derived by Fulling et al. (2007) (0.00041 animals/km^2) in Mariana waters, Bradford et al. (2013) (0.00033 animals/km^2) in Hawaiian waters, and Ferguson and Barlow (2001, 2003) for the ETP.

Common minke whale: Minke whales have been reported from the Sea of Okhotsk, Sea of Japan, and East China Sea (Yellow Sea), with recent sighting surveys by Japan and Korea designed to update abundance through the International Whaling Commission (Miyashita and Okamura, 2011). No recent surveys have occurred in the South China Sea, but to be conservative, minke whales from the Yellow Sea "Y" stock are estimated to be present, with an abundance estimate for the Y stock of 4,492 animals (Hakamada and Hatanaka, 2010; Miyashita and Okamura, 2011). A density estimate of 0.0018 animals/km^2 (SE=0.17) was derived based on encounter rates (Buckland et al., 1992).

Fin whale: De Boer (2000) conducted a research cruise in the Indian Ocean Sanctuary and the South China Sea from 29 March to 17 April, 1999, during which fin whales and a sperm whale were sighted west of the Balabac Strait, suggesting a possible migration route of these species between the South China Sea and the Sulu Sea. De Boer's cruise is the first record of fin whales in the South China Sea (De Boer, 2000). A population of fin whales is thought to be resident and may represent a distinct East China Sea population (Evans, 1987). Without any population data for fin whales in the South China Sea, data from the WNP stock are estimated to be most appropriate to represent fin whales in this model area (Mizroch et al., 2009). Density (0.0002 animals/km^2) and abundance (9,250 animals) estimates were derived from encounter rates of Japanese scouting boats in the northwest Pacific (Tillman, 1977). This density is comparable to density estimates in other areas of the ETP (Ferguson and Barlow, 2001, 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are only expected to occur in the South China Sea model area during winter, spring, and fall. In addition, approximately one-quarter of the population is expected to be found in water depths of less than 1,000 m (3,281 ft), which was implemented in the modeling as a depth aversion. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales (Calambokidis et al., 2008), which has increased annually to an abundance estimate of 1,328 individuals (Bettridge et al., 2015). A density of 0.00036 animals/km^2 was estimated for the WNP stock of humpback whales (Calambokidis et al., 2008; LGL, 2008).

North Pacific right whale: During limited survey effort in the South China Sea, no observations of right whales have ever been reported in the area (Clapham et al., 2004). In addition, right whales migrate further north to feed during summer, and are thus not expected in this model at that time of year. Right whales are likely to occur in the South China Sea primarily during winter but also may be found in these waters as they migrate north and south in spring. Due to the lack of population level data for the North Pacific right whale in this region, an abundance estimate of 922 animals derived from Japanese sighting cruises in the Okhotsk Sea (Best et al., 2001) was used for this model area. No density estimates are available for this very rare marine mammal species, therefore, the nominal minimum density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during winter and spring seasons.

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) was used (0.00004 animals/km^2).

Western North Pacific gray whale: Gray whales found in the western and eastern North Pacific are genetically and distributionally distinct (LeDuc et al., 2002). New data photographing western North Pacific gray whales off the U.S. west coast has prompted NMFS to draft the first ever stock assessment report for this population (Carretta et al., 2015). Gray whales are expected to occur principally in this model area during the winter season but also may occur in these waters as they migrate north and south during spring and fall. Exact wintering grounds of this species are not known but are believed to be located in the South China Sea, in the vicinity of Korea, and China (Evans, 1987; Omura, 1988). Presumably, gray whales maintain a shallow water/nearshore affinity throughout this southern portion of their range. The exact migration route of gray whales in the western North Pacific is not known, but they are believed to migrate directly across the East China Sea, which is one of the few times that they leave their shallow, nearshore habitat (Omura ,1988). During this time, they may be found up to 741 km (400 nmi) offshore (Weller et al., 2002). In addition, some individuals that summer off Sakhalin Island have also been documented off the west coast of North America (Carretta et al., 2015). Photo-identification studies off Sakhalin Island estimate a population size of 140 (CV=0.043) animals in the WNP stock (Cooke et al., 2013; Carretta et al., 2015). With no density estimate for this rare species available, a minimal density of 0.0001 animals/km^2 was used in risk computation for this model area to reflect the extremely low potential for this species occurring.

Blainville's beaked whale: Miyazaki et al. (1987) did not report any strandings of *M. densirostris* from the South China Sea. Neither De Boer (2000) nor Miyashita et al. (1996) observed any *M. densirostris* during their research cruises. Lacking data on stock or density estimates for the western North Pacific for this species, data from the ETP surveys (Ferguson and Barlow, 2001, 2003) are most appropriate to represent this species in this model area. The *Mesoplodon densirostris* estimate added to one-fifth of the *Mesoplodon* spp. abundance estimate in the ETP data results in an abundance estimate of 8,032 animals while the *Mesoplodon* spp. density estimate, 0.0005 animals/km^2, is best for use at this area (Ferguson and Barlow, 2001, 2003). This density estimate can be compared to that for Blainville's beaked whales in the Hawaii EEZ (0. 00086 animals/km^2; Bradford et al., 2017), in the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001), and the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). The best density estimate (0.1158 animals/km^2) and abundance estimate (279,182 animals) are from a line-transect survey off the North American west coast (Carretta et al., 2011a).

Common bottlenose dolphin: Smith et al. (1997) reported that bottlenose dolphins are found in "whale temples" in South China Sea nations. Miyashita (1993) reported that reproductive differences suggest that animals from the Sea of Japan and East China Sea are a separate, IA stock than animals in the western North Pacific. It is highly likely that bottlenose dolphins found in the Sea of Japan, East China Sea, and South China Sea belong to the same IA stock. For this reason, the stock of bottlenose dolphins in the South China Sea is classified as part of the IA stock. Kishiro and Kasuya (1993) cite Miyashita (1986) as estimating the abundance of the stock in the East China Sea as 35,046 animals. Since these data represent only about one-third of the habitat of bottlenose dolphins in the East China Sea, the population estimate was tripled (105,138 animals) to represent the IA stock, and that abundance represents the IA stock in this sea. No density estimates are available for this stock; therefore, a density estimate was derived 0.00077 animals/km^2 estimated by LGL (2011) was most appropriate. This is within the range of densities estimated in the eastern North Pacific (Ferguson and Barlow, 2001, 2003) and lower than those around Hawaii, 0.0103 animals/km^2 (Mobley et al. 2000), 0.0025 animals/km^2 (Bradford et al., 2013), and around Guam and the Mariana Islands, 0.00021 animals/km^2 (Fulling et al., 2011).

Cuvier's beaked whale: De Boer (2000) sighted Cuvier's beaked whales during his cruise through the South China Sea. No density or stock estimate data are available for this region, however. Considering habitat preferences (e.g., water temperature, bathymetry), the best available data to characterize the WNP stock found in this model area are the density estimate (0.0003 animals/km^2) and the abundance estimate of 90,725 animals from the same latitude in the eastern Pacific (Ferguson and Barlow, 2001, 2003). This density is comparable to that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but less than the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Deraniyagala beaked whale: Dalebout et al. (2014) conducted genetic and molecular analyses to demonstrate that *Mesoplodon hotaula* was genetic distinct from the ginkgo-toothed beaked whale (*M. ginkgodens*). Little is known about this beaked whale species. No abundance or stock information is available for the Deraniyagala beaked whale. Given that this species was synonymous with the ginkgo-toothed beaked whale, which is part of the *Mesoplodon* spp. complex, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density estimate of 0.0005 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the Deraniyagala beaked whale in this model area.

False killer whale: False killer whales are sighted infrequently in the South China Sea (De Boer, 2000; Miyashita et al., 1996; Smith et al., 1997). Miyashita (1993) suggested that animals summering in the Sea of Japan are probably from a separate, IA stock, by analogy of Pacific white-sided dolphins, than animals from the WNP stock. It is reasonable to assume that false killer whales occurring in the Sea of Japan, East China Sea, and South China Sea are all part of same, IA stock. Kishiro and Kasuya (1993) cited Miyashita (1986) as estimating the population wintering in the East China Sea at 3,259 animals. Since these data represent only about one-third of the habitat of false killer whales in the area, the population estimate was tripled (9,777 individuals) to represent the IA stock estimate. With no data available on density estimates for this species in the South China Sea, the best available density estimate (0.0011 animals/km^2) calculated from the winter/spring survey around Guam and the Mariana Islands (Fulling et al., 2011) was used for this species in this model area. This density is comparable to the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the

Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015).

Fraser's dolphin: Kishiro and Kasuya (1993) report catches of Fraser's dolphins off the Pacific coast of Japan in drive fisheries. No population data are available on this species in the western North Pacific Ocean or in the South China Sea. Lacking stock or density data, an abundance most appropriate to represent the WNP stock of Fraser's dolphins of 220,789 animals is derived from the ETP (Ferguson and Barlow, 2001, 2003) while the best available density estimate of 0.0069 animals/km^2 is derived from the Hawaii EEZ survey (Bradford et al., 2013).

Ginkgo-toothed beaked whale: Miyazaki et al. (1987) report no strandings of *M. ginkgodens* from the South China Sea. Neither De Boer (2000) nor Miyashita et al. (1996) observed ginkgo-toothed beaked whales during their research cruises. Since no data on density or stock estimates are available for this species in the North Pacific Ocean, a density (0.0005 animals/km^2) and abundance (22,799 animals) estimated for *Mesoplodon* spp. at the same latitude in the eastern Pacific (Ferguson and Barlow, 2001, 2003) was considered most appropriate to characterize this species' population in this model area. This density estimate is an order of magnitude less than that for unidentified beaked whales in the Hawaii EEZ (0.0.0021 animals/km^2; Bradford et al., 2013) but comparable to the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Killer whale: Killer whales are considered rare with limited sightings reported (Carretta et al., 2014), especially in the western North Pacific Ocean. The best available density estimate (0.00009 animals/km^2) derived by LGL (2011) and abundance estimate (12,256 animals) calculated from ETP survey data (Ferguson and Barlow, 2001 and 2003) are used to characterize the WNP stock of killer whales found in this model area. Mobley et al. (2000) did not report any sightings in their surveys of waters within 25 nmi of the Main Hawaiian Islands, nor did the 2007 surveys around the Mariana Islands (Fulling et al., 2011).

***Kogia* spp.**: Both *Kogia breviceps* and *Kogia sima* potentially may occur in this region. Smith et al. (1997) reported that *Kogia* were found in "whale temples" in nations surrounding the South China Sea. No sightings of *Kogia* spp. were made by De Boer (2000) during his survey. No density or abundance estimates are available for this species in this region. Summing the abundances of *Kogia* spp. in the geographic strata defined by Ferguson and Barlow (2001, 2003), an overall abundance of 350,553 animals is computed in the ETP and best represents the WNP stock of *Kogia* spp. Reviewing density estimates calculated in the eastern Pacific Ocean at about 20°N, the derived density estimate of 0.0017 animals/km^2 from that area best represents the WNP stock (Ferguson and Barlow, 2001 and 2003). This density is comparable to the density estimates for pygmy sperm whale (0.00291 animals/km^2 CV=1.12) and dwarf sperm whale (0.00714 animals/km^2 CV=0.74) observed within the Hawaii EEZ (Barlow, 2006).

Longman's beaked whale: Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings occurred south of 25°N. No population data are available for this species in this model area or for the WNP stock. Lacking data, the best available density estimate for Longman's beaked whales in the WNP stock is that estimated of by LGL (2011) as 0.00025 animals/km^2, while the best available abundance for this stock is that estimated as 7,619 animals in offshore Hawaiian waters (Bradford et al., 2017).

Melon-headed whale: Leatherwood and Reeves (1983) stated that melon-headed whales are rare except in the Philippine Sea. Distributed in tropical and subtropical waters, melon-headed whales have been observed in the South China Sea (De Boer, 2000) and are reported from "whale temples" on islands surrounding the South China Sea (Smith et al., 1997). However, they were not observed by Miyashita et al. (1996). With no specific population data for this model area, the best available density estimate (0.00428 animals/km^2) is calculated from the winter/spring surveys around Guam and the Mariana Islands (Fulling et al., 2011). This density is comparable to the density estimate calculated in nearshore Hawaii waters (0.0021 animals/km^2) during the spring, summer and fall (Mobley et al., 2000). An abundance estimated by Kanaji et al. (2018) from the Pacific coast of Japan of 56,213 animals (CV=0.56) is the best available for this region.

Pantropical spotted dolphin: This species has been reported during the De Boer (2000) research cruise, observed in winter (January to February) in the South China Sea by Miyashita et al. (1996), reported from historical "whale temples" (Smith et al., 1997), and also summarized by Gilpatrick et al. (1987) from one record west of Taiwan in the northern portion of the South China Sea. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) for surveys off the Pacific coast of Japan. Miyashita (1993) summarized data from 34 sighting cruises conducted as part of the Japanese drive fishery and derived a density estimate as 0.01374 animals/km^2. This density is comparable to those observed in the Hawaii EEZ (0.0067 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0407 animals/km^2; Mobley et al., 2000).

Pygmy killer whale: Pygmy killer whales were seen by De Boer (2000) during his research cruise through the South China Sea, known from historical "whale temples" (Smith et al., 1997), but not seen by Miyashita et al. (1996). No mention of these animals exists in Japanese whaling records (Kishiro and Kasuya, 1993). There are no data on density or stock estimates off Japan or Taiwan (Miyashita, 1993) or nearshore Hawaii (Mobley et al., 2000). Therefore, the best available density estimate to represent the WNP stock in this model area was judged to be 0.00014 animals/km^2 derived from the winter/spring 2007 surveys around Guam and the Mariana Islands (Fulling et al., 2011). This density is an order of magnitude less than that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017). The best available abundance estimate of 30,214 animals from the eastern Pacific (Ferguson and Barlow, 2001, 2003) was considered to best represent the WNP stock of pygmy killer whales.

Risso's dolphin: Smith et al. (1997) reported that Risso's dolphin bones were found in "whale temples" in nations along the South China Sea, but this species was not seen by Miyashita et al. (1996) or De Boer (2000) during their surveys. Miyashita (1993) suggested by analogy to bottlenose dolphins and Pacific white-sided dolphins that Risso's dolphins summering in the Sea of Japan are part of a separate, IA stock different from the WNP stock. Since it is reasonable to assume that Risso's dolphins occurring in the Sea of Japan, East China Sea, and South China Sea are all part of same, IA stock, Risso's in this model area are considered to be part of the IA stock. Since population data are lacking for the IA stock region, the WNP stock estimate (143,374 animals, CV=0.69; Kanaji et al., 2018) and the density estimate (0.0106 animals/km^2 derived for southeast Pacific coast of Japan/east of Taiwan; Miyashita, 1993) were used to represent the IA stock. Miyashita's density is within the range of densities estimated in the eastern North Pacific (Ferguson and Barlow, 2001, 2003) and higher than those around Hawaii (0.0067 animals/km^2, Bradford et al., 2013).

Rough-toothed dolphin: Rough-toothed dolphins have been reported from "whale temples" in South China Sea nations (Smith et al., 1997). Few other population data, however, are available for this dolphin species in this region. Given that lack of data, the best available data are for the WNP stock of rough-toothed dolphins. The best available density estimate (0.00224 animals/km^2) is from habitat-based models in the central North Pacific (Forney et al., 2015). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. This density is comparable to that observed in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: Smith et al. (1997) reported that short-finned pilot whales are found in "whale temples" on islands surrounding the South China Sea. De Boer (2000) did not observe pilot whales during his research cruise, but Miyashita et al. (1996) did observe them in the western North Pacific. The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). With limited data for this particular region, data from the Pacific coast of Japan were used to estimate population data for the WNP stock of pilot whales in this region. Using the results of Miyashita (1993), an abundance estimate of 31,396 individuals (CV=0.65) was calculated for the WNP southern stock. The best available density estimate (0.00159 animals/km^2) was calculated from the winter/spring 2007 surveys around Guam and the Mariana Islands (Fulling et al., 2011). This density is comparable to the density estimate (0.0051 animals/km^2) calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al. 2013) and an order of magnitude less than in nearshore Hawaii waters (0.0237 animals/km^2) during the spring, summer and fall (Mobley et al., 2000).

Sperm whale: The population structure of sperm whales throughout the North Pacific Ocean remains largely unresolved. De Boer (2000) sighted sperm whales in the South China Sea (March through April) and suggested that animals seen west of the Balabac Strait might be migrating between the South China and Sulu Seas. Miyashita et al. (1996) also observed sperm whales in the winter in the South China Sea, very close to the Philippines. No data on density or stock estimates were derived from either the De Boer (2000) or Miyashita et al. (1996) studies. The only available abundance estimate for the NP population of sperm whales is 102,112 animals (CV=0.155) (Kato and Miyashita, 1998). The best available density estimate, 0.00123 animals/km^2, for use in this region was derived from recent survey in waters of Guam and the Mariana Islands (Fulling et al., 2011). This is comparable to the density estimate of sperm whales in the Hawaii EEZ (0.00158 animals/km^2; Forney et al., 2015).

Spinner dolphin: Gilpatrick et al. (1987) reported a high density of spinner dolphin sightings in the Korea Strait and adjacent waters to the north but none were reported from the South China Sea or Philippine Sea. Spinner dolphins were not mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993), nor were they reported during the De Boer (2000) research cruise, nor encountered in historical "whale temples" (Smith et al., 1997). No data on density or stock estimates are available (Miyashita, 1993). Given that lack of regional data, the best available density estimate for the WNP stock found in this model area is that derived (0.00083 animals/km^2) from the Hawaii EEZ (Barlow, 2006); no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013). This density is orders of magnitude less than that observed in nearshore waters of Hawaii (0.0443 animals/km^2; Mobley et al., 2000). The best available abundance estimate for spinner dolphins (1,015,059 animals) in the WNP stock is derived from the ETP surveys (Ferguson and Barlow, 2001, 003).

Striped dolphin: These dolphins were not reported during the De Boer (2000) research cruise in March to April but were sighted by Miyashita et al. (1996) in the South China Sea during the January to February cruise. No data on density or abundance estimates for the South China Sea are available on striped dolphins. Kasuya and Perrin (2017) recognize a southern offshore population, with an abundance estimate of 52,682 individuals (Miyashita, 1993). LGL's (2011) density of 0.00584 animals/km^2 was considered best for this species in this region. This density is comparable to the density estimates from the Hawaii EEZ (0.0084 animals/km^2; Bradford et al., 2013)), from nearshore Hawaii (0.0016 animals/km^2; Mobley et al., 2000), and from Guam and the Mariana Islands (0.00616 animals/km^2; Fulling et al., 2011).

D-8. MODEL AREA 8—OFFSHORE JAPAN/WESTERN NORTH PACIFIC 25º TO 40ºN

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage in the mid-latitudes off Japan, there was some coverage near the Kamchatka Peninsula and along the western Aleutian Islands chain. All calls recorded on these hydrophones were northwest Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the North Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977, Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde’s whales in the western North Pacific: Solomon Islands/Southeast Asia, East China Sea, and offshore western North Pacific. Ohizumi et al. (2002) conducted winter sighting surveys, observing Bryde’s whales at about 20°N, which is the southern limit of their summer range. The IWC provides the best available population estimate, 20,501 whales, for the WNP Bryde’s whale stock (IWC, 2009). The best available density estimate for this species in this region, 0.0003 animals/km^2, is calculated by LGL (2011). This density is comparable to density estimates from offshore areas of the ETP (0.00003/km^2; Ferguson and Barlow, 2001, 2003) and the Hawaii EEZ (0.00033 animals/km^2; Bradford et al., 2013).

Common minke whale: Several stocks of minke whales are recognized in the western North Pacific Ocean, including the western North Pacific “O” east (WNP OE) stock, and the western North Pacific “J” west (WNP JW) stock (Miyashita & Okamura, 2011; Wade & Baker, 2011). Minke whales potentially occurring in the waters of this model area are believed to be part of the “WNP OE” stock. Buckland et al. (1992) conducted sighting surveys during July and August in the western North Pacific Ocean and Sea of Okhotsk, from which a density estimate of 0.0003 animals/km^2 (SE = 0.17) from encounter rates and effective search widths was derived for the offshore population. The abundance estimate for the WNP “OE” stock is estimated as 25,049 individuals (Buckland et al., 1992). Ferguson and Barlow (2001; 2003) computed density estimates in offshore areas of the ETP that are of the same magnitude.

Fin whale: Fin whales have been reported migrating south in the winter to about 20°N (Mizroch et al., 2009), have been observed in summer from near Japan north to the Chukchi Sea and Aleutian Islands, and may occur in the waters of this model area seasonally (Evans, 1987). Density and stock estimates, 0.0001 animals/km^2 and 9,250 animals, respectively, for the WNP stock of fin whales were derived from encounter rates of Japanese scouting boats in the northwest Pacific (Tillman, 1977). This density is comparable to density estimates in offshore areas of the ETP (Ferguson and Barlow, 2001, 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they proposed revising the ESA status for humpback whales in this region to be part of the WNP DPS and listed as threatened (Bettridge et al., 2015). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are only expected to occur in model area #8 during summer and fall. In addition, approximately one-quarter of the population is expected to be found in water depths of less than 1,000 m (3,281 ft), which was implemented in the modeling as a depth aversion. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales, which has increased annually to an abundance estimate of 1,328 individuals (Calambokidis et al., 2008; Bettridge et al., 2015). A density of 0.00036 animals/km^2 was estimated for the WNP stock of humpback whales (Acebes et al., 2007; LGL, 2008).

Sei whale: Sei whales are present throughout the temperate waters of the North Pacific Ocean but have been observed as far south as 20°N (Horwood, 1987). The IWC recognizes one stock of sei whales in the North Pacific (Donovan, 1991), although some evidence exists for several populations (Carretta et al., 2015). Very few sightings of sei whales have occurred in any region of the North Pacific, and adding to the difficulty, sei whales are extremely difficult to differentiate from Bryde's whales at sea. Tillman (1977) derived an abundance estimate of 8,600 individuals for sei/Bryde's whale in the North Pacific from whaling catch statistics. Mizroch et al. (2015) estimated the size of the pelagic migratory stock in 1975 at approximately 4,000 animals, but their "single stock" (coastal and pelagic) state space analysis estimated a population size of 7,000 animals in 1974, which is used here as the best available data. Initial estimates for a portion of the sei whale population off Japan indicate abundance estimates of similar magnitude (7,744 for May to June and 5,406 for July to September; Hakamada et al., 2009). With no specific densities derived for these waters, the best available density estimate (0.00029 animals/km^2 CV=48.7) for the sei whales in this model area is calculated from the winter/spring surveys around Guam and the Mariana Islands (Fulling et al., 2011). This is similar to that calculated for around Hawaii (0.00016 animals/km^2; Bradford et al., 2017).

Baird's beaked whale: Kasuya (1986) reported the presence of Baird's beaked whales off the east coast of Japan, as did Leatherwood and Reeves (1983). Miyazaki et al. (1987) did not report any Baird's beaked whale strandings along the Pacific coast of Japan. Ohizumi et al. (2003) examined the stomach content of Baird's whales caught off the east coast of Japan and reported that the observed prey species were demersal fish that were identical to those caught in bottom-trawl nets at depths greater than 1,000 m (3,281 ft). Kasuya (1986) collected sighting data from 25 years of aerial survey records and 1984 shipboard sightings off the Pacific coast of Japan; based on Kasuya's (1986) encounter rate and effective search width, a density estimate of 0.0001 animals/km^2 was derived for the Baird's beaked whale stock in this model area. The density estimate is comparable to the most western strata density estimates in the eastern Pacific (Ferguson and Barlow, 2003). Kasuya and Perrin (2017) cited an abundance estimate by Miyashita (1986, 1990) of 5,688, and is the abundance estimated for the WNP stock of Baird's beaked whales

Blainville's beaked whale: Lacking data on population estimates for the Blainville's beaked whale in the western North Pacific, the data derived for this species in waters of the ETP (Ferguson and Barlow, 2001, 2003) are deemed most appropriate to represent the species in the WNP stock. Ferguson and Barlow's (2001, 2003) abundance derived for *Mesoplodon densirostris* added to one-fifth of the *Mesoplodon* spp. abundance provides an estimate of 8,032 animals to represent this stock. The density estimate of 0.0007 animals/km^2 is most appropriate (LGL, 2011). This density estimate is similar to that derived for Blainville's beaked whales in the Hawaii EEZ (0.0086 animals/km^2; Bradford et al., 2013), in the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001), and the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). Due to this lack of information, population data derived from ETP surveys of 3,286,163 animals and 0.0863 animals/km^2 (Ferguson and Barlow, 2001, 2003) are the most appropriate to represent the WNP stock of common dolphins.

Common bottlenose dolphin: Kasuya and Perrin (2017) define a WNP Northern Offshore Stock for this region. Using a subset of the survey data from Miyashita (1993), Kasuya and Perrin (2017) report an abundance estimate of 100,281 individuals (CV=0.261). LGL (2011) derived a density estimate of 0.00077 animals/km^2 for pelagic bottlenose dolphins in this region. This is comparable to the density estimate around Guam and the Mariana Islands (0.00021 animals/km^2; Fulling et al., 2011).

Cuvier's beaked whale: No density or stock estimate data are available for Cuvier's beaked whales in this region. Considering habitat preferences (e.g., water temperature, bathymetry), it was determined that the best available abundance of 90,725 animals derived from the long-term ETP time series (Ferguson and Barlow, 2001, 2003) and the best available density estimate of 0.0037 animals/km^2 derived by LGL (2011) most optimally represent this stock in this region. This density estimate is greater than that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but comparable to the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Dall's porpoise: Dall's porpoise are found only in the North Pacific, primarily north of 36°N in the western North Pacific Ocean. This species has two distinct color morphs: one with a white flank patch that extends forward to the dorsal fin (*dalli* type) and one with a flank patch extending all the way to the front flippers (*truei* type). These morphological differences have been noted between animals from the Pacific coast of Japan (the *truei*-type), the Sea of Japan, and Sea of Okhotsk (the *dalli*-type), and the offshore northwestern Pacific and western Bering Sea (the *dalli*-type) (Hayano et al., 2003). Hayano et al. (2003) conducted genetic studies on the three populations and found a low, but significant, difference between the Sea of Japan-Okhotsk population and the other two populations. Kasuya and Perrin (2017) cite Miyashita (1991) for an abundance estimate of 162,000 animals in this region. Based on surveys of the eastern North Pacific, a density estimate of 0.0520 animals/km^2 was derived for the WNP stock, with ¼ less (0.0390 animals/km^2) during the winter season (Ferguson and Barlow, 2001, 2003). This density estimates a concentration of Dall's porpoises probably larger than what would be encountered by LFA operations in the western North Pacific since it includes survey effort in nearshore waters where animals are more often found.

Dwarf sperm whale: Evans (1987) reported records of *Kogia* spp. off the Japanese coast with primarily an oceanic, non-aggregated distribution. Although only the pygmy sperm whale is expected to occur in this area, given the lack of information about this species in this region, the dwarf sperm whale is also included in this model area. Given the lack of population level data on either *Kogia* species in the western North Pacific, the most representative abundance for the WNP stock of the dwarf sperm whale was derived by summing the abundances of *Kogia* spp. in the geographic ETP strata defined by Ferguson and Barlow (2001, 2003), resulting in an overall abundance of 350,553 animals. LGL's (2011) density estimate of 0.0043 animals/km^2 is the best available for this species in this region. This density is comparable to the density estimates for pygmy sperm whale (0.00291 animals/km^2 CV=1.12) and dwarf sperm whale (0.00714 animals/km^2 CV=0.74) observed within the Hawaii EEZ (Barlow, 2006).

False killer whale: Little occurrence or population data are available in these waters for the false killer whale. The most representative estimates of the WNP stock and density of false killer whales is Miyashita's (1993) estimated abundance of 16,668 animals (CV=0.263) from 34 sighting cruises associated with the Japanese drive fishery and his density estimate of 0.0036 animals/km^2. This density is higher than the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015).

Hubbs' beaked whale: All known occurrences to date of Hubb's beaked whales in the western North Pacific Ocean having been strandings along Japan's shore (MacLeod et al., 2006). Miyazaki et al. (1987) reported five strandings of Hubbs' beaked whales along the Pacific coast of northern Honshu. Since no data on density or stock estimates are available for the Hubb's beaked whale in the waters of this model area, *Mesoplodon* spp. data from the ETP (Ferguson and Barlow, 2001 and 2003) are considered to be the most appropriate population estimates available from which to extrapolate population estimates for this model area. Using the northernmost strata from Ferguson and Barlow's (2001, 2003) data, a density of 0.0005 animals/km^2 and an abundance of 22,799 animals are estimated for the NP stock of Hubb's beaked whales. Ferguson and Barlow's (2001, 2003) density is comparable to that estimated for unidentified *Mesoplodon* whales in the Hawaii EEZ (0.0021 animals/km^2; Bradford et al., 2013) and the mean predicted density estimated for the ETP Mesoplodon spp. (0.000296 animals/km2; Ferguson et al., 2006).

Killer whale: Killer whales have been observed in the waters off the southeast coast of Honshu, Japan, but no killer whales were taken in Japanese drive fisheries (Miyashita, 1993). Without any population or occurrence data on killer whales for the western North Pacific, the best available abundance estimate of 12,256 animals is derived from Ferguson and Barlow's (2001, 2003) long time series in the ETP while the best available density estimate of 0.00009 animals/km2 is derived from LGL's (2011) compilation of data for the Marianas area. LGL's (2011) density is comparable to the density, 0.00004 animals/km2, estimated for killer whales in the Hawaii EEZ (Bradford et al., 2013).

Longman's beaked whale: Considering the lack of occurrence or population data for the WNP stock of Longman's beaked whales, the abundance of 7,619 animals estimated for Longman's beaked whales in offshore Hawaiian waters (Bradford et al., 2017) and the density of 0.00025 animals per km^2 (LGL, 2011) derived from the Marianas regions are considered most appropriate to represent the WNP stock in this model area.

Melon-headed whale: Leatherwood and Reeves (1983) stated that melon-headed whales are rare except in the Philippine Sea. Distributed in tropical and subtropical waters, preferring equatorial water masses, they are probably uncommon outside of the warm waters of the Kuroshio Current. With these limited data and information available, a density estimate of 0.00267 animals/km^2 from LGL (2011) was considered most appropriate to represent the WNP stock in this region. This density is comparable to Mobley et al.'s (2000) density estimate for Hawaii waters of 0.0021 animals/km^2 and the

Guam/Marianas estimate of 0.00428 animals/km^2 (Fulling et al., 2011). An abundance estimate of 56,213 whales (CV=0.58) was derived from surveys off the Pacific coast of Japan (Kanaji et al., 2018).

***Mesoplodon* spp:** Miyazaki et al. (1987) reported five strandings of *M. ginkgodens* from the east coast of Japan. Of the 15 known strandings of *M. ginkgodens,* Palacios (1996) reported eight off Taiwan and Japan. Since so very little occurrence or population data are available for this species, especially in this oceanic region, data on *Mesoplodon* spp. from the northernmost ETP stratum (Ferguson and Barlow, 2001, 2003) were considered most appropriate to represent the Mesoplodon genus in this model area. Ferguson and Barlow's (2001, 2003) derived density estimate of 0.0005 animals/km^2 and abundance estimate of 22,799 animals represents *Mesoplodon* whales in the WNP stock. This density estimate is comparable to that for unidentified beaked whales in the Hawaii EEZ (0.00015 animals/km^2; Barlow, 2006) and the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Northern right whale dolphin: The northern right whale dolphin is found in deep, temperate waters of the North Pacific Ocean, between about 30°N and 50°N. Buckland et al. (1993) estimated an abundance of 68,000 animals (CV=0.71) in the oceanic North Pacific based on sightings data, which represents the best available estimate for this region. No surveys have estimated density; therefore, a nominal density of 0.0001 animals/km^2 was used in exposure modeling to represent the low probability that this species would be encountered.

Pacific white-sided dolphin: No data on density or stock estimates of Pacific white-sided dolphins in this region are available (Miyashita, 1993). Due to this lack, the density (0.0048 animals/km^2) estimated from eastern Pacific waters (Ferguson and Barlow, 2001, 2003) was used to best represent the WNP stock of these dolphins in this model area, while Buckland et al.'s (1993) abundance of 931,000 animals is most appropriate to characterize the WNP stock of Pacific white-sided dolphins. No sightings of Pacific white-sided dolphins were reported in Hawaii surveys (Mobley et al., 2000; Barlow, 2006).

Pantropical spotted dolphin: Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) based on surveys off the Pacific coast of Japan. LGL's (2011) density estimate of 0.0113 animals/km^2 best characterizes this species in this oceanic area. This density is an order of magnitude higher than that derived for the Hawaii EEZ (0.0067 animals/km^2; Bradford et al., 2013), and nearshore Hawaii waters (0.0407 animals/km^2; Mobley et al., 2000).

Pygmy killer whale: Kishiro and Kasuya (1993) reviewed the historical catches of Japanese drive fisheries and reported that no pygmy killer whales were caught in Taiji fisheries (located on the south coast of Kii Peninsula of Japan). Leatherwood and Reeves (1983), however, reported that pygmy killer whales were seen relatively frequently in the tropical Pacific off Japan. Given such sparsely available data on this species in this region, the best available density estimate (0.00014 animals/km^2) was derived from LGL (2011) data in the Mariana Islands. This density is an order of magnitude less than that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017). No pygmy killer whales were seen in nearshore aerial during the spring, summer, and fall (Mobley et al., 2000). The best available abundance estimate of 30,214 animals from the eastern Pacific survey data (Ferguson and Barlow, 2001, 2003) best represents the WNP stock of this species.

Pygmy sperm whale: Evans (1987) reported records of *Kogia* spp. off the Japanese coast with primarily an oceanic, non-aggregated distribution. At this northern latitude, only *Kogia breviceps* is expected to occur. With so few *Kogia* data available in this region, an abundance was derived for the WNP stock by summing the abundances of *Kogia* spp. in the ETP geographic strata defined by Ferguson and Barlow

(2001, 2003), which resulted in an overall abundance of 350,553 animals. LGL (2011) calculated a density estimate of 0.0018/km^2 for the pygmy sperm whale in the Mariana region and this estimate was considered to be represent this species in this model area. This density is comparable to the density estimates for pygmy sperm whale (0.00291 animals/km^2 CV=1.12) observed within the Hawaii EEZ (Barlow, 2006).

Risso's dolphin: With little occurrence information available on the Risso's dolphin in this ocean model area, Kanaji et al.'s (2018) abundance (143,374 animals, CV=0.69) best represents the WNP stock, while LGL's (2011) density estimate of 0.0005 animals/km^2 derived for the species in the waters of the Mariana Islands is the best available density. This is an order of magnitude lower than that observed in the Hawaii EEZ (0.0067 animals/km^2; Bradford et al., 2013).

Rough-toothed dolphin: Due to the very limited amount of population data available on this dolphin species in this offshore Japan model area, the best available density estimate of 0.0019 animals/km^2 derived from LGL's (2011) data from the Mariana region. This density is comparable to that observed in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000). The best available abundance of 5,002 animals is estimated from western Pacific waters (Kanaji et al., 2018).

Short-finned pilot whale: The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). Using the results of Miyashita (1993), an abundance estimate of 20,884 individuals (CV=0.332) was calculated for the WNP northern stock. The most appropriate density estimate for this offshore site, 0.0021 animals/km^2, was derived from LGL (2011) data in the Mariana region. This density estimate is similar to that found in pelagic waters of the Hawaii EEZ (0.0051 animals/km^2; Bradford et al., 2013).

Sperm whale: Stock structure of sperm whales in the North Pacific is not well resolved. Sightings collected by Kasuya and Miyashita (1988) suggest that in the summer, the density of sperm whales is high south of the Kuroshio Current System (south of approximately 35°N) but extremely low north of 35°N. These data suggest two stocks of sperm whales in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands (~50°N) and winter off Hokkaido and Sanriku (~40°N) and the southern WNP stock with females that summer off Hokkaido and Sanriku (~40°N) and winter around the Bonin Islands (~25°N) (Kasuya and Miyashita, 1988). The males of these two stocks are found north of the range of the corresponding females, i.e., in the Bering Sea (~55°N) and off Hokkaido and Sanriku (~40°N), respectively, during the summer (Kasuya and Miyashita, 1988). However, until further data are available, sperm whales are considered to belong to only one NP stock. Potentially, sperm whales of the NP stock, numbering 102,112 individuals (Kato and Miyashita, 1998), may occur year-round in the waters of this offshore model area. The best density estimated for sperm whales in model area 8 is 0.0022 animals/km^2, derived by LGL (2011). This density is higher but in the same order of magnitude as that derived by Forney et al. (2015; 0.00158 animals/km^2) for the Hawaii EEZ and Fulling et al. (2011; 0.00123 animals/km^2) for the waters around Guam and Mariana Islands.

Spinner dolphin: Gilpatrick et al. (1987) did not report any sightings of spinner dolphins from the Pacific coast of Japan and neither is this species mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993). With no data on density or stock estimates available (Miyashita, 1993), the best stock and density estimates for the WNP stock of spinner dolphins is considered to be Ferguson and Barlow

(2001, 2003) estimate of 1,015,059 spinner dolphins from a similar latitude of the ETP and LGL's (2011) estimate of 0.0019 animals/km^2, respectively.

Stejneger's beaked whale: Strandings along the Pacific coast of Japan in winter and spring suggest a migratory pattern (Mead, 1989; Yamada, 1997), but density or stock estimate data are not available for the WNP stock in this region. Considering habitat preferences (e.g., water temperature, bathymetry), the most appropriate Stejneger's density estimate of 0.0005 animals/km^2 is derived from ETP data of Ferguson and Barlow (2001, 2003), with the most appropriate abundance (8,000 animals) approximated from that derived for the WNP stock of Baird's beaked whales (Kasuya, 1986).

Striped dolphin: Kasuya and Perrin (2017) recognize a northern offshore population, with an abundance estimate of 497,725 individuals (CV=0.179) (Miyashita, 1993). LGL (2011) derived a density estimate of 0.0058 animals/km^2 from data derived from the Mariana region. This density is comparable to the density estimates from the Hawaii EEZ (0.0084 animals/km^2; Bradford et al., 2013), from nearshore Hawaii (0.0016 animals/km^2; Mobley et al., 2000), and from Guam and the Mariana Islands (0.00616 animals/km^2; Fulling et al., 2011).

Hawaiian monk seal: Monk seals are known to haul out on Kure Atoll, the westernmost atoll in the northwest Hawaiian Islands (NWHI) (Carretta et al., 2015). Monk seals from Kure Atoll may forage on the Hancock Banks, NW of Kure Atoll. Parrish et al. (2002) compiled information on monk seal diving wherein the authors referenced a study by Abernathy (1999), who reported that monk seals may travel up to 400 km (216 nmi) to forage. The Hancock Banks are approximately 300 km (162 nmi) NW of Kure Atoll and are characterized by a single pinnacle that is shallower than 450 m (1,476 ft); this single pinnacle is within the known range of movements of monk seals. However, it appears unlikely that many, if any, seals would travel a distance near their maximum-recorded and dive to a depth near their maximum recorded depth to access a small potential foraging area. However, to account for the possibility that monk seals may forage such distances from known foraging areas, monk seals were included in the marine mammal fauna for this model area. The abundance of the Hawaiian monk seal stock is estimated at 1,427 animals (NMFS, 2018). Although no density for the very rare Hawaiian monk seal is available, a density estimate is necessary to compute the potential risk to this species. Thus, a density estimate of 0.00001 animals/km^2 was used in the impact analysis for this species to reflect the very low probability of occurrence in this region.

Northern fur seal: Northern fur seals in this region are part of the Western Pacific stock. Northern fur seals only go ashore on their breeding grounds further north; after breeding and molting, many northern fur seals travel southward, where they remain at sea and may be found in this region during the winter and spring (Buckland et al., 1993; Allen and Angliss, 2015). The Western Pacific stock is estimated at 503,609 animals (Gelatt et al., 2015; Kuzin, 2015). Buckland et al. (1993) estimated a density of 0.0123 animals/km^2 in offshore waters of the western North Pacific, which represents the best available estimate for this model area, in which northern fur seals are expected in winter.

D-9. MODEL AREA 9—OFFSHORE JAPAN/WESTERN NORTH PACIFIC 10º TO 25ºN

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage in the mid-latitudes off Japan, there was some coverage near the Kamchatka Peninsula and along the western Aleutian Islands chain. All calls recorded on these hydrophones were northwest Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the

North Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977, Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Bryde's whale: Yoshida and Kato (1999) identified three stocks of Bryde's whales in the western North Pacific: Solomon Islands/Southeast Asia, East China Sea, and offshore western North Pacific. Ohizumi et al. (2002) conducted winter sighting surveys, observing Bryde's whales at about 20°N, which is the southern limit of their summer range. The IWC provides the best available population estimate, 20,501 whales, for the WNP Bryde's whale stock (IWC, 2009). The best available density estimate for this species in this region, 0.0003 animals/km^2, is calculated by LGL (2011). This density is comparable to density estimates from offshore areas of the ETP (0.00003/km^2; Ferguson and Barlow, 2001, 2003) and the Hawaii EEZ (0.00033 animals/km^2; Bradford et al., 2013).

Fin whale: Fin whales have been reported migrating south in the winter to about 20°N (Mizroch et al., 2009) and may occur in the northern portion of this model area. An abundance for the WNP stock (9,250 animals) was derived from whaling data (Tillman, 1977). No density information is available for the fin whale in this region, therefore a density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during winter, spring, and fall. This is comparable to that calculated for around Hawaii (0.00006 animals/km^2; Bradford et al., 2017).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are only expected to occur in the model area #9 during winter, spring, and fall. In addition, approximately one-quarter of the population is expected to be found in water depths of less than 1,000 m (3,281 ft), which was implemented in the modeling as a depth aversion. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales (Calambokidis et al., 2008), which has increased annually to an abundance estimate of 1,328 individuals (Bettridge et al., 2015). A density of 0.00036 animals/km^2 was estimated for the WNP stock of humpback whales (Calambokidis et al., 2008; LGL, 2008).

Omura's whale: Little population information is known or available for this species only described in 2003 but this baleen whale ranges from roughly northern Japan to Australia in the eastern Indian Ocean and western Pacific Ocean (Yamada, 2009). With so little information available, the Omura's whale is assumed to comprise one stock, the WNP, throughout its range in the western Pacific Ocean. The only abundance information available is an estimate made by Ohsumi (1980) for Bryde's whales in the Solomon Sea, which are now known to have been Bryde's and Omura's whales. Lacking other data, Ohsumi's (1980) abundance of 1,800 animals was used to represent the WNP stock of Omura's whales. A density estimate from the NMSDD (DoN, 2017) was used (0.00004 animals/km^2).

Sei whale: Sei whales are present throughout the temperate North Pacific Ocean but have been observed as far south as 20°N (Horwood, 1987). The IWC recognizes one stock of sei whales in the North Pacific (Donovan, 1991), although some evidence exists for several populations (Carretta et al., 2014). Very few sightings of sei whales have occurred in any region of the North Pacific, and adding to the difficulty, sei whales are extremely difficult to differentiate from Bryde's whales at sea. Tillman (1977) derived an abundance estimate of 8,600 individuals for sei/Bryde's whale in the North Pacific from whaling catch statistics. Mizroch et al. (2015) estimated the size of the pelagic migratory stock in 1975 at approximately 4,000 animals, but their "single stock" (coastal and pelagic) state space analysis estimated a population size of 7,000 animals in 1974, which is used here as the best available data. Initial estimates for a portion of the sei whale population off Japan indicate abundance estimates of similar magnitude (7,744 for May to June and 5,406 for July to September; Hakamada et al., 2009). With no specific densities derived for these waters, the best available density estimate (0.00029 animals/km^2 CV=48.7) for the sei whales in this model area is calculated from the winter/spring surveys around Guam and the Mariana Islands (Fulling et al., 2011). This is similar to that calculated for around Hawaii (0.00016 animals/km^2; Bradford et al., 2017).

Blainville's beaked whale: Lacking data on population estimates for the Blainville's beaked whale in the western North Pacific, the abundance data derived for this species in waters of the ETP (Ferguson and Barlow, 2001, 2003) are deemed most appropriate to represent the species in the WNP stock. Ferguson and Barlow's (2001, 2003) abundance derived for *Mesoplodon densirostris* added to one-fifth of the *Mesoplodon* spp. abundance provides an estimate of 8,032 animals to represent the WNP stock. The density estimate derived by LGL (2011), 0.0007 animals/km^2; is most appropriate for this beaked whale in this oceanic model area. This density estimate is similar to that derived for Blainville's beaked whales in the Hawaii EEZ (0.0086 animals/km^2; Bradford et al., 2013), in the main Hawaiian Islands (0.0012 animals/km^2; Mobley et al., 2001), and the mean predicted density estimate for the ETP *Mesoplodon* spp. (0.000296 animals/km^2; Ferguson et al., 2006).

Common bottlenose dolphin: Kasuya and Perrin (2017) define a WNP Southern Offshore Stock for this region. Kanaji et al. (2018) report an abundance estimate of 40,769 individuals. The best available density of bottlenose dolphins in this model area of 0.00077 animals/km^2 as derived by LGL (2011) for this species in waters of the Mariana region. This density is comparable to the density estimate around Guam and the Mariana Islands (0.00021 animals/km^2; Fulling et al., 2011).

Cuvier's beaked whale: No density or stock estimate data are available for Cuvier's beaked whales in this oceanic region. Considering habitat preferences (e.g., water temperature, bathymetry), the best available abundance for the WNP stock of 90,725 animals was derived for this beaked whale from long-term time ETP series data (Ferguson and Barlow, 2001, 2003). The best density for this species in this region is LGL's (2011) estimate of 0.0037 animals/km^2. This density estimate is greater than that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but comparable to the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Deraniyagala beaked whale: Dalebout et al. (2014) conducted genetic and molecular analyses to demonstrate that *M. hotaula* was genetic distinct from the ginkgo-toothed beaked whale (*M. ginkgodens*). Little is known about this beaked whale species. No abundance or stock information is available for the Deraniyagala beaked whale. Given that this species was synonymous with the ginkgo-toothed beaked whale, which is part of the *Mesoplodon* spp. complex, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density estimate of 0.0009 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the Deraniyagala beaked whale in this model area.

Dwarf sperm whale: Evans (1987) reported records of *Kogia* spp. off the Japanese coast with primarily an oceanic, disbursed distribution. Although at this latitude, only the pygmy sperm whale is expected to occur, the dwarf sperm whale is included in this model area due to the lack of concrete data and information on its deep ocean occurrence. To derive the best available abundance for the WNP stock of dwarf sperm whales, the abundances of *Kogia* spp. in the appropriate geographic ETP strata were summed to derive an overall abundance of 350,553 animals (Ferguson and Barlow, 2001 and 2003). LGL's density estimate of 0.0043 animals/km^2 best represents this species in this region. This density is comparable to the density estimates for pygmy sperm whale (0.00291/km^2 (CV=1.12) and dwarf sperm whale (0.00714 animals/km^2 CV=0.74) observed within the Hawaii EEZ (Barlow, 2006).

False killer whale: With so sparse occurrence data available for false killer whales in this oceanic model area, Miyashita's (1993) abundance of 16,668 false killer whales (CV=0.263) from 34 sighting cruises associated with the Japanese drive fishery best typifies the WNP stock. LGL's (2011) density of 0.0006 animals/km^2 is most representative of this species in model area #9. This density is comparable to the density estimated for the pelagic stock of false killer whales in the Hawaii EEZ (0.0006 animals/km^2; Bradford et al., 2012) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000), including the Main Hawaiian Islands insular stock (0.0008 animals/km^2; Bradford et al., 2015; Oleson et al., 2010) and the Northwest Hawaiian Islands insular stock (0.0006 animals/ km^2; Bradford et al., 2015; Forney et al., 2015).

Fraser's dolphin: Without data on abundance or density estimates for the western North Pacific Ocean for the Fraser's dolphin, Bradford et al. (2013) abundance estimate of 16,992 animals is extrapolated to represent the central North Pacific stock of Fraser's dolphins. The density estimated by LGL (2011) as 0.0025 animals/km^2 is considered the best available and most appropriate to characterize Fraser's dolphin in this model area.

Gingko-toothed beaked whale: During the genetic and molecular analyses of Dalebout et al. (2014), additional distribution information about the ginkgo-toothed beaked whale was demonstrated, suggesting that it may occur in this model area. Little is known about this beaked whale species, with no live sightings having been recorded. No abundance or stock information is available; therefore, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density estimate of 0.0009 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the ginkgo-toothed beaked whale in this model area.

Killer whale: Without any population or occurrence data on killer whales for the western North Pacific, the best available abundance estimate of 12,256 animals for the WNP stock was derived from Ferguson and Barlow's (2001, 2003) long time series of ETP data. The best available density for the killer whale in this region is represented by the density of 0.00009 animals/km^2 (LGL, 2011) estimated for the Marianas area. LGL's (2011) density is comparable to the density, 0.00004 animals/km^2, estimated for killer whales in the Hawaii EEZ (Bradford et al., 2013).

Longman's beaked whale: Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings in their ETP surveys occurred south of 25°N. Considering the lack of occurrence or population data for the WNP stock of Longman's beaked whales, the abundance of 7,619 animals estimated for Longman's beaked whales in offshore Hawaiian waters (Bradford et al., 2017) and the density of

0.00025 animals per km^2 (LGL, 2011) derived from the Marianas regions are considered most appropriate to represent the WNP stock in this oceanic region.

Melon-headed whale: Leatherwood and Reeves (1983) stated that melon-headed whales are rare in all western North Pacific waters except those of the Philippine Sea. With such limited data available, a density estimate derived by LGL (2011) of 0.00267 animals/km^2 is the best available to characterize the occurrence of melon-headed whales in this region. This density is very comparable to Mobley et al.'s (2000) density estimate for Hawaii waters of 0.0021 animals/km^2 and the Guam/Marianas estimate of 0.00428 animals/km^2 (Fulling et al., 2011). An abundance estimate of 56,213 whales (CV=0.58) was derived from surveys off the Pacific coast of Japan (Kanaji et al., 2018).

Pantropical spotted dolphin: Gilpatrick et al. (1987) cited a known distribution of pantropical spotted dolphins east of Japan. Kanaji et al. (2018) report an abundance estimate of 130,002 individuals (CV=0.43) from surveys off the Pacific coast of Japan. The best available density of 0.0113 animals/km^2 is estimated from this species data from the Mariana region (LGL, 2011). This density is comparable to that observed in the Hawaii EEZ (0.00369 animals/km^2; Forney et al., 2015) and an order of magnitude less than that observed in nearshore waters of Hawaii (0.0407 animals/km^2; (Mobley et al., 2000).

Pygmy killer whale: Kishiro and Kasuya (1993) reviewed the historical catches of Japanese drive fisheries and reported that no pygmy killer whales were caught in Taiji fisheries (located on the south coast of Kii Peninsula of Japan). However, Leatherwood and Reeves (1983) reported that pygmy killer whales were seen relatively frequently in the tropical Pacific waters off Japan. Few data are available for this species in this oceanic model area. Thus, the best available density estimate of 0.00006 animals/km^2 for this area was derived by LGL (2011) from Mariana Islands data. This density is an order of magnitude less than that observed for pygmy killer whales in the Hawaii EEZ (0.00435 animals/km^2; Bradford et al., 2017). No pygmy killer whales were seen in nearshore aerial during the spring, summer, and fall by Mobley et al. (2000). The best abundance estimate to represent the WNP stock of pygmy killer whales is 30,214 animals derived from the eastern Pacific survey data (Ferguson and Barlow, 2001, 2003).

Pygmy sperm whale: Evans (1987) reported records of *Kogia* spp. off the Japanese coast with primarily an oceanic, dispersed distribution. Although only this species of *Kogia* is expected to occur at this the latitude of this site, due to the lack of concrete data, to be conservative both *Kogia* species are included for this model area. The best estimated abundance for the WNP stock of pygmy sperm whales is derived by summing the abundances of *Kogia* spp. in the ETP geographic strata defined by Ferguson and Barlow (2001, 2003), which results in an overall abundance of 350,553 animals. The density of 0.00176 animals/km^2 derived for the greater Mariana Islands region (LGL, 2011) is the most representative of this species in this region. This density is comparable to the density estimates for pygmy sperm whale (0.00291/km^2 (CV=1.12) and dwarf sperm whale (0.00714 animals/km^2 CV=0.74) observed within the Hawaii EEZ (Barlow, 2006).

Risso's dolphin: Very sparse occurrence or population level data are available for the Risso's dolphin in this oceanic area. Kanaji et al. (2018) estimated abundance for the WNP stock of 143,374 animals (CV=0.69) is the best data available. Likewise, LGL's (2011) density estimate of 0.00046 animals/km^2 best represents this species in this region. This density is lower than the density estimate off Hawaii (0.0067 animals/km^2; Bradford et al., 2013).

Rough-toothed dolphin: With few data available for this species, the best available density estimate (0.00185 animals/km^2) is from LGL (2011). Kanaji et al. (2018) report an abundance estimate (5,002 individuals, CV=1.24) from their sighting surveys in the western North Pacific. This density is comparable to that observed in the Hawaii EEZ (0.0026 animals/km^2; Bradford et al., 2013) and in nearshore Hawaii waters (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: The stock delineation of the short-finned pilot whale in the western North Pacific is not fully resolved, but a northern ecotype and southern ecotype are recognized, segregating at Choshi Point (35°42'N, 140°51'E) (Kasuya and Perrin, 2018). Using the results of Miyashita (1993), an abundance estimate of 31,396 individuals (CV=0.65) was calculated for the WNP southern stock. The most appropriate and best available density for this whale in this region is 0.0021 animals/km^2, estimated by LGL (2011). This density estimate is similar to that found in pelagic waters of the Hawaii EEZ (0.0051 animals/km^2; Bradford et al., 2013).

Sperm whale: Sightings collected by Kasuya and Miyashita (1988) suggest that in the summer, the density of sperm whales is high south of the Kuroshio Current System (south of approximately 35°N) but extremely low north of 35°N. Kasuya and Miyashita's (1988) data suggest that there are two stocks of sperm whales in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands (~50°N) and winter off Hokkaido and Sanriku (~40°N), and the southwestern North Pacific stock with females that summer off Hokkaido and Sanriku (~40°N) and winter around the Bonin Islands (~25°N). Male sperm whales of these two stocks are found north of the range of the corresponding females. Based on this information, sperm whales may occur throughout the year in this model area. However, data is insufficient to clearly define the stock structure of sperm whales in the North Pacific Ocean, except in the U.S. EEZ waters. For this reason, Kato and Miyashita's (1988) stock estimate of 102,112 animals is the best available estimate of the NP stock of sperm whales in this model area. A density estimate of 0.0022 animals/km^2 was derived from LGL data (2011) and is considered optimal to represent this species occurrence in this area. This density is higher than the Forney et al. (2015) estimate (0.00158 animals/km^2) calculated from the summer/fall survey off Hawaii in 2010 and the density estimate (0.00123 animals/km^2) calculated from the winter/spring surveys around Guam and Mariana Islands (Fulling et al., 2011).

Spinner dolphin: The spinner dolphin is not mentioned in historical Japanese whaling records (Kishiro and Kasuya, 1993), and no data on density or stock estimates are available for this species from data compiled by Miyashita (1993). The best available density estimate (0.00187 animals/km^2) is calculated by LGL (2011) and is comparable to that observed in the Hawaii EEZ (0.00137 animals/km^2; Barlow, 2006) but is an order of magnitude less than that observed in nearshore waters of Hawaii (0.0443 animals/km^2; Mobley et al., 2000); no sightings of spinner dolphins occurred during systematic effort in the 2010 summer/fall survey (Bradford et al., 2013). The abundance estimated as 1,015,059 animals for spinner dolphins from the ETP data (Ferguson and Barlow, 2001, 2003) is the best available to characterize the WNP stock.

Striped dolphin: Kasuya and Perrin (2017) recognize a southern offshore population, with an abundance estimate of 52,682 individuals (Miyashita, 1993). The best existing density of 0.0058 animals/km^2 was derived by LGL (2011) and is comparable to the density estimates from nearshore Hawaii (0.0016/km^2; Mobley et al., 2000), and the Hawaii EEZ (0.0084 animals/km^2; Bradford et al., 2013) and Guam and the Mariana Islands (0.00616/km^2; Fulling et al., 2011).

D-10. MODEL AREA 10—HAWAII NORTH

Blue whale: Due to the general lack of occurrence data for blue whales in the North Pacific Ocean, stock structure remains uncertain. NMFS recognizes a central North Pacific stock around Hawaii and an eastern North Pacific stock around California (Carretta et al., 2015). Blue whales occur rarely in the central North Pacific, with few sightings and acoustic detections having been made. No sightings of blue whales were made around Hawaii during the Acoustic Thermometry of Ocean Climate Marine Mammal Research Program aerial surveys or during a summer/fall 2002 line-transect survey (Barlow, 2006; Mobley, 2006). Line-transect surveys of the Hawaii EEZ estimated an abundance of 133 (CV=1.09) animals and a density of 0.00005 animals/km^2 (Bradford et al., 2017).

Bryde's whale: Sightings of the Bryde's whale in Hawaiian waters have been recorded sporadically since 1977 (Carretta et al., 2014). Occurrence data are sufficient to define a Hawaii stock of Bryde's whales. Bradford et al.'s (2017) abundance estimate of the Hawaii stock of Bryde's whales is the best available (1,751 animals, CV=0.29). The best density for Bryde's whales is 0.00009 animals/km^2, derived from habitat-based modeling (Forney et al., 2015).

Common minke whale: A Hawaii stock is recognized that occurs seasonally (November-March) in Hawaiian waters, though no estimate of abundance has been calculated (Carretta et al., 2014). Minke whales were observed and acoustically detected during the 2002 summer/fall survey of the Hawaiian EEZ (Barlow, 2006). One off-effort sighting was made during the 2010 summer/fall survey (Bradford et al., 2013). A year-long analysis of acoustic recordings made at Station ALOHA (A Long-term Oligotrophic Habitat Assessment) 100 km (54 nmi) north of Oahu detected "central" or "Hawaii" boings from 22 October 2007 to 21 May 2008 but none were detected during the months of June to September, though this does not indicate that minke whales were not present (Oswald et al., 2011). Using passive acoustic detections from hydrophones on the Pacific Missile Range Facility off Kauai, Martin et al. (2015) estimated density as 0.00423 animals/km^2, which is used as the best available data. Lacking abundance data for this stock in Hawaiian waters, the best estimate of abundance (25,049 animals) is derived from sighting surveys in July and August in the western North Pacific and Sea of Okhotsk (Buckland et al., 1992).

Fin whale: There has been acoustic evidence for fin whale presence in fall and winter (Thompson and Friedl, 1982; Moore et al., 1998) and one sighting in nearshore waters (February) (Mobley et al., 1996). From the sightings reported during line-transect surveys, an abundance estimate of 154 animals and a density estimate of 0.00006 animals/km^2 (CV=1.05) was calculated for the Hawaii stock of fin whales (Bradford et al., 2017). This estimate is similar to that of McDonald and Fox (1999) who derived an average calling whale density estimate of 0.000027 animals/km^2 based on recordings made north of Oahu, Hawaii. The seasonal maximum calling whale density was about three times the average, or 0.000081 animals/km^2 (McDonald and Fox, 1999).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales with animals in this region defined as part of the Hawaii DPS and not listed under the ESA (Bettridge et al., 2015; NOAA, 2016a). The Hawaii DPS is synonymous with the Central North Pacific (CNP) stock identified under the MMPA and evaluated in the NMFS stock assessment reports (Muto et al., 2016). The CNP/Hawaii DPS breeds/winters within the Main Hawaiian Islands and migrates to mostly known feeding grounds in the North Pacific, with about half of the stock/DPS migrating to southeast Alaska and northern British Columbia. Thus, humpback whales are only expected to occur in the Hawaii-North model area during winter, spring, and fall. The best available abundance estimate for the CNP stock/Hawaii DPS of humpback whales is 10,103 individuals (Calambokidis et al., 2008; Muto et al., 2016). A density of 0.00529 animals/km^2 was estimated (Mobley et al., 2001; Calambokidis et al., 2008).

Sei whale: Sei whales are present throughout the temperate North Pacific Ocean but have been observed as far south as 20°N (Horwood, 1987), with whaling effort distributed continuously across the North Pacific between 45°N and 55°N (Masaki, 1977). The IWC only considers one stock of sei whales in the North Pacific (Donovan, 1991), but NMFS recognizes three stocks, including a Hawaii stock. The best estimates of abundance and density are from line-transect surveys of the entire Hawaiian Islands EEZ that estimated 391 animals and 0.00016 animals/km^2 (CV=0.90) (Bradford et al., 2017). Sei whales may occur in the Hawaii-North model area in fall, winter, and spring.

Blainville's beaked whale: Blainville's beaked whales potentially occur in the deep waters of this model area. The best available density estimate (0.00086 animals/km^2) and abundance estimate (2,105 animals, CV=1.13) are calculated from the surveys in the Hawaii EEZ (Bradford et al., 2017).

Common bottlenose dolphin: Recent photo-id and genetic studies around the main Hawaiian Islands suggest limited movements among islands and offshore waters (Baird et al., 2009). Five Pacific Islands Region stocks are identified: (1) Kauai and Niihau; (2) Oahu; (3) the "4-Island Region" including Molokai, Lanai, Maui, and Kahoolawe; (4) Hawaii Island; and (5) Hawaii pelagic stock (Carretta et al., 2018). The boundary between the insular stocks and the pelagic stock is the 1,000-m (3,281-ft) isobath.

Hawaii pelagic stock: The best available density estimate (0.00118 animals/km^2) is from habitat-based modeling (Forney et al., 2015). The abundance estimate (21,815 animals, CV=0.57) for the pelagic stock of bottlenose dolphins is calculated from the line-transect surveys in the Hawaii EEZ (Bradford et al., 2017).

Kauai/Niihau stock: The best abundance estimate for this insular stock is 184 dolphins based on 2003 to 2005 photo-ID studies (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.065 animals/km^2; Baird et al., 2009). The density estimate is an order of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

Oahu stock: The best abundance estimate for this insular stock is 743 dolphins based on 2002, 2003, and 2006 in Oahu waters (except the windward waters) (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.187 animals/km^2; Baird et al., 2009). The density estimate is an order of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

4-Islands stock: The best abundance estimate for this insular stock is 191 dolphins based on 2002 to 2006 photo-ID studies of individual common bottlenose dolphins in the waters of Maui and Lanai (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.017 animals/km^2; Baird et al., 2009). The density estimate is two orders of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

Hawaii Island stock: The best abundance estimate for this insular stock is 128 dolphins based on 2003 to 2006 photo-ID studies (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.028 animals/km^2; Baird et al., 2009). The density estimate is an order of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

Cuvier's beaked whale: The best available density estimate (0.0003 animals/km^2) and abundance estimate (723 individuals, CV=0.69) for the Hawaii stock of Cuvier's beaked whales are calculated from line-transect surveys in the Hawaii EEZ (Bradford et al., 2017). The density estimate is comparable to the density estimate in nearshore Hawaiian waters (0.0008 animals/km^2; Mobley et al., 2000).

Dwarf sperm whale: Dwarf sperm whales are known in Hawaii from both strandings and sightings, with Mobley et al. (2000) having observed two pods of dwarf and pygmy sperm whales for a total of five individuals during his 1993 to 1998 survey efforts, although no density or abundance estimates were derived. Dwarf sperm whales were also observed near Niihau, Kauai, Lanai, and Hawaii during small boat surveys between 2000 and 2003 (Baird, 2005). The best available estimates for the Hawaiian stock of dwarf sperm whales are the density and abundance, 0.00714 animals/km^2 and 17,519 animals, respectively, estimated from the summer/fall survey in the Hawaii EEZ (Barlow, 2006).

False killer whale: Three stocks are recognized within the Hawaiian Island Stock Complex (Carretta et al., 2016): the main Hawaiian Islands insular stock (which includes false killer whales occurring within 72 km [approximately 40 nmi] of the main Hawaiian Islands); the Northwestern Hawaiian Islands stock (which includes false killer whales inhabiting waters within 93 km [50 nmi] of the NWHI and Kauai); and the Hawaii pelagic stock (including false killer whales occurring in waters further than 11 km [approximately 6 nmi] of the main Hawaiian Islands with no inner boundary within the NWHI). It is recognized that the stocks have partially overlapping ranges (Bradford et al., 2015).

Main Hawaiian Islands insular stock/DPS: The best available abundance estimate is 167 animals for the Main Hawaiian Islands insular stock (Muto et al., 2018; Bradford et al., in review). A density estimate of 0.00080 animals/km^2 is the best available estimate of the insular stock (Oleson et al., 2010; Bradford et al., 2015).

Hawaii pelagic stock: The abundance of the Hawaii pelagic stock of false killer whales is estimated as 1,540 individuals CV=0.66) from 2010 visual line-transect data (Carretta et al., 2016; Bradford et al., 2014, 2015). The best available density estimate for the Hawaii pelagic stock, 0.00060 individuals/km^2, was also estimated from the 2010 dedicated survey of Hawaiian EEZ waters (Bradford et al., 2015; Forney et al., 2015).

Northwestern Hawaiian Islands stock/DPS: This stock was defined only recently, and the abundance of this stock estimated from 2010 visual line-transect survey data is 617 whales (CV=1.09) (Carretta et al., 2016; Bradford et al., 2014, 2015). The most current density estimated for the Northwestern Hawaiian Island stock is 0.00060 individuals/km^2, was also estimated from the 2010 dedicated survey of Hawaiian EEZ waters (Bradford et al., 2015; Forney et al., 2015).

Fraser's dolphin: Fraser's dolphins were first documented in Hawaiian waters during the 2003 summer/fall survey (Barlow, 2006). The best available density estimate of 0.02104 animals/km^2 and abundance estimate of 51,491 animals (CV=0.66) are from the 2010 summer/fall survey (Bradford et al., 2017).

Killer whale: Killer whales are considered rare in Hawaiian waters with limited sightings having been reported (Carretta et al., 2014). The best available density estimate (0.00006 animals/km^2) and abundance estimate (146 animals, CV=0.96) are calculated from the summer/fall survey in the waters of the Hawaii EEZ (Bradford et al., 2017). Mobley et al. (2000) did not report any sightings in their surveys of coastal waters of the Main Hawaiian Islands.

Longman's beaked whale: Longman's beaked whale has only recently been identified to species (Dalebout et al., 2003; Pitman et al., 1999) and is considered one of the rarest and least known of cetacean species. The best available density estimate (0.00311 animals/km^2) and abundance estimate (7,619 animals, CV=0.66) for the Hawaiian stock of this beaked whale were calculated from the 2010 summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). No other density estimates exist for this species around Hawaii (Mobley et al., 2000).

Melon-headed whale: Recent studies reveal evidence for island-associated stock structure in melon-headed whales in the main Hawaiian Islands and NMFS now recognizes two stocks (Carretta et al., 2014): (1) a Kohala Resident Stock, consisting of animals within the 2,500 m (8,202.5 ft) isobath around the west and northwest sides of Hawaii Island (Oleson et al., 2013); and (2) a Hawaiian Islands Stock, consisting of the remainder of melon-headed whales found within the Hawaii EEZ. The northern boundary between the two stocks provisionally runs through the Alenuihaha Channel between Hawaii Island and Maui, bisecting the distance between the 1,000-m (3,281-ft) depth contours (Oleson et al., 2013).

Hawaiian Islands stock: Recent studies of photo-identification data using mark-recapture techniques provide the best available abundance estimate (8,666 animals CV=0.20) (Bradford et al., 2017). The best available density estimate (0.0020 animals/km^2) is calculated from the summer/fall survey in the Hawaii EEZ (Aschettino, 2010; Bradford et al., 2017). The density estimate is comparable to nearshore Hawaiian waters (0.0021 animals/km^2; Mobley et al., 2000).

Kohala Resident stock: Individuals in the smaller Kohala resident stock have a range restricted to shallower waters of the Kohala shelf and west side of Hawaii Island (Aschettino et al., 2012). Satellite telemetry data indicate they occur in waters less than 2,500 m (8,202.5 ft) depth around the northwest and west shores of Hawaii Island, west of 1560 45’ W and north of 190 15’N (Oleson et al., 2013). The best available abundance estimate (447 animals, CV=0.12) is from photo-identification work between 2002 and 2009 (Aschettino, 2010). Similarly, a density estimate (0.1 animals/km^2) was derived from the photo- identification work and the estimated spatial range of the stock (Aschettino, 2010).

Pantropical spotted dolphin: Genetic analyses support the recognition of three island-associated insular stocks: a Hawaii Island Stock that extends 65 km (35 nmi) from shore, a 4-Islands Stock that extends 20 km (11 nmi) from shore, and an Oahu Stock that extends 20 km (11 nmi) from shore (Oleson et al., 2013), in addition to a Hawaii Pelagic Stock that consists of all other pantropical spotted dolphins within the Hawaii EEZ (Carretta et al., 2018).

Hawaii Pelagic stock: The best available density estimate (0.00369 animals/km^2) and abundance estimate (55,795 animals, CV=0.40) are calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017).

Hawaii Island stock: The best abundance estimate for this insular stock is the effective population size estimated by Courbis et al. (2014) as 220 animals. The best available estimate of abundance is 0.061 animals/km^2 (Oleson et al., 2013).

Oahu stock: There are no data to estimate the abundance of this stock. Therefore, the best available data are those from the Hawaii Island Stock (220 animals). The best available estimate of abundance is 0.072 animals/km^2 (Oleson et al., 2013).

4-Islands stock: There are no data to estimate the abundance of this stock. Therefore, the best available data are those from the Hawaii Island Stock (220 animals). The best available estimate of abundance is 0.061 animals/km^2 (Oleson et al., 2013).

Pygmy killer whale: Very little information exists about this species in the Hawaii region. Mobley et al. (2000) did not report any sightings in their surveys of the Main Hawaiian Islands. The summer/fall survey in the Hawaii EEZ resulted in the best available density estimate (0.00435 animals/km^2) and abundance estimate (10,640 animals, CV=0.53) (Bradford et al., 2017).

Pygmy sperm whale: Mobley et al. (2000) observed pygmy sperm whales during his 1993 to 1998 survey efforts, while two sightings were observed during Barlow's (2006) 2002 sighting survey; many strandings of this species are also recorded in Hawaiian waters (Carretta et al., 2014). A Hawaii stock of pygmy sperm whales is recognized (Carretta et al., 2014). The best available estimates for the Hawaiian stock of pygmy sperm whales is the density of 0.0029 animals/km^2 and the abundance 7,138 animals calculated from the summer/fall survey data in the Hawaii EEZ (Barlow, 2006; Carretta et al., 2014).

Risso's dolphin: A Hawaiian stock of Risso's dolphins is recognized, although this dolphin appears to occur rarely in the Hawaiian waters (Carretta et al., 2014). Mobley et al. (2000) observed insufficient sightings of Risso's dolphins to derive density or abundance estimates in nearshore waters. NMFS suggests that based on the locations of Hawaiian longline-fishery interactions of this species, it is likely that Risso's dolphins primarily occur in pelagic waters tens to hundreds of miles from the main Hawaiian Islands and are only occasionally found nearshore (Carretta et al., 2014). The best available density estimate (0.00474 animals/km^2) and abundance estimate (11,613 animals, CV=0.43) are calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017).

Rough-toothed dolphin: A Hawaiian stock of rough-toothed dolphins is recognized. The best available density estimate (0.00224 animals/km^2) is from habitat-based modeling (Forney et al., 2015) and the abundance estimate (72,528 animals, CV=0.39) is calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). This density estimate is comparable to nearshore Hawaiian waters (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: Short-finned pilot whales occur both in the NWHI and the MHI, where they occur commonly, and a Hawaiian stock is recognized (Carretta et al., 2014). The best available density estimate (0.00459 animals/km^2) is from habitat-based modeling (Forney et al., 2015) and the abundance estimate (19,503 animals, CV=0.49) is calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). This density estimate is less than near-shore Hawaiian waters (0.0237 animals/km^2; Mobley et al., 2000).

Sperm whale: Sperm whales are known from many strandings and sightings in Hawaiian waters, and sperm whales occurring in the deep waters of the Hawaiian Islands are considered to be part of the Hawaiian stock, which numbers 4,559 animals (CV=0.33) (Bradford et al., 2017). The best available density estimate (0.00158 animals/km^2) for sperm whales in this model area was calculated from the habitat-based modeling (Forney et al., 2015; DoN, 2017). This density estimate is comparable to near-shore Hawaiian waters (0.0010 animals/km^2; Mobley et al., 2000).

Spinner dolphin: Based on analyses of genetic data, movement patterns of dolphins, and the geographic distances among the Hawaiian Islands, five separate island-associated, insular stocks are recognized in the central North Pacific: Hawaii Island, Oahu/4-Islands Region, Kauai/Niihau, Pearl and Hermes Reef, and Midway Atoll/Kure (Hill et al., 2010; Carretta et al., 2014). The seaward boundary of the insular stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). All five of the Hawaii spinner dolphin insular stocks are found in the Hawaii North model area, as well as the Hawaii Pelagic stock.

Hawaii Pelagic stock: Spinner dolphins beyond 18.5 km (10 nmi) from shore or around other islands within the Hawai'i EEZ belong to the Hawaii Pelagic Stock. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 3,351 (CV=0.74) spinner dolphins (Barlow, 2006). However, this study assumed a single Hawaiian Islands stock and occurred over eight years old. A 2010 shipboard line-transect study within the Hawaiian EEZ did not record any sightings of pelagic spinner dolphins (Bradford et al., 2013). The best available density estimate (0.00159 animals/km^2) is based on habitat modeling of existing sightings (Forney et al., 2015). This density estimate is an order of magnitude less than nearshore Hawaiian waters (0.0443 animals/km^2; Mobley et al., 2000).

Hawaii Island stock: The seaward boundary of the island-associated stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). The best estimate of abundance for the Hawaii Island Stock is from intensive year-round photo-identification surveys in Kauhako Bay, Kealakekua Bay, Honaunau Bay, and Makako Bay along the Kona Coast of Hawaii Island in 2010 and 2011, 631 animals (CV=0.09) (Tyne et al. 2013; Carretta et al., 2014). The best available density estimate (0.066 animals/km^2) is derived from Tyne et al. (2013) to account for animals within 18.5 km (10 nmi) of the Hawaii Island (DoN, 2017).

Oahu/4 Islands stock: The seaward boundary of the island-associated stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). The best estimate of abundance for the Oahu/4-Islands Region Stock is from a photo-identification study conducted July to September 2007 on the leeward coast of Oahu, which resulted in an estimate of 355 animals (CV=0.09), though it is recognized that this is likely an underestimate because of its limited spatial scope (Carretta et al., 2014). The best available density estimate (0.023 animals/km^2) is derived from Hill et al. (2011) to account for animals within 18.5 km (10 nmi) of the Oahu/4-Island Complex (DON, 2017).

Kauai/Niihau stock: The seaward boundary of the island-associated stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). The best estimate of abundance for the Kauai/Niihau Stock is from a photo-identification study conducted October to November 2005 on the leeward coast of Kauai, which resulted in an estimate of 601 animals (CV=0.20), though it is recognized that this is likely an underestimate because of its limited spatial scope (Carretta et al., 2014). The best available density estimate (0.097 animals/km^2) is derived from Hill et al. (2011) to account for animals within 18.5 km (10 nmi) of Kauai/Niihau (DON, 2017).

Kure/Midway Atoll stock: During a 2010 shipboard line-transect survey within the Hawaiian EEZ, only one off-effort spinner dolphin was sighted at Kure Atoll (Carretta et al., 2014). An earlier multi-year photo-identification study at Midway Atoll identified a population of 260 spinner dolphins based on 139 identified individuals (Karczmarski et al., 1998), which remains the best available stock estimate for the Kure/Midway Atoll stock of spinner dolphins (Carretta et al., 2014). The best available density estimate (0.0070 animals/km^2) is from the 2002 summer/fall survey in the Hawaii EEZ (Barlow, 2006).

Pearl and Hermes Reef stock: While spinner dolphins in this area have been photo-identified, little survey and low re-sighting rates of these dolphins makes estimating an abundance challenging. However, based on the work of Andrews et al. (2006) and Hoos (2013), the best available abundance for the Pearl and Hermes Reef stock has been estimated at 300 animals, while the best density estimate for this stock, 0.0070 animals/km^2, is derived from the summer/fall survey of the Hawaiian EEZ waters (Barlow, 2006).

Striped dolphin: Striped dolphins in Hawaiian waters are separated into a discrete Hawaiian stock (Carretta et al., 2014). The best available density estimate for the Hawaiian stock of striped dolphins is 0.00385 animals/km^2 based on habitat modeling (Forney et al., 2015; DON, 2017) and the best abundance is 61,201 individuals (CV=0.38) as derived from the summer/fall surveys in the Hawaiian EEZ (Bradford et al., 2017). This density estimate is comparable to nearshore Hawaiian waters (0.0016 animals/km^2; Mobley et al., 2000).

Hawaiian monk seal: Monk seals primarily occur in the NWHI, though a respectable population began to establish itself throughout the MHI in 2006 (Carretta et al., 2016). Migration occurs amongst the NWHI subpopulations, so these subpopulations are not isolated (Harting, 2002). Foraging behavior suggests offshore movement patterns (Parrish et al., 2000; Parrish et al., 2002). The current abundance estimated for the stock of Hawaiian monk seals is 1,427 animals (NMFS, 2018) and the best available density estimate is of 0.00004 animals/km^2 (DoN, 2017; NMFS, 2018).

D-11. MODEL AREA 11—HAWAII SOUTH

Blue whale: Due to the general lack of occurrence data for blue whales in the North Pacific Ocean, stock structure remains uncertain. NMFS recognizes a central North Pacific stock around Hawaii and an eastern North Pacific stock around California (Carretta et al., 2015). Blue whales occur rarely in the central North Pacific, with few sightings and acoustic detections having been made. No sightings of blue whales were made around Hawaii during the Acoustic Thermometry of Ocean Climate Marine Mammal Research Program aerial surveys or during a summer/fall 2002 line-transect survey (Barlow, 2006; Mobley, 2006). Line-transect surveys of the Hawaii EEZ estimated an abundance of 133 (CV=1.09) animals and a density of 0.00005 animals/km^2 (Bradford et al., 2017).

Bryde's whale: Sightings of the Bryde's whale in Hawaiian waters have been recorded sporadically since 1977 (Carretta et al., 2014). Occurrence data are sufficient to define a Hawaii stock of Bryde's whales. Bradford et al.'s (2017) abundance estimate of the Hawaii stock of Bryde's whales is the best available (1,751 animals, CV=0.29). The best density for Bryde's whales is 0.00012 animals/km^2, derived from habitat-based modeling (Forney et al., 2015; DoN, 2017).

Common minke whale: A Hawaii stock is recognized that occurs seasonally (November-March) in Hawaiian waters, though no estimate of abundance has been calculated (Carretta et al., 2014). Minke whales were observed and acoustically detected during the 2002 summer/fall survey of the Hawaiian EEZ (Barlow, 2006). One off-effort sighting was made during the 2010 summer/fall survey (Bradford et al., 2013). A year-long analysis of acoustic recordings made at Station ALOHA (A Long-term Oligotrophic Habitat Assessment) 100 km (54 nmi) north of Oahu detected "central" or "Hawaii" boings from 22 October 2007 to 21 May 2008 but none were detected during the months of June to September, though this does not indicate that no minke whales were present (Oswald et al., 2011). Using passive acoustic detections from hydrophones on the Pacific Missile Range Facility off Kauai, Martin et al. (2015) estimated density as 0.00423 animals/km^2, which is used as the best available data. Lacking abundance data for this stock in Hawaiian waters, the best estimate of abundance (25,049 animals) is derived from sighting surveys in July and August in the western North Pacific and Sea of Okhotsk (Buckland et al., 1992).

Fin whale: There has been acoustic evidence for fin whale presence in fall and winter (Thompson and Friedl, 1982; Moore et al., 1998) and one sighting in nearshore waters (February) (Mobley et al., 1996). From the sightings reported during line-transect surveys, an abundance estimate of 154 animals and a density estimate of 0.00006 animals/km^2 (CV=1.05) was calculated for the Hawaii stock of fin whales (Bradford et al., 2017). This estimate is similar to that of McDonald and Fox (1999) who derived an average calling whale density estimate of 0.000027 animals/km^2 based on recordings made north of Oahu, Hawaii. The seasonal maximum calling whale density was about three times the average, or 0.000081 animals/km^2 (McDonald and Fox, 1999).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Hawaii DPS and not listed under the ESA (Bettridge et al., 2015). The Hawaii DPS is synonymous with the Central North Pacific (CNP) stock identified under the MMPA and evaluated in the NMFS stock assessment reports (Carretta et al., 2015). The CNP/Hawaii DPS breeds/winters within the Main Hawaiian Islands and migrates to most known feeding grounds in the North Pacific, though about half of the stock/DPS migrate to southeast Alaska and northern British Columbia. Thus, humpback whales are only expected to occur in the Hawaii-South model area during winter, spring, and fall. Based on Calambokidis et al. (2008), the best available abundance estimate for the CNP stock/Hawaii DPS of humpback whales is 10,103 individuals (Muto et al., 2016). A density of 0.00631 animals/km^2 was estimated (Calambokidis et al., 2008; Mobley et al., 2001; DON, 2017).

Sei whale: Sei whales are present throughout the temperate North Pacific Ocean but have been observed as far south as 20°N (Horwood, 1987), with whaling effort distributed continuously across the North Pacific between 45°N and 55°N (Masaki, 1977). The IWC only considers one stock of sei whales in the North Pacific (Donovan, 1991), but NMFS recognizes three stocks, including a Hawaii stock. The best estimates of abundance and density are from line-transect surveys of the entire Hawaiian Islands EEZ that estimated 391 animals and 0.00016 animals/km^2 (CV=0.90) (Bradford et al., 2017). Sei whales may occur in the Hawaii-South model area in fall, winter, and spring.

Blainville's beaked whale: Blainville's beaked whales potentially occur in the deep waters of this model area. The best available density estimate (0.00086 animals/km^2) and abundance estimate (2,105 animals, CV=1.13) are calculated from the surveys in the Hawaii EEZ (Bradford et al., 2017).

Common bottlenose dolphin: Recent photo-id and genetic studies around the main Hawaiian Islands suggest limited movements among islands and offshore waters (Baird et al., 2009). Five Pacific Islands Region stocks are identified: (1) Kauai and Niihau; (2) Oahu; (3) the "4-Island Region" including Molokai, Lanai, Maui, and Kahoolawe; (4) Hawaii Island; and (5) Hawaii pelagic stock (Carretta et al., 2014). The boundary between the insular stocks and the pelagic stock is the 1,000-m (3,281-ft) isobath.

Hawaii pelagic stock: The best available density estimate (0.00126 animals/km^2) is from habitat-based modeling (Forney et al., 2015; DON, 2017). The abundance estimate (21,815 animals, CV=0.57) for the pelagic stock of bottlenose dolphins is calculated from the line-transect surveys in the Hawaii EEZ (Bradford et al., 2017).

Kauai/Niihau stock: The best abundance estimate for this insular stock is 184 dolphins based on 2003 to 2005 photo-ID studies (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.065 animals/km^2; Baird et al., 2009). The density estimate is an order of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

Oahu stock: The best abundance estimate for this insular stock is 743 dolphins based on 2002, 2003, and 2006 in Oahu waters (except the windward waters) (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.187 animals/km^2; Baird et al., 2009). The density estimate is an order of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

4-Islands stock: The best abundance estimate for this insular stock is 191 dolphins based on 2002 to 2006 photo-ID studies of individual common bottlenose dolphins in the waters of Maui and Lanai (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.017 animals/km^2; Baird et al., 2009). The density estimate is two orders of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

Hawaii Island stock: The best abundance estimate for this insular stock is 128 dolphins based on 2003 to 2006 photo-ID studies (Baird et al., 2009; Carretta et al., 2014). Density estimates are for this insular stock (0.028 animals/km^2; Baird et al., 2009). The density estimate is an order of magnitude higher than that calculated for nearshore Hawaiian waters (0.0013 animals/km^2) by Mobley et al. (2000).

Cuvier's beaked whale: The best available density estimate (0.0003 animals/km^2) and abundance estimate (723 individuals, CV=0.69) for the Hawaii stock of Cuvier's beaked whales are calculated from line-transect surveys in the Hawaii EEZ (Bradford et al., 2017). The density estimate is comparable to the density estimate in nearshore Hawaiian waters (0.0008 animals/km^2; Mobley et al., 2000).

Deraniyagala beaked whale: Dalebout et al. (2014) conducted genetic and molecular analyses to demonstrate that *M. hotaula* was genetic distinct from the ginkgo-toothed beaked whale (*M. ginkgodens*). Little is known about this beaked whale species. No abundance or stock information is available for the Deraniyagala beaked whale. Given that this species was synonymous with the ginkgo-toothed beaked whale, which is part of the *Mesoplodon* spp. complex, the best available density and abundance estimates for *Mesoplodon* spp. at the same latitudes in the ETP are most appropriate for this region (Ferguson and Barlow, 2001, 2003). Using Ferguson and Barlow's (2001, 2003) northernmost strata, a density estimate of 0.0009 animals/km^2 and abundance estimate of 22,799 animals were used for analyses for the Deraniyagala beaked whale in this model area.

Dwarf sperm whale: Dwarf sperm whales are known in Hawaii from both strandings and sightings, with Mobley et al. (2000) having observed two pods of dwarf and pygmy sperm whales for a total of five individuals during his 1993 to 1998 survey efforts, although no density or abundance estimates were derived. Dwarf sperm whales were also observed near Niihau, Kauai, Lanai, and Hawaii during small boat surveys between 2000 and 2003 (Baird, 2005). The best available estimates for the Hawaiian stock of dwarf sperm whales are the density and abundance, 0.00714 animals/km2 and 17,519 animals, respectively, estimated from the summer/fall survey in the Hawaii EEZ (Barlow, 2006).

False killer whale: Three stocks are recognized within the Hawaiian Island Stock Complex (Carretta et al., 2016), two of which may be affected by operations in this model area: the main Hawaiian Islands insular stock (which includes false killer whales occurring within 72 km [approximately 40 nmi] of the main Hawaiian Islands); and the Hawaii pelagic stock (including false killer whales occurring in waters further than 11 km [approximately 6 nmi] of the main Hawaiian Islands with no inner boundary within the NWHI). It is recognized that the stocks have partially overlapping ranges (Bradford et al., 2015).

Main Hawaiian Islands insular stock: The best available abundance estimate is 167 animals for the Main Hawaiian Islands insular stock (Muto et al., 2018; Bradford et al., in review). A density estimate of 0.00080 animals/km^2 is the best available estimate of the insular stock (Oleson et al., 2010; Bradford et al., 2015).

Hawaii pelagic stock: The abundance of the Hawaii pelagic stock of false killer whales is estimated as 1,540 individuals CV=0.66) from 2010 visual line-transect data (Carretta et al., 2016; Bradford et al., 2014, 2015). The best available density estimate for the Hawaii pelagic stock, 0.00086 individuals/km^2, was also estimated from the 2010 dedicated survey of Hawaiian EEZ waters (Bradford et al., 2015; Forney et al., 2015; DON, 2017).

Fraser's dolphin: Fraser's dolphins were first documented in Hawaiian waters during the 2003 summer/fall survey (Barlow, 2006). The best available density estimate of 0.02104 animals/km^2 and abundance estimate of 51,491 animals (CV=0.66) are from the 2010 summer/fall survey (Bradford et al., 2017).

Killer whale: Killer whales are considered rare in Hawaiian waters with limited sightings having been reported (Carretta et al., 2014). The best available density estimate (0.00006 animals/km^2) and abundance estimate (146 animals, CV=0.96) are calculated from the summer/fall survey in the waters of the Hawaii EEZ (Bradford et al., 2017). Mobley et al. (2000) did not report any sightings in their surveys of coastal waters of the Main Hawaiian Islands.

Longman's beaked whale: Longman's beaked whale has only recently been identified to species (Dalebout et al., 2003; Pitman et al., 1999) and is considered one of the rarest and least known of cetacean species. The best available density estimate (0.00311 animals/km^2) and abundance estimate (7,619 animals, CV=0.66) for the Hawaiian stock of this beaked whale were calculated from the 2010 summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). No other density estimates exist for this species around Hawaii (Mobley et al., 2000).

Melon-headed whale: Recent studies reveal evidence for island-associated stock structure in melon-headed whales in the main Hawaiian Islands and NMFS now recognizes two stocks (Carretta et al., 2014): (1) a Kohala Resident Stock, consisting of animals within the 2,500 m (8,202.5 ft) isobath around the west and northwest sides of Hawaii Island (Oleson et al., 2013); and (2) a Hawaiian Islands Stock, consisting of the remainder of melon-headed whales found within the Hawaii EEZ. The northern boundary between the two stocks provisionally runs through the Alenuihaha Channel between Hawaii Island and Maui, bisecting the distance between the 1,000-m (3,281-ft) depth contours (Oleson et al., 2013).

Hawaiian Islands stock: Recent studies of photo-identification data using mark-recapture techniques provide the best available abundance estimate (8,666 animals CV=0.20) (Bradford et al., 2017). The best available density estimate (0.0020 animals/km^2) is calculated from the summer/fall survey in the Hawaii EEZ (Aschettino, 2010; Bradford et al., 2017). The density estimate is comparable to nearshore Hawaiian waters (0.0021 animals/km^2; Mobley et al., 2000).

Kohala Resident stock: Individuals in the smaller Kohala resident stock have a range restricted to shallower waters of the Kohala shelf and west side of Hawaii Island (Aschettino et al., 2012). Satellite telemetry data indicate they occur in waters less than 2,500 m (8,202.5 ft) depth around the northwest and west shores of Hawaii Island, west of 1560 45' W and north of 190 15'N (Oleson et al., 2013). The best available abundance estimate (447 animals, CV=0.12) is from photo-identification work between 2002 and 2009 (Aschettino, 2010). Similarly, a density estimate (0.1 animals/km^2) was derived from the photo- identification work and the estimated spatial range of the stock (Aschettino, 2010).

Pantropical spotted dolphin: Genetic analyses support the recognition of three island-associated insular stocks: a Hawaii Island Stock that extends 65 km (35 nmi) from shore, a 4-Islands Stock that extends 20 km (11 nmi) from shore, and an Oahu Stock that extends 20 km (11 nmi) from shore (Oleson et al., 2013), in addition to a Hawaii Pelagic Stock that consists of all other pantropical spotted dolphins within the Hawaii EEZ (Carretta et al., 2014).

Hawaii Pelagic stock: The best available density estimate (0.00541 animals/km^2) and abundance estimate (55,795 animals, CV=0.40) are calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017).

Hawaii Island stock: The best abundance estimate for this insular stock is the effective population size estimated by Courbis et al. (2014) as 220 animals. The best available estimate of abundance is 0.061 animals/km^2 (Oleson et al., 2013).

Oahu stock: There are no data to estimate the abundance of this stock. Therefore, the best available data are those from the Hawaii Island Stock (220 animals). The best available estimate of abundance is 0.072 animals/km^2 (Oleson et al., 2013).

4-Islands stock: There are no data to estimate the abundance of this stock. Therefore, the best available data are those from the Hawaii Island Stock (220 animals). The best available estimate of abundance is 0.061 animals/km^2 (Oleson et al., 2013).

Pygmy killer whale: Very little information exists about this species in the Hawaii region. Mobley et al. (2000) did not report any sightings in their surveys of the Main Hawaiian Islands. The summer/fall survey in the Hawaii EEZ resulted in the best available density estimate (0.00435 animals/km^2) and abundance estimate (10,640 animals, CV=0.53) (Bradford et al., 2017).

Pygmy sperm whale: Mobley et al. (2000) observed pygmy sperm whales during his 1993 to 1998 survey efforts, while two sightings were observed during Barlow's (2006) 2002 sighting survey; many strandings of this species are also recorded in Hawaiian waters (Carretta et al., 2014). A Hawaii stock of pygmy sperm whales is recognized (Carretta et al., 2014). The best available estimates for the Hawaiian stock of pygmy sperm whales is the density of 0.0029 animals/km^2 and the abundance 7,138 animals calculated from the summer/fall survey data in the Hawaii EEZ (Barlow, 2006; Carretta et al., 2014).

Risso's dolphin: A Hawaiian stock of Risso's dolphins is recognized, although this dolphin appears to occur rarely in the Hawaiian waters (Carretta et al., 2014). Mobley et al. (2000) observed insufficient sightings of Risso's dolphins to derive density or abundance estimates in nearshore waters. NMFS suggests that based on the locations of Hawaiian longline-fishery interactions of this species, it is likely that Risso's dolphins primarily occur in pelagic waters tens to hundreds of miles from the main Hawaiian Islands and are only occasionally found nearshore (Carretta et al., 2014). The best available density estimate (0.00474 animals/km^2) and abundance estimate (11,613 animals, CV=0.43) are calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017).

Rough-toothed dolphin: A Hawaiian stock of rough-toothed dolphins is recognized. The best available density estimate (0.00257 animals/km^2) is from habitat-based modeling (Forney et al., 2015; DON, 2017) and the abundance estimate (72,528 animals, CV=0.39) is calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). This density estimate is comparable to nearshore Hawaiian waters (0.0017 animals/km^2; Mobley et al., 2000).

Short-finned pilot whale: Short-finned pilot whales occur both in the NWHI and the MHI, where they occur commonly, and a Hawaiian stock is recognized (Carretta et al., 2014). The best available density estimate (0.00549 animals/km^2) is from habitat-based modeling (Forney et al., 2015; DON, 2017) and the abundance estimate (19,503 animals, CV=0.49) is calculated from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). This density estimate is less than near-shore Hawaiian waters (0.0237 animals/km^2; Mobley et al., 2000).

Sperm whale: Sperm whales are known from many strandings and sightings in Hawaiian waters, and sperm whales occurring in the deep waters of the Hawaiian Islands are considered to be part of the Hawaiian stock, which numbers 4,559 animals (CV=0.33) from the summer/fall survey in the Hawaii EEZ (Bradford et al., 2017). The best available density estimate (0.00131 animals/km^2) for sperm whales in this model area was calculated from habitat-based modeling (Forney et al., 2015; DON, 2017). This density estimate is comparable to near-shore Hawaiian waters (0.0010 animals/km^2; Mobley et al., 2000).

Spinner dolphin: Based on analyses of genetic data, movement patterns of dolphins, and the geographic distances among the Hawaiian Islands, five separate island-associated, insular stocks are recognized in the central North Pacific, three of which might be exposed in this model area, as well as the Hawaii Pelagic stock: Hawaii Island, Oahu/4-Islands Region, and Kauai/Niihau (Hill et al., 2010; Carretta et al., 2014). The seaward boundary of the insular stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010).

Hawaii Pelagic stock: Spinner dolphins beyond 18.5 km (10 nmi) from shore or around other islands within the Hawai'i EEZ belong to the Hawaii Pelagic Stock. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 3,351 (CV=0.74) spinner dolphins (Barlow, 2006). However, this study assumed a single Hawaiian Islands stock and occurred over eight years old. A 2010 shipboard line-transect study within the Hawaiian EEZ did not record any sightings of pelagic spinner dolphins (Bradford et al., 2013). The best available density estimate (0.00348 animals/km^2) is based on habitat modeling of existing sightings (Forney et al., 2015). This density estimate is an order of magnitude less than nearshore Hawaiian waters (0.0443 animals/km^2; Mobley et al., 2000).

Hawaii Island stock: The seaward boundary of the island-associated stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). The best estimate of abundance for the Hawaii Island Stock is from intensive year-round photo-identification surveys in Kauhako Bay, Kealakekua Bay, Honaunau Bay, and Makako Bay along the Kona Coast of Hawaii Island in 2010 and 2011, 631 animals (CV=0.09) (Tyne et al. 2013; Carretta et al., 2014). The best available density estimate (0.066 animals/km^2) is derived from Tyne et al. (2013) to account for animals within 18.5 km (10 nmi) of the Hawaii Island (DON, 2017).

Oahu/4 Islands stock: The seaward boundary of the island-associated stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). The best estimate of abundance for the Oahu/4-Islands Region Stock is from a photo-identification study conducted July to September 2007 on the leeward coast of Oahu, which resulted in an estimate of 355 animals (CV=0.09), though it is recognized that this is likely an underestimate because of its limited spatial scope (Carretta et al., 2014). The best available density estimate (0.023 animals/km^2) is derived from Hill et al. (2011) to account for animals within 18.5 km (10 nmi) of the Oahu/4-Island Complex (DON, 2017).

Kauai/Niihau stock: The seaward boundary of the island-associated stocks is 18.5 km (10 nmi) around each island or island group (Hill et al., 2010). The best estimate of abundance for the Kauai/Niihau Stock is from a photo-identification study conducted October to November 2005 on the leeward coast of Kauai, which resulted in an estimate of 601 animals (CV=0.20), though it is recognized that this is likely an underestimate because of its limited spatial scope (Carretta et al., 2014). The best available density estimate (0.097 animals/km^2) is derived from Hill et al. (2011) to account for animals within 18.5 km (10 nmi) of Kauai/Niihau (DON, 2017).

Striped dolphin: Striped dolphins in Hawaiian waters are separated into a discrete Hawaiian stock (Carretta et al., 2014). The best available density estimate for the Hawaiian stock of striped dolphins is 0.00475 animals/km^2 based on habitat modeling (Forney et al., 2015; DON, 2017) and the best abundance is 61,201 individuals (CV=0.38) as derived from the summer/fall surveys in the Hawaiian EEZ (Bradford et al., 2017). This density estimate is comparable to nearshore Hawaiian waters (0.0016 animals/km^2; Mobley et al., 2000).

Hawaiian monk seal: Monk seals primarily occur in the NWHI, though a respectable population began to establish itself throughout the MHI in 2006 (Carretta et al., 2016). Migration occurs amongst the NWHI subpopulations, so these subpopulations are not isolated (Harting, 2002). Foraging behavior suggests offshore movement patterns (Parrish et al., 2000; Parrish et al., 2002). The current abundance estimated for the stock of Hawaiian monk seals is 1,427 animals (NMFS, 2018) and the best available density estimate is of 0.00004 animals/km^2 (DoN, 2017; NMFS, 2018).

D-12. MODEL AREA 12—OFFSHORE SRI LANKA

Population and even occurrence data for most species of marine mammals are sparsely available for much of the Indian Ocean except in very limited regions, typically for coastal waters. Thus, because abundance and density estimates were needed for the acoustic impact analyses for the model areas in the Indian Ocean, abundances for many of the marine mammal species potentially occurring in the model areas of the Indian Ocean were extrapolated from well-studied oceanic areas with similar oceanographic and/or ecological characteristics and density estimates were derived from relative environmental suitability (RES) models (DoN, 2017).

Blue whale: Blue whales are found year-round in the northern and equatorial Indian Ocean, especially around Sri Lanka and the Maldives (Jefferson et al., 2008, 2015). Because of their year-round presence, a northern Indian stock of blue whales is identified, with a best abundance estimate of 3,691 animals (IWC, 2016). With no direct data available on density estimates in the region, seasonally-specific, RES-modeled density estimates of 0.000035 animals/km^2 for winter and spring, and 0.000036 animals/km^2 for summer and fall were calculated from the NMSDD (DoN, 2017).

Bryde's whale: Bryde's whales occur throughout the Indian Ocean north of about 35°S. The IWC has identified two stocks in the Indian Ocean, a northern and a southern stock (IWC, 2016). The best available abundance estimate is an extrapolation from the eastern tropical Pacific of 9,176 animals (Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00041 animals/km^2 for winter, spring, summer, and fall calculated from the NMSDD (DoN, 2011).

Common minke whale: A single stock is identified for the Indian Ocean (IWC, 2016), though minke whales are considered rare in the northern Indian Ocean (Salm et al., 1993; Sathasivam, 2002). It is likely they migrate to Antarctic waters during the austral summer for better foraging conditions. The best available abundance estimate is one-half of the overall southern hemisphere estimate (257,500 animals; IWC, 2016). The best available density estimates are a RES-modeled density estimates of 0.00625 animals/km^2 for summer calculated from the NMSDD (DoN, 2011) and the nominal minimum density estimate of 0.00001 animals/km^2 for fall and spring.

Fin whale: Fin whales are not common in the Indian Ocean, though their presence has been documented by strandings. With no direct population data for this species, an abundance estimate of one-half (1,846 animals) that estimated for blue whales in the Indian Ocean has been used. The nominal minimum density estimate of 0.00001 animals/km^2 was used for all seasons since no RES-modeled density estimates were available (DoN, 2017).

Humpback whale: The NMFS Humpback Whale BRT conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Arabian Sea (AS) DPS and listed as endangered under the ESA (Bettridge et al., 2015). The AS stock/DPS is resident in the Arabian Sea, with no migratory movements (Bettridge et al., 2015). The best abundance estimate for the stock/DPS is 200 animals (Rosenbaum et al., 2009; Minton et al., 2008; Minton et al., 2011). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000051 animals/km^2 for winter and fall, 0.000053 animals/km^2 for spring, and 0.000052 animals/km^2 for summer calculated from the NMSDD (DoN, 2017).

Omura's whale: Although it was only recently described (Wada et al., 2003), the separate species status of Omura's whale is now well established (Sasaki et al., 2006). However, because it was believed to be a pygmy form of the Bryde's whale for many years, distinct information on its distribution and abundance is not available. Therefore, the best available data are those for the Bryde's whale with an abundance estimate of 9,176 animals (Wade and Gerrodette, 1993). The best available density estimates is a RES-modeled density estimate of 0.00041 animals/km^2 calculated from the NMSDD (DoN, 2017).

Sei whale: Limited information is available on sei whales in the northern Indian Ocean, but animals are likely to occur primarily in this region in winter, migrating to Antarctic waters in the austral summer. The best available data are those of the similar species, the Bryde's whale[42] with an abundance estimate of 9,176 animals (Wade and Gerrodette, 1993). The best available density estimates are RES-modeled density estimates of 0.00141, 0.00045, 0.00045, and 0.00095 animals/km^2 calculated from the NMSDD (DoN, 2018) for winter, spring, summer, and fall, respectively.

Blainville's beaked whale: Blainville's beaked whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008; Lambert et al., 2014). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00105 animals/km^2 calculated from the NMSDD (DoN, 2018).

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). The best available abundance estimate is extrapolated from the eastern tropical Pacific (1,819,882 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00513 animals/km^2 for winter, 0.00516 animals/km^2 for spring, 0.00541 animals/km^2 for summer, and 0.00538 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Common bottlenose dolphin: Common bottlenose dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (785,585 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.04839 animals/km^2 for winter, 0.04829 animals/km^2 for spring, 0.04725 animals/km^2 for summer, and 0.04740 animals/km^2 for fall calculated from the NMSDD (DoN, 2018).

Cuvier's beaked whale: Cuvier's beaked whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (27,272 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00506 animals/km^2 for winter, 0.00508 animals/km^2 for spring, 0.00505 animals/km^2 for summer, and 0.00505 animals/km^2 for fall calculated from the NMSDD (DoN, 2018).

Deraniyagala's beaked whale: The Deraniyagala's beaked whale has been documented in the northern Indian Ocean (Dalebout et al., 2014; Lambert et al., 2014). The best available abundance estimate is extrapolated from ginkgo-toothed whales in the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00513 animals/km^2 for winter, 0. 00516 animals/km^2 for spring, 0.00541 animals/km^2 for summer, and 0.00538 animals/km^2 for fall calculated from the NMSDD (DoN, 2018) for ginkgo-toothed whales. (Deraniyagala's beaked whale is recently resurrected species for which no population data are available.)

Dwarf sperm whale: Dwarf sperm whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (10,541 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00005 animals/km^2 for winter, spring, summer, and fall calculated from the NMSDD (DoN, 2011).

False killer whale: False killer whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015; Minton et al., 2010). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (144,188 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000248 animals/km^2 for winter and fall, and 0.000247 animals/km^2 for spring and summer calculated from the NMSDD (DoN, 2011).

Fraser's dolphin: Fraser's dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (151,554 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00207 animals/km^2, calculated from the NMSDD (DoN, 2018).

Indo-Pacific bottlenose dolphin: Indo-Pacific bottlenose dolphins are typically found inshore of SURTASS LFA operations; however, Afsal et al. (2008) documented sightings farther from shore that may result in exposures. There are no data on abundance or density estimates for this region. The best available abundance estimate is 1/100 of the common bottlenose dolphin estimate (7,850 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00048 animals/km^2 for winter, 0.00048 animals/km^2 for spring, 0.00047 animals/km^2 for summer, and 0.00047 animals/km^2 for fall calculated from the NMSDD (DoN, 2018).

Killer whale: Killer whales are distributed throughout all waters of the world, including the Indian Ocean (Baldwin et al., 2001; Minton et al., 2010). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (12,593 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00697 animals/km^2 for winter, 0.00155 animals/km^2 for spring, 0.00693 animals/km^2 for summer, and 0.00694 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Longman's beaked whale: Longman's beaked whale may be more common in the Indian Ocean than in the Pacific Ocean (Anderson et al., 2006). The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00513 animals/km^2 for winter, 0.00516 animals/km^2 for spring, 0.00541 animals/km^2 for summer, and 0.00538 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Melon-headed whale: Melon-headed whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (64,600 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00921 animals/km^2 for winter, 0.00920 animals/km^2 for spring, 0.00937 animals/km^2 for summer, and 0.00936 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Pantropical spotted dolphin: Pantropical spotted dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (736,575 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00904 animals/km^2, calculated from the NMSDD (DoN, 2018).

Pygmy killer whale: Pygmy killer whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (22,029 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00138 animals/km^2 for winter, 0.00137 animals/km^2 for spring, 0.00152 animals/km^2 for summer, and 0.00153 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Pygmy sperm whale: Pygmy sperm whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). They have been documented in the western Indian Ocean (Vivekanandan and Jeyabaskaran, 2012). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the dwarf sperm whale in the eastern tropical Pacific (10,541 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00001 animals/km^2, calculated from the NMSDD (DoN, 2018).

Risso's dolphin: Risso's dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (452,125 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.08641 animals/km^2 for winter, 0.08651 animals/km^2 for spring, 0.08435 animals/km^2 for summer, and 0.08466 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Rough-toothed dolphin: Rough-toothed dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (156,690 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00071 animals/km^2, calculated from the NMSDD (DoN, 2018).

Short-finned pilot whale: Short-finned pilot whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (268,751 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.03219 animals/km^2 for winter, 0.03228 animals/km^2 for spring, 0.03273 animals/km^2 for summer, and 0.03279 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Sperm whale: The IWC divides the Indian Ocean into two stocks, a northern Indian stock and a southern Indian stock (Perry et al., 1999). The best available abundance estimate is extrapolated from the eastern tropical Pacific (24,446 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00129 animals/km^2 for winter, 0.00118 animals/km^2 for spring, 0.00126 animals/km^2 for summer, and 0.00121 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Spinner dolphin: Spinner dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (634,108 animals; Wade and Gerrodette, 1993). The best available density estimate is a RES-modeled density estimate of 0.00678 animals/km^2, calculated from the NMSDD (DoN, 2018).

Striped dolphin: Striped dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (674,578 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.14601 animals/km^2 for winter, 0.14629 animals/km^2 for spring, 0.14780 animals/km^2 for summer, and 0.14788 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

D-13. MODEL AREA 13—ANDAMAN SEA

Population and even occurrence data for most species of marine mammals are sparsely available for much of the Indian Ocean except in very limited regions, typically for coastal waters. Thus, because abundance and density estimates were needed for the acoustic impact analyses for the model areas in the Indian Ocean, abundances for many of the marine mammal species potentially occurring in the model areas of the Indian Ocean were extrapolated from well-studied oceanic areas with similar oceanographic and/or ecological characteristics and density estimates were derived from RES models (DoN, 2017).

Blue whale: Blue whales are found year-round in the northern and equatorial Indian Ocean, especially around Sri Lanka and the Maldives (Jefferson et al., 2008, 2015). Because of their year-round presence, a northern Indian stock of blue whales is identified, with a best abundance estimate of 3,691 animals (IWC, 2016). With no direct data available on density estimates in the region, seasonally-specific, RES-modeled density estimates of 0.000029 animals/km^2 for winter and 0.000027 animals/km^2 for spring, summer, and fall were calculated from the NMSDD (DoN, 2018).

Bryde's whale: Bryde's whales occur throughout the Indian Ocean north of about 35°S. The IWC has identified two stocks in the Indian Ocean, a northern and a southern stock (IWC, 2016). The best available abundance estimate is an extrapolation from the eastern tropical Pacific of 9,176 animals (Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000375 animals/km^2 for winter, 0.000363 animals/km^2 for spring, and 0.000373 animals/km^2 for summer and fall calculated from the NMSDD (DoN, 2011).

Common minke whale: A single stock is identified for the Indian Ocean (IWC, 2016), though minke whales are considered rare in the northern Indian Ocean (Salm et al., 1993; Sathasivam, 2002). It is likely they migrate to Antarctic waters during the winter (austral summer) for better foraging conditions. The best available abundance estimate is one-half of the overall southern hemisphere estimate (257,500 animals; IWC, 2016). The best available density estimates are a RES-modeled density estimate of 0.009679 animals/km^2 for summer calculated from the NMSDD (DoN, 2011) and the nominal minimum density estimate of 0.00001 animals/km^2 for spring and fall.

Fin whale: Fin whales are not common in the Indian Ocean, though their presence has been documented by strandings (Sathasivam, 2002). With no direct data for this species, an abundance estimate of one-half of blue whales is calculated (1,716 animals). The best available density estimates is the nominal minimum of 0.00001 animals/km^2 for winter, spring, and fall since no RES-modeled density estimates are available (DoN, 2017).

Omura's whale: Although it was only recently described (Wada et al., 2003), the separate species status of Omura's whale is now well established (Sasaki et al., 2006). However, because it was believed to be a pygmy form of the Bryde's whale for many years, distinct information on its distribution and abundance is not available. Therefore, the best available data are those for the Bryde's whale with an abundance estimate of 9,176 animals (Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000375 animals/km^2 for winter, 0.000363 animals/km^2 for spring, and 0.000373 animals/km^2 for summer and fall calculated from the NMSDD (DoN, 2017).

Blainville's beaked whale: Blainville's beaked whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008; Lambert et al., 2014). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000940 animals/km^2 for winter, 0.000890 animals/km^2 for spring, 0.000935 animals/km^2 for summer, and 0.000990 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Common bottlenose dolphin: Common bottlenose dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (785,585 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.075781 animals/km^2 for winter, 0.077811 animals/km^2 for spring, 0.072605 animals/km^2 for summer, and 0.072122 animals/km^2 for fall calculated from the NMSDD (DoN, 2018).

Cuvier's beaked whale: Cuvier's beaked whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (27,272 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.004656 animals/km^2 for winter, 0.004824 animals/km^2 for spring, 0.004795 animals/km^2 for summer, and 0.004734 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Deraniyagala's beaked whale: The Deraniyagala's beaked whale has been documented in the northern Indian Ocean (Dalebout et al., 2014). The best available abundance estimate is extrapolated from ginkgo-toothed whales in the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000935 animals/km^2 for winter, 0.000919 animals/km^2 for spring, 0.000972 animals/km^2 for summer, and 0.000988 animals/km^2 for fall calculated from the NMSDD (DoN, 2018) for ginkgo-toothed beaked whales.

Dwarf sperm whale: Dwarf sperm whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (10,541 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000054 animals/km^2 for winter and fall, and 0.000056 animals/km^2 for spring and summer, calculated from the NMSDD (DoN, 2018).

False killer whale: False killer whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015; Minton et al., 2010). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (144,188 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000229 animals/km^2 for winter, 0.000231 animals/km^2 for spring, 0.000237 animals/km^2 for summer, and 0.000230 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Fraser's dolphin: Fraser's dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (151,554 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.001762 animals/km^2 for winter, 0.001787 animals/km^2 for spring, and 0.001795 animals/km^2 for summer and fall, calculated from the NMSDD (DoN, 2018).

Ginkgo-toothed beaked whale: The ginkgo-toothed beaked whale occurs in temperate and tropical waters of the world (Jefferson et al., 2008, 2015). The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000935 animals/km^2 for winter, 0.000919 animals/km^2 for spring, 0.000972 animals/km^2 for summer, and 0.000988 animals/km^2 for fall calculated from the NMSDD (DoN, 2018).

Indo-Pacific bottlenose dolphin: Indo-Pacific bottlenose dolphins are typically found inshore of SURTASS LFA operations; however, Afsal et al. (2008) documented sightings farther from shore that may result in exposures. There are no data on abundance or density estimates for this region. The best available abundance estimate is 1/100 of the common bottlenose dolphin estimate (7,850 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000758 animals/km^2 for winter, 0.000778 animals/km^2 for spring, 0.000726 animals/km^2 for summer, and 0.000721 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Killer whale: Killer whales are distributed throughout all waters of the world, including the Indian Ocean (Baldwin et al., 2001; Minton et al., 2010). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (12,593 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.007436 animals/km^2 for winter, 0.001781 animals/km^2 for spring, 0.007298 animals/km^2 for summer, and 0.007343 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Longman's beaked whale: Longman's beaked whale may be more common in the Indian Ocean than in the Pacific (Anderson et al., 2006). The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.004437 animals/km^2 for winter, 0.004290 animals/km^2 for spring, 0.004586 animals/km^2 for summer, and 0.004403 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Melon-headed whale: Melon-headed whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (64,600 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.008835 animals/km^2 for winter, 0.008476 animals/km^2 for spring, 0.008778 animals/km^2 for summer, and 0.008464 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Pantropical spotted dolphin: Pantropical spotted dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (736,575 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.008682 animals/km^2 for winter, 0.008406 animals/km^2 for spring, 0.008290 animals/km^2 for summer, and 0.008730 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Pygmy killer whale: Pygmy killer whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). Sathasivam (2002) reported them from around Sri Lanka. A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (22,029 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.001213 animals/km^2 for winter, 0.001126 animals/km^2 for spring, 0.001249 animals/km^2 for summer, and 0.001311 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Pygmy sperm whale: Pygmy sperm whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). They have been documented in the Andaman Islands (Sathasivam, 2002; Vivekanandan and Jeyabaskaran, 2012). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the dwarf sperm whale in the eastern tropical Pacific (10,541 animals; Wade and Gerrodette, 1993). The best available density estimates is a RES-modeled density estimate of 0.000009 animals/km^2 for winter, spring, summer, and fall, calculated from the NMSDD (DoN, 2018).

Risso's dolphin: Risso's dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (452,125 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.091970 animals/km^2 for winter, 0.092146 animals/km^2 for spring, 0.091726 animals/km^2 for summer, and 0.093658 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Rough-toothed dolphin: Rough-toothed dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (156,690 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000770 animals/km^2 for winter, 0.000775 animals/km^2 for spring, 0.000769 animals/km^2 for summer, and 0.000744 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Short-finned pilot whale: Short-finned pilot whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (268,751 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.033542 animals/km^2 for winter, 0.033638 animals/km^2 for spring, 0.035427 animals/km^2 for summer, and 0.035039 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Sperm whale: The IWC divides sperm whales in the Indian Ocean into two stocks, a northern and southern Indian stock (Perry et al., 1999). Since no abundance data are available for either stock of the sperm whales in the Indian Ocean, the best available abundance estimate was extrapolated from the eastern tropical Pacific (24,446 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.001092 animals/km^2 for winter, 0.000989 animals/km^2 for spring, 0.001072 animals/km^2 for summer, and 0.001050 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Spinner dolphin: Spinner dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (634,108 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.007364 animals/km^2 for winter, 0.007109 animals/km^2 for spring, 0.007006 animals/km^2 for summer, and 0.007259 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Striped dolphin: Striped dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (674,578 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.144134 animals/km^2 for winter, 0.141739 animals/km^2 for spring, 0.141232 animals/km^2 for summer, and 0.144024 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

D-14. MODEL AREA 14—NORTHWEST OF AUSTRALIA

Population and even occurrence data for most species of marine mammals are sparsely available for much of the Indian Ocean except in very limited regions, typically for coastal waters. Thus, because abundance and density estimates were needed for the acoustic impact analyses for the model areas in the Indian Ocean, abundances for many of the marine mammal species potentially occurring in the model areas of the Indian Ocean were extrapolated from well-studied oceanic areas with similar oceanographic and/or ecological characteristics and density estimates were derived from RES models (DoN, 2017).

Note that the seasons listed in this model area are northern-hemisphere seasons to match the seasonality of the remainder of model areas, which all occur in the northern hemisphere. Thus, “winter” for model area 14 represents austral summer (the months of December, January, and February) while “summer” is actually austral winter (the months of June, July, and August).

Antarctic minke whale: Since 2000, the IWC has recognized the Antarctic minke whale as a distinct species from the common minke whale, which is found in the northern hemisphere and as the “dwarf” form in the southern hemisphere. The Antarctic minke whale is abundant south of 60°S during the austral summer, but the winter distribution is less defined, suggesting that it is dispersed and offshore. The best estimate of abundance is 90,000 animals in IWC Area IV (Bannister et al., 1996). With no known density estimate, the default density of 0.00001 animals/km^2 was used for exposure estimates.

Blue whale: There is ongoing research into the population structure of blue whales throughout the world. The Society for Marine Mammalogy currently recognizes five subspecies: the true or northern blue whale, the Antarctic blue whale, the northern Indian Ocean blue whale, the pygmy blue whale, and the Chilean blue whale (SMM, 2017). Pygmy blue whales as well as Antarctic blue whales are found in waters off western and northwestern Australia, though blue whales do leave the region in the austral summer for better foraging grounds (Branch et al., 2007; Double et al., 2014). The best abundance estimate for this model area is 1,657 animals based on a combination of passive acoustics and mark-recapture data (Jenner et al., 2008; McCauley and Jenner, 2010). With no direct data available on density estimates in the region, a RES-modeled density estimate of 0.000028 animals/km^2 was calculated for spring, summer, and fall from the NMSDD (DoN, 2018).

Bryde's whale: Bryde's whales occur throughout the Indian Ocean north of about 35°S. The IWC has identified two stocks in the Indian Ocean, a northern and a southern stock (IWC, 2016). Population data are sparse for the Bryde's whale in the Indian Ocean, as shown by the best available abundance estimate being twenty-five years old (13,854 animals; IWC, 1981). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000318 animals/km^2 for winter, 0.000315 animals/km^2 for spring, 0.000317 animals/km^2 for summer, and 0.000316 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Common minke whale: A single stock is identified for the Indian Ocean (IWC, 2016). It is likely they migrate to Antarctic waters during the winter (austral summer) for better foraging conditions. The best available abundance estimate is one-half of the overall southern hemisphere estimate (257,500 animals; IWC, 2016). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.012270 animals/km^2 for spring, 0.019285 animals/km^2 for summer, and 0.019469 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Fin whale: A southern Indian stock is identified, with animals that migrate to Antarctic waters in the winter (austral summer). The best available abundance estimate is 38,185 animals (Branch and Butterworth, 2001; Mori and Butterworth, 2006). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.00001 animals/km^2 for winter, 0.000985 animals/km^2 for spring, 0.001276 animals/km^2 for summer, and 0.001210 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Humpback whale: The Western Australian stock and DPS occurs in this model area during spring, summer, and fall as animals migrate between possible breeding ground in Indonesia and feeding grounds in Antarctica (Australian Government, 2010). There is some uncertainty surrounding the abundance of this stock/DPS, with the IWC (2016) estimating a population size of 29,000 animals and Bettridge et al. (2015) estimating less than 2,000 animals. However, Bannister and Hedley (2001) estimated a population of 13,640, which is considered the best available population estimate. The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000065 animals/km^2 for spring, 0.000067 animals/km^2 for summer, and 0.000066 animals/km^2 for fall, calculated from the NMSDD (DoN, 2017).

Omura's whale: Although it was only recently described (Wada et al., 2003), the separate species status of Omura's whale is now well established (Sasaki et al., 2006). However, because it was believed to be a pygmy form of the Bryde's whale for many years, distinct information on its distribution and abundance is not available. Therefore, the best available data are those for the Bryde's whale with an abundance estimate of 13,854 animals (IWC, 1981). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000318 animals/km^2 for winter, 0.000315 animals/km^2 for spring, 0.000317 animals/km^2 for summer, and 0.000316 animals/km^2 for fall calculated from the NMSDD (DoN, 2017).

Sei whale: Sei whales occur in the southern Indian Ocean, with a summer distribution mainly around 40° to 50° S and a winter distribution primarily known from hunting grounds (Reilly et al., 2008b). Similar to other baleen whales, the IWC divides southern hemisphere sei whales into six management areas, but no recent sighting surveys have occurred in the distributional range of sei whales to provide insight into abundance or density estimates. Therefore, the best available data are those for the Bryde's whale, a species similar to the sei whale[42], with an abundance estimate of 13,854 animals (IWC, 1981). With no known density estimate, the default density of 0.00001 animals/km^2 was used for exposure estimates.

Blainville's beaked whale: Blainville's beaked whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015; Lambert et al., 2014). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000830 animals/km^2 for winter, spring, and fall, and 0.000822 animals/km^2 for summer, calculated from the NMSDD (DoN, 2011).

Common bottlenose dolphin: Common bottlenose dolphins are distributed throughout temperate and tropical waters of the world, with pockets of smaller subpopulations such as the one present in Shark Bay (Preen et al., 1997). The best available abundance estimate for common bottlenose dolphins in this model area is 3,000 animals (Preen et al., 1997). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.036293 animals/km^2 for winter, 0.036517 animals/km^2 for spring, 0.034592 animals/km^2 for summer, and 0.037247 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Cuvier's beaked whale: Cuvier's beaked whales are principally known from strandings in Australia, recorded between January and June, of which five occurred in Western Australia (Ross, 2006). A single stock is recognized in the Indian Ocean. The best available abundance estimate in this model area is the median value of the southern hemisphere population (76,500 animals; Dalebout et al., 2005). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.003993 animals/km^2 for winter, 0.004059 animals/km^2 for spring, 0.004017 animals/km^2 for summer, and 0.004052 animals/km^2 for fall calculated from the NMSDD (DoN, 2011).

Dwarf sperm whale: Dwarf sperm whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (10,541 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000044 animals/km^2 for winter, spring, and summer, and 0.000043 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

False killer whale: False killer whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015; Minton et al., 2010). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (144,188 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000199 animals/km^2 for winter, 0.000201 animals/km^2 for spring, 0.000193 animals/km^2 for summer, and 0.000195 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Fraser's dolphin: Fraser's dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (151,554 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.001454 animals/km^2 for winter, 0.001484 animals/km^2 for spring, 0.001486 animals/km^2 for summer, and 0.001470 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Killer whale: Killer whales are distributed throughout all waters of the world, including the Indian Ocean (Baldwin et al., 2001; Minton et al., 2010). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (12,593 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.005847 animals/km^2 for winter, 0.004350 animals/km^2 for spring, 0.005878 animals/km^2 for summer, and 0.005797 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Longman's beaked whale: Longman's beaked whale may be more common in the western Indian Ocean than in the Pacific (Anderson et al., 2006). The best available abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.003934 animals/km^2 for winter and spring, 0.004029 animals/km^2 for summer, and 0.004120 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Melon-headed whale: Melon-headed whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (64,600 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.007165 animals/km^2 for winter and spring, 0.006348 animals/km^2 for summer, and 0.006367 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Pantropical spotted dolphin: Pantropical spotted dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (736,575 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.007269 animals/km^2 for winter and spring, 0.007145 animals/km^2 for summer, and 0.007455 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Pygmy killer whale: Pygmy killer whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). Strandings have been reported in Western Australia (Ross, 2006). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (22,029 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000995 animals/km^2 for winter, 0.001036 animals/km^2 for spring, 0.001012 animals/km^2 for summer, and 0.000965 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Risso's dolphin: Risso's dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (452,125 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.071516 animals/km^2 for winter, 0.072144 animals/km^2 for spring, 0.069443 animals/km^2 for summer, and 0.027159 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Rough-toothed dolphin: Rough-toothed dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (156,690 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000594 animals/km^2 for winter, 0.000599 animals/km^2 for spring, 0.000588 animals/km^2 for summer, and 0.000590 animals/km^2 for fall, calculated from the NMSDD (DoN, 2011).

Short-finned pilot whale: Short-finned pilot whales are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (268,751 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.026984 animals/km^2 for winter, 0.027585 animals/km^2 for spring, 0.026887 animals/km^2 for summer, and 0.027159 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Southern bottlenose whale: Kasamatsu and Joyce (1995) estimated an abundance of 559,300 (CV=15%) beaked whales south of the Antarctic Convergence Zone in January, most of which were considered to be southern bottlenose whales; this is the best estimate of abundance for this model area. The best available density estimates are extrapolated from the seasonally-specific, RES-modeled density estimates of Blainville's beaked whales: 0.000830 animals/km^2 for winter, spring, and fall, and 0.000822 animals/km^2 for summer, calculated from the NMSDD (DoN, 2018).

Spade-toothed whale: The spade-toothed whale has been documented from only three specimens, two from New Zealand, and one from Chile. Based on these data, it is estimated that it may be found in southern hemisphere waters. As a proxy, data from the Blainville's beaked whale are used as the best available. The abundance estimate is extrapolated from the eastern tropical Pacific (16,867 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000830 animals/km^2 for winter, spring, and fall, and 0.000822 animals/km^2 for summer, calculated from the NMSDD (DoN, 2018).

Sperm whale: The IWC divides the Indian Ocean into two stocks, a northern Indian stock and a southern Indian stock (Perry et al., 1999). The best available abundance estimate is extrapolated from the eastern tropical Pacific (24,446 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.000955 animals/km^2 for winter, 0.000872 animals/km^2 for spring, 0.000971 animals/km^2 for summer, and 0.000915 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Spinner dolphin: Spinner dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (634,108 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.005607 animals/km^2 for winter, 0.005492 animals/km^2 for spring, 0.005683 animals/km^2 for summer, and 0.005626 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

Striped dolphin: Striped dolphins are distributed throughout temperate and tropical waters of the world (Jefferson et al., 2008, 2015). A single stock is recognized in the Indian Ocean. The best available abundance estimate is extrapolated from the eastern tropical Pacific (674,578 animals; Wade and Gerrodette, 1993). The best available density estimates are seasonally-specific, RES-modeled density estimates of 0.120177 animals/km^2 for winter, 0.120411 animals/km^2 for spring, 0.116797 animals/km^2 for summer, and 0.117268 animals/km^2 for fall, calculated from the NMSDD (DoN, 2018).

D-15. MODEL AREA 15—NORTHEAST OF JAPAN

Blue whale: Few data are available on blue whale occurrence in the North Pacific Ocean and the stock structure in the North Pacific remains uncertain. Stafford et al. (2001) studied the geographic variation of blue whale calls in the North Pacific, and although there was no hydrophone coverage in the mid-latitudes off Japan, there was some coverage near the Kamchatka Peninsula and along the western

Aleutian Islands chain. All calls recorded on these hydrophones were northwest Pacific blue whale calls (Stafford et al., 2001). Although the blue whale was the initial focus of Japanese whaling effort in the North Pacific, limited data were reported on blue whales. Therefore, sighting surveys associated with Japanese whaling of fin whales were judged to be the most appropriate proxy for blue whale occurrence estimates (Tillman, 1977; Carretta et al., 2015). Thus, the best available abundance for the WNP blue whale stock is 9,250 animals (Tillman, 1977). The best density for blue whales in this model area is 0.0001 whales/km^2, which was estimated for the winter, spring, and fall seasons (Tillman, 1977, Ferguson and Barlow, 2001 and 2003; LGL, 2008). This density for blue whales is comparable to density estimates of the blue whale in offshore areas of the ETP (Ferguson and Barlow, 2003) and to the waters surrounding Guam (Fulling et al., 2011).

Common minke whale: Several stocks of minke whales are recognized in the western North Pacific Ocean, including the western North Pacific "O" east (WNP OE) stock, and the western North Pacific "J" west (WNP JW) stock (Miyashita & Okamura, 2011; Wade & Baker, 2011). Minke whales potentially occurring in the waters of this model area are believed to be part of the "WNP OE" stock. Buckland et al. (1992) conducted sighting surveys during July and August in the western North Pacific Ocean and Sea of Okhotsk, from which a density estimate of 0.0022 animals/km^2 (SE = 0.17) from encounter rates and effective search widths was derived for the offshore population. The abundance estimate for the WNP "OE" stock is estimated as 25,049 individuals (Buckland et al., 1992). Ferguson and Barlow (2001; 2003) computed density estimates in offshore areas of the ETP that are of the same magnitude.

Fin whale: Fin whales have been reported in this region from spring, summer, and fall, migrating south in the winter to about 20°N (Mizroch et al., 2009). Density and stock estimates, 0.0002 animals/km^2 and 9,250 animals, respectively, for the WNP stock of fin whales, were derived from encounter rates of Japanese scouting boats in the northwest Pacific (Tillman, 1977). This density is comparable to density estimates in offshore areas of the ETP (Ferguson and Barlow, 2001, 2003) and an order of magnitude higher than that calculated for around Hawaii (0.00002 animals/km^2; Bradford et al., 2013).

Humpback whale: The NMFS Humpback Whale Biological Review Team (BRT) conducted a comprehensive status review in which they revised the ESA status for humpback whales in this region to be part of the Western North Pacific Distinct Population Segment (WNP DPS) and listed as endangered (Bettridge et al., 2015; NOAA, 2016a). The WNP DPS breeds/winters in the region of Okinawa and the Philippines and migrates to feeding grounds in the North Pacific, primarily off the Russian coast. Thus, humpback whales are expected to occur in model area #15 during spring, summer, and fall. In addition, approximately one-quarter of the population is expected to be found in water depths of less than 1,000 m (3,281 ft), which was implemented in the modeling as a depth aversion. The SPLASH consortium derived an average abundance for the Asian wintering grounds of approximately 1,000 humpback whales, which has increased annually to an abundance estimate of 1,328 individuals (Calambokidis et al., 2008; Bettridge et al., 2015). A density of 0.000498 animals/km^2 was estimated for the WNP stock of humpback whales (DoN, 2017).

North Pacific right whale: The WNP stock of North Pacific right whales is considered distinct from the eastern population, arbitrarily separated by the 180° line of longitude (Best et al., 2001). The Okhotsk Sea, Kuril Islands, and eastern Kamchatka coast represent major feeding grounds for the western population (Brownell et al., 2001) where animals are typically found May through September (Clapham et al. 2004). Various areas have been proposed for breeding and calving grounds, including the Ryukyu Islands, Yellow Sea, Sea of Japan, offshore waters far from land, and the Bonin Islands, but a lack of winter sightings (December to February) makes a definitive assessment impossible (Brownell et al., 2001). Clapham et al. (2004) note the extensive offshore component to the right whale's distribution in the 19th century data. Data from Japanese sighting cruises in the Okhotsk Sea provide an abundance estimate of 922 animals (CV=0.433, 95% CI=404 to 2,108) (Best et al., 2001) for the WNP population. No density estimates are available for this very rare marine mammal species, therefore, the nominal minimum density estimate of 0.00001 animals/km^2 was used in the risk analysis to reflect the very low probability of occurrence in this region during summer and fall seasons.

Sei whale: Sei whales are present throughout the temperate North Pacific Ocean but have been observed as far south as 20°N (Horwood, 1987). The IWC recognizes one stock of sei whales in the North Pacific (Donovan, 1991), although some evidence exists for several populations (Carretta et al., 2015). Very few sightings of sei whales have occurred in any region of the North Pacific, and adding to the difficulty, sei whales are extremely difficult to differentiate from Bryde's whales at sea. Tillman (1977) derived an abundance estimate of 8,600 individuals for sei/Bryde's whale in the North Pacific from whaling catch statistics. Mizroch et al. (2015) estimated the size of the pelagic migratory stock in 1975 at approximately 4,000 animals, but their "single stock" (coastal and pelagic) state space analysis estimated a population size of 7,000 animals in 1974, which is used here as the best available data. Initial estimates for a portion of the sei whale population off Japan indicate abundance estimates of similar magnitude (7,744 for May to June and 5,406 for July to September; Hakamada et al., 2009). With no specific densities derived for these waters, the best available density estimate (0.00029 animals/km^2 CV=48.7) for the sei whales in this model area is calculated from the winter/spring surveys around Guam and the Mariana Islands (Fulling et al., 2011). This is similar to that calculated for around Hawaii (0.00016 animals/km^2; Bradford et al., 2017).

Western North Pacific gray whale: Gray whales in the western North Pacific Ocean are genetically distinct from those gray whales occurring in the eastern North Pacific Ocean (LeDuc et al., 2002). New data photographing western North Pacific gray whales off the U.S. west coast has prompted NMFS to draft the first ever stock assessment report for this population (Carretta et al., 2015). The present day distribution of the WNP gray whale stock appears to range from summering grounds in west central Okhotsk Sea off the northeast coast of Sakhalin Island to wintering grounds in the South China Sea (Meier et al., 2007; Weller et al., 2002). However, some individuals that summer off Sakhalin Island have also been documented off the west coast of North America, suggesting long seasonal migrations (Carretta et al., 2015). Photo-identification studies off Sakhalin Island estimate a population size of 140 (CV=0.043) animals in the WNP stock (Cooke et al., 2013; Carretta et al., 2015). With no density estimate for this rare species available, a minimal density of 0.0001 animals/km^2 was used in risk computation for this model area to reflect the extremely low potential for this species occurring.

Baird's beaked whale: Baird's beaked whales are migratory, arriving in continental slope waters in April to May and remaining through October (Dohl et al., 1983; Kasuya, 1986). Ohizumi et al. (2003) examined the stomach content of Baird's whales caught off the east coast of Japan and reported that the observed prey species were demersal fish that were identical to those caught in bottom-trawl nets at depths greater than 1,000 m (3,281 ft). Kasuya (1986) collected sighting data from 25 years of aerial survey records and 1984 shipboard sightings off the Pacific coast of Japan; based on Kasuya's (1986) encounter rate and effective search width, a density estimate of 0.0029 animals/km^2 was derived for the Baird's beaked whale stock in this model area during summer and fall, and 0.0015 animals/km^2 for the spring. Kasuya and Perrin (2017) cited an abundance estimate by Miyashita (1986, 1990) of 5,688, and is the abundance estimated for the WNP stock of Baird's beaked whales.

Common dolphin: Short-beaked and long-beaked common dolphins were redefined as one species, common dolphin (*Delphinus delphis*) (SMM, 2017). No data on density or abundance estimates of common dolphins are available for the waters of the western North Pacific (Miyashita, 1993). Due to this lack of information, population data derived from ETP surveys of 3,286,163 animals and 0.0863 animals/km^2 (Ferguson and Barlow, 2001, 2003) are the most appropriate to represent the WNP stock of common dolphins.

Cuvier's beaked whale: No density or stock estimate data are available for Cuvier's beaked whales in this region. Considering habitat preferences (e.g., water temperature, bathymetry), it was determined that the best available abundance of 90,725 animals derived from the long-term ETP time series (Ferguson and Barlow, 2001, 2003) and the best available density estimate of 0.0054 animals/km^2 (Ferguson and Barlow, 2001, 2003) most optimally represent this stock in this region. This density estimate is greater than that estimated for the Hawaii EEZ (0.0003 animals/km^2; Bradford et al., 2017) but comparable to the mean predicted density estimate for the ETP (0.00455 animals/km^2; Ferguson et al., 2006).

Dall's porpoise: Dall's porpoise are found only in the North Pacific, primarily north of 36°N in the western North Pacific Ocean. This species has two distinct color morphs: one with a white flank patch that extends forward to the dorsal fin (*dalli* type) and one with a flank patch extending all the way to the front flippers (*truei* type). These morphological differences have been noted between animals from the Pacific coast of Japan (the *truei*-type), the Sea of Japan, and Sea of Okhotsk (the *dalli*-type), and the offshore northwestern Pacific and western Bering Sea (the *dalli*-type) (Hayano et al., 2003). Hayano et al. (2003) conducted genetic studies on the three populations and found a low, but significant, difference between the Sea of Japan-Okhotsk population and the other two populations. Based on surveys of the eastern North Pacific, a density estimate of 0.0520 animals/km^2 was derived for the spring and fall, with slightly lower (0.0390 animals/km^2) and slightly higher (0.650 animals/km^2) densities in the winter and summer, respectively (Ferguson and Barlow, 2001, 2003). Kasuya and Perrin (2017) cite Miyashita (1991) for an abundance estimate of 162,000 animals in this region. This density estimates a concentration of Dall's porpoises probably larger than what would be encountered by LFA operations in the model area since it includes survey effort in nearshore waters where animals are more often found.

Killer whale: Killer whales have been observed in waters northeast of Japan (Forney and Wade, 2006) and along the Aleutian archipelago and in the Bering Sea (Springer et al., 2003). Without any population or occurrence data on killer whales for the western North Pacific, the best available abundance estimate of 12,256 animals is derived from Ferguson and Barlow's (2001, 2003) long-term time series in the ETP. The best available density estimate of 0.0036 animals/km^2 is derived from Springer et al.'s (2013) survey data of the central Aleutian Islands. This is two orders of magnitude higher than LGL's (2011) density (0.00009 animals/km^2) and the density in the Hawaii EEZ (0.00006 animals/km^2, Bradford et al., 2017).

Pacific white-sided dolphin: No data on density or stock estimates of Pacific white-sided dolphins in this region are available (Miyashita, 1993), but one NP stock is estimated for this species. Due to this lack, the density (0.0048 animals/km^2) estimated from eastern Pacific waters (Ferguson and Barlow, 2001, 2003) was used to best represent the NP stock of these dolphins in this model area, while Buckland et al.'s (1993) abundance of 931,000 animals is most appropriate. No sightings of Pacific white-sided dolphins were reported in Hawaii surveys (Barlow, 2006; Bradford et al., 2017; Mobley et al., 2000).

Sperm whale: Stock structure of sperm whales in the North Pacific is not well resolved. Sightings collected by Kasuya and Miyashita (1988) suggest that in the summer, the density of sperm whales is high south of the Kuroshio Current System (south of approximately 35°N) but extremely low north of 35°N. These data suggest two stocks of sperm whales in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands (~50°N) and winter off Hokkaido and Sanriku (~40°N) and the southern WNP stock with females that summer off Hokkaido and Sanriku (~40°N) and winter around the Bonin Islands (~25°N) (Kasuya and Miyashita, 1988). The males of these two stocks are found north of the range of the corresponding females, i.e., in the Bering Sea (~55°N) and off Hokkaido and Sanriku (~40°N), respectively, during the summer (Kasuya and Miyashita, 1988). However, until higher resolution population and distributional data are available, sperm whales are considered to belong to only one NP stock. Potentially, sperm whales of the NP stock, numbering 102,112 individuals (Kato and Miyashita, 1998; Allen and Angliss, 2015), may occur year-round in the waters of this offshore model area. The best density estimated for sperm whales is 0.0022 animals/km^2 in the spring, summer, and fall, as derived by LGL (2011), and slightly smaller in the winter (0.0017 animals/km^2). These densities are similar to that derived by Forney et al. (2015; 0.00158 animals/km^2) for the Hawaii EEZ and Fulling et al. (2011; 0.00123 animals/km^2) for the waters around Guam and Mariana Islands.

Stejneger's beaked whale: Considering habitat preferences (e.g., water temperature, bathymetry), the most appropriate density estimate for Stejneger's beaked whale is 0.0005 animals/km^2, which is derived from ETP data (Ferguson and Barlow, 2001, 2003), with the most appropriate abundance (8,000 animals) extrapolated from the abundance estimate derived for the WNP stock of Baird's beaked whales (Kasuya, 1986).

Northern fur seal: Northern fur seals in this region are part of the Western Pacific stock. Northern fur seals only go ashore on their breeding grounds; after breeding and molting, many northern fur seals travel southward, where they remain at sea (Buckland et al., 1993; Allen and Angliss, 2015). During the reproductive season, adult males haul-out from May to August, whereas adult females are ashore from June to November. The Western Pacific stock is estimated at 503,609 animals (Gelatt et al., 2015; Kuzin, 2015). Averaging the densities for the areas surveyed in Buckland et al. (1993) that occur in the waters of Model area 15, the average density of 0.0138 animals/km^2 was estimated for northern fur seals in this region during spring, summer, and fall. Fewer animals are expected in winter when most fur seals migrate southward, resulting in a density estimate of 0.0069 animals/km^2.

Ribbon seal: Ribbon seals occupy the pack ice that overlies deeper water near the continental shelf break from late winter until summer. When the pack ice breaks up in summer, their distribution is not well known, though satellite data suggest they disperse widely. Ten seals tagged near the eastern coast of Kamchatka spent the summer and fall throughout the Bering Sea and Aleutian Islands (Boveng et al., 2008). The best available data suggest an abundance estimate for the North Pacific stock of 365,000 animals (Lowry, 2016). The best density data are from the Bering Sea, with a winter/spring density estimate of 0.0904 animals/km^2 and a summer/fall density of 0.0452 animals/km^2 (Moreland et al., 2012).

Spotted seal: The Bering Sea DPS (Boveng et al., 2009) is synonymous with the MMPA Alaska stock of spotted seals (Allen and Angliss, 2015) and includes seals that breed in the Bering Sea. Spotted seals inhabit the southern edge of the pack ice from winter to early summer. Although population data are limited on spotted seals in northwestern Pacific waters, spotted seals have been observed in the waters off eastern Kamchatka during spring and summer (Boveng et al., 2009). The best available abundance estimate is 461,625 animals (Conn et al., 2014; Muto et al., 2018) and the best available density estimate is from the Bering Sea, with the spring season density estimate (0.277 animals/km^2; Moreland et al., 2008) and half that density estimate for the summer season (0.1385 animals/km^2).

Steller sea lion: Steller sea lions range along the North Pacific Rim from northern Japan to California (Muto et al., 2018). They are divided into two stocks, of which animals from the western/Asian stock and western DPS may occur in this model area year-round, though in low numbers in winter. The best available abundance estimate is 71,221 animals (Burkanov, 2017; Muto et al., 2018). There are no density estimates for this species; therefore, the default minimum density of 0.0001 animals/km^2 was used in the exposure estimates.

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APPENDIX E: AIR QUALITY ANALYSIS

APPENDIX E: AIR QUALITY ANALYSIS, EMISSIONS CALCULATIONS, AND RECORD OF NON-APPLICABILITY

This appendix discusses the air emissions' factor development and calculations during training and testing activities of the action alternatives, including assumptions employed in the analyses presented in the Air Quality section of Chapter 4 (Section 4.3). Air emissions analysis was conducted in a Navy-proprietary air emissions and marine fuel consumption analysis system.

E.1 Air Quality Calculations

E.1.1 Surface Activity Emissions

Surface activities consist of SURTASS LFA sonar vessel traffic during training and testing activities of the action alternatives. In addition to propulsion engines, all SURTASS LFA sonar vessels are equipped with generators operating onboard to provide electricity for non-propulsion functions. The engine configurations or propulsion methods may differ amongst the classes of SURTASS LFA sonar vessels, such as marine outboard engines, diesel engines, and gas turbines. Calculations of air emissions are based on the combustion of the marine fuel F-76 or equivalent that fuel the SURTASS LFA sonar vessel engines and the amount of time the engines are estimated to be in operation, based upon the action alternatives.

E.1.1.1 Diesel Engines

The air emissions generated by SURTASS LFA sonar vessels were calculated using emission factors from the Naval Sea Systems Command Navy and Military Sealift Command Marine Engine Fuel Consumption and Emission Calculator for the propulsion system and the supplemental ship service generator(s). Engine emission factors were multiplied by the engine horsepower and annual hours of operation to calculate the pounds of pollutant emissions per year. These values were converted to a metric ton per year unit for comparison across alternatives and to allow ease in discussion of the summed total emissions on an individual pollutant basis.

E.1.2 Air Emission Estimates

The following analysis input, assumptions, and resulting data summary illustrate the air emissions output from the Navy proprietary emissions and marine fuel consumption analysis system computed for the existing four SURTASS LFA sonar vessels (Figure E-1).

SURTASS VESSEL EMISSIONS

Assumptions:

EO 12114 - Analysis to Cover the Training and Testing Hours Only outside US and Foreign Nation Territorial Seas
SURTASS FLEET Composition: T-AGOS 19 -Three (3) in this Class; T-AGOS 23 - One (1) in this Class
Alternative Hours represent estimated actual reviewable training/testing hours (those hours identified by SURTASS operations)
All other hours are associated with Normal Mission Operations
5% hours in US Federal Waters greater than 3 Nm but within 12 Nm
95% hours in outside US and Foreign Nation Territorial Seas (> 12 Nm in Pacific Ocean)
Hours Assumption based on total per vessel type not per engine;

* SURTASS calculations in NAVSEA/MSC system results assume: Training and Testing hours is represented by restricted waters results
Marine Fuel - F-76; Sulfur content is based on OCONUS Bunkering
Emissions Worse Case Assumptions
All PM10 is PM 2.5 as well
SOX = SO2 for EO 12114 analysis

No Action Alternative
No Hours and therefore No Emissions from Training or Testing

Testing and Training Time Alternatives
Alternative 1
Total Annual 90 Hours Operation Per Vessel
Alternative 2 (Preferred Alternative)
Total Annual 148 Hours Operation Per Vessel

Per Vessel Estimates

Surtass Operations estimated Ops Training Hours for Alternative 1	90
Surtass Operations estimated Ops Training Hours for Alternative 2	148

Vessel Type In Service (#/Type Engines)	No Action Alternative	Action Alternative 1 (TPY) Low T&T	Action Alternative 2 - Preferred (TPY) High T&T
T-AGOS 19 (1 EDG / 4 IPG)	0	3	3
T-AGOS 23 (1 EDG / 3 IPG)	0	1	1

Load Factors not used - Assumption is that NAVSEA system has load factors included in calculations of emissions
IPG - Integrated Prppulsion Generator
EDG - Emergency Diesel Generator Engine

Vessel Hours(Per Vessel) Per Year	No Action	Alternative 1	Alternative 2 Preferred Max Hours Year 5
Testing and Training Hours Per Year	0	90	148

Figure E-1. Air Emissions Calculation Summary for SURTASS LFA Sonar Vessels.

Per Vessel Type Vessel Emissions

T-AGOS 19	Tons Per Year							MT
	CO	NOx	PM10	PM2.5	SOx	VOC	CO2	CO2e
Restricted Waters (Ocean Operations)* No Action Alternative	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restricted Waters (Ocean Operations)* Alt #1	0.21	3.00	0.06	0.06	0.49	0.13	130.15	118.05
Restricted Waters (Ocean Operations)* Alt #2	0.35	4.93	0.10	0.10	0.81	0.22	214.02	194.12

T-AGOS 23	Tons Per Year							MT
	CO	NOx	PM10	PM2.5	SOx	VOC	CO2	CO2e
Restricted Waters (Ocean Operations)* No Action Alternative	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Restricted Waters (Ocean Operations)* Alt #1	0.11	5.87	0.06	0.06	0.79	0.08	197.11	178.78
Restricted Waters (Ocean Operations)* Alt #2	0.18	9.65	0.09	0.09	1.30	0.14	324.11	293.98

EMISSIONS SUMMARY

	Fraction of Total Vessel Training Hour by location
Vessel Training Ops (>12 Nm Open Ocean - OEIS - EO12114)	0.95
Vessel Training Ops (3 Nm > X > 12Nm - EIS - NEPA)	0.05

Primary Event Activity - SURTASS FLEET	No Action Alternative (Tons Per Year)							MT/YR
	CO	NOx	PM10	PM2.5	SOx	VOC	CO2	CO2e
Vessel Training Ops Totals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vessel Training Ops (>12 Nm Open Ocean - OEIS - EO12114)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vessel Training Ops (3 Nm > X > 12Nm - EIS - NEPA)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Primary Event Activity - SURTASS FLEET	Action Alternative 1 (Tons Per Year) Low T&T							MT/YR
	CO	NOx	PM10	PM2.5	SOx	VOC	CO2	CO2e
Vessel Training Ops Totals	0.74	14.87	0.24	0.24	2.26	0.47	587.56	532.93
Vessel Training Ops (>12 Nm Open Ocean - OEIS - EO12114)	0.70	14.13	0.23	0.23	2.15	0.45	558.18	506.29
Vessel Training Ops (3 Nm > X > 12Nm - EIS - NEPA)	0.04	0.74	0.01	0.01	0.11	0.02	29.38	26.65

Primary Event Activity - SURTASS FLEET	Action Alternative 2 - Preferred (Tons Per Year) High T&T							MT/YR
	CO	NOx	PM10	PM2.5	SOx	VOC	CO2	CO2e
Vessel Training Ops Totals	1.23	24.44	0.39	0.39	3.73	0.80	966.17	876.34
Vessel Training Ops (>12 Nm Open Ocean - OEIS - EO12114)	1.17	23.22	0.37	0.37	3.54	0.76	917.86	832.53
Vessel Training Ops (3 Nm > X > 12Nm - EIS - NEPA)	0.06	1.22	0.02	0.02	0.19	0.04	48.31	43.82

Figure E-1 (Continued). Air Emissions Calculation Summary for SURTASS LFA Sonar Vessels.